EVALUATION OF CARBOFURAN FOR THE CONTROL OF SOLDIER FLY IN PASTURE

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Summary

The first of a succession of trials was commenced at Raglan in 1973 to study the effect of under-drilling the insecticide carbofuran with ryegrass seed into land infested with soldier fly larvae. Carbofuran 2 kg/ha resulted in a highly significant (1% level) reduction in soldier fly (*Inopus rubriceps*) larvae 3 and 12 months after application and a similar increase in total dry matter measured at six separate harvests during that year. A combination of a pre-sowing application of paraquat followed by carbofuran significantly (1% level) reduced the soldierfly larvae numbers in comparison with all other treatments 3 and 12 months after application.

INTRODUCTION

The pest status of soldier fly (*Inopus rubriceps*) in Australia and New Zealand has been well documented (Saunders, 1963; Hitchcock, 1970; Hewitt, 1969 and Wilcocks, 1974). Present control methods involving surface cultivation (Wilcocks and Hewitt, 1971; Dixon and Grimmer, 1973, and Cumberland *et al*, 1973) have been shown to reduce larval numbers. Such methods are however considered to be expensive and are advocated as a last resort (Wilcocks, 1974). Due largely to the high rates required, early workers considered that chemical control of soldier fly in pastures would also prove expensive (Dumbleton, 1949; Saunders, 1963; Hewitt, 1964, 1969 and Cumberland and Honore 1973). In a pasture screening trial Dixon and Grimmer (1973) reported a promising kill of larvae from the systemic insecticides carbofuran (93%) phorate (76%) and fenamiphos (71%). They considered that these materials would warrant further consideration as a possible means of controlling soldier fly.

In May of 1973 a series of trials was initiated at Raglan to study the effect of underdrilling the insecticide carbofuran together with grass seed into land infested with soldier fly larvae. A randomised block design trial was sited at Raglan, Waikato on a clay loam and the treatments shown in Table 2, were replicated 5 to 6 times on plots 10 x 2.6 m. Treatments were applied on the 31st May, 1973 with a Duncan triple disc "Multiseeder drill" in 15 cm rows with serpentine superphosphate drilled at a rate of 1000 kg/ha on all plots. Carbofuran as 5% granules was mixed and drilled with fertiliser. The grass seed mixture used in the trial was 11 kg/ha of perennial and 5.5 kg/ha of short rotation ryegrass (*Lolium* spp.). Treatments 2 and 4 were sprayed with paraquat 0.6 kg in 500 litres/ha on the 28th May 1973.

Larvae Assessment

Treatment effect on the soil population of soldier fly was measured by taking eight random 8 cm diameter soil cores to a depth of 10 cm per plot and counting the larvae. Larval assessment was carried out before treatment and 2, 3 and 12 months post-treatment.

The effect of paraquat and carbofuran on the larval population was measured 2 months after treatment. Eight soil cores were taken at random on the 15 cm rows of treatments 2 and 4 and a similar

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number of cores taken *between* the rows for larvae assessment. A standard sieve and floatation technique involving the use of magnesium sulphate and water was used in these procedures.

Plant Assessment

The effect of soldier fly and treatment on ryegrass seedling emergence was assessed by counting the number of seedlings present in twelve 1 m lengths of row in each of the non carbofuran treated plots and four 1 m length of row in the carbofuran treated plots.

Plant vigour was assessed by four independent observers on the 1st August 1973. The visual scale used to assess treatment response was as follows:

- 1 = no pasture growth response
- 5 = maximum growth response

Pasture production was measured at six intervals during the year. A randomly selected area of 5 m² was harvested from each plot for dry matter and herbage composition determination. After each harvest the area was heavily block grazed with sheep and closed for the next assessment.

RESULTS

Soldier fly larvae numbers: (Divide larvae counts by 36.5 to get 1000s/m²)

TABLE 1: THE EFFECT OF CARBOFURAN ON SOLDIER FLY LARVAE UNDER NEW PASTURE ESTABLISHED WITH THE AID OF PARAQUAT SIX WEEKS AFTER TREATMENT

Treatment	Mean larvae per treatment
paraquat+seed	425 aA
paraquat+seed+carbofuran 2 kg/ha	31 bB
CV%	20

A highly significant reduction in the number of larvae was measured on the carbofuran treatment (Table 1).

TABLE 2: THE EFFECT OF TREATMENT ON NUMBER OF SOLDIER FLY LARVAE AND PASTURE VIGOUR

Treatment	3 months* mean larvae, no.	12 months mean larvae	2 months No. pasture vigour
seed	297 abA	63 aAB	1.7 bB
paraquat + seed	269 bA	55 aAB	1.3 bB
carbofuran 2 kg/ha + seed	118cB	24 bBC	4.4 aA
paraquat + carbofuran 2 kg/ha	50 dC	5 cD	4.6 aA
undersow carbofuran 2 kg/ha (no seed)	144 cB	17 bC	4.4 aA
control	358 aA	75 aA	1.6 bB
CV%	27	54	14
Main Effects:			
no paraquat	aA	no carbofuran	aA
paraquat	bB	carbofuran	bB
Interaction 1%			

* the 3 month treatment means have been adjusted for co-variance.

Three month assessment:

Carbofuran 2 kg/ha significantly reduced the number of larvae in comparison with all other treatments (Table 2) and pre-treatment with paraquat gave a further significant reduction. In comparison with control a significant reduction in the number of larvae occurred when paraquat was used as an aid to pasture establishment.

Twelve months assessment

The same superiority of paraquat and carbofuran was shown as at the three month assessment. The carbofuran effect on larvae numbers was stronger than the paraquat effect.

Both *on* and *between* the row carbofuran caused a highly significant reduction of larvae numbers (1% level) (Table 3). With paraquat a one larvae numbers *between* the row were significantly lower than those *on* the row.

TABLE 3: NUMBER OF SOLDIER FLY LARVAE ASSESSED ON AND BETWEEN THE 15 cm DRILLED ROW TWO MONTHS AFTER TREATMENT AND NUMBER OF RYEGRASS SEEDLINGS PRESENT SIX WEEKS AFTER TREATMENT

Treatment	Mean Larvae No.*		Mean No. Seedlings/ on row †
	on row	between rows	
paraquat pre-sowing + seed	331 aA	211 bB	40 a
paraquat pre-sowing + seed + carbofuran 2 kg/ha	33 cC	60 cC	48 a
CV%	29		17

* The interaction is significant at 1%

† Minimum significant difference = 11

Dry matter production

Table 4 summarises the dry matter production measured within the period 31 May 1973 to 16 May 1974.

At the 3 September and 12 October 1973 cuts a significant response in ryegrass and clover production was measured from the addition of carbofuran 2 kg/ha. Similarly a significant decline in both ryegrass and clover was measured on paraquat treatments.

At the 16 November 1973 cut a significant increase in drymatter was measured on the carbofuran treated plots in comparison with all other treatments. At this harvest drymatter production on the carbofuran and paraquat treatments did not differ significantly from the carbofuran alone. The interaction between carbofuran and paraquat on drymatter production was significant at the 1% level.

Carbofuran recorded a significant response in dry matter production in comparison with all other treatments on 31 January, 3 April and 16 May 1974.

Without carbofuran paraquat significantly (5% level) reduced total dry matter in comparison with untreated on 16 May 1974.

During the full year of treatment all treatments with carbofuran significantly increased dry matter production. Paraquat reduced dry matter production but the interaction between carbofuran and paraquat was significant.

Additional work

Further experiments gave similar statistically significant responses in terms of reduction in larvae numbers and increased production. (Mackay, Rowe *et al*, 1974).

TABLE 4: DRY MATTER AND HERBAGE ANALYSIS MEASUREMENTS (kg/ha) RECORDED AT INTERVALS
WITHIN THE PERIOD 31 MAY 1973 TO 16 MAY 1974

Treatment rate/ha	Ryegrass	Clover	3.9.73 Weeds	12.10.73 Total D.M.	16.11.73 Total DM	31.1.74 Total DM	3.4.74 Total DM	16.5.74 Total DM	3.9.73 to 16.5.74 Total DM
undersow seed	345 bcB	155 bABC	215 aA	540 bB	735 bB	172 bBC	76 cB	374 bB	2622 cC
paraquat pre-sowing + seed	85 dC	0 dD	0 bB	140 cC	346 dD	153 bC	51 cB	189 cB	965 dD
undersow seed + carbofuran 2 kg	620 aA	275 aA	170 aA	1270 aA	1458 aA	344 aA	380 bA	837 aA	5351 aA
paraquat pre-sowing + seed+carbofuran 2 kg	200 cdBC	15cdCD	0 bB	720 bB	1373 aA	426 aA	528 aA	706 aA	3970 bB
undersow carbofuran	665 aA	220 abAB	270 aA	1100 aA	1276 aA	289 aAB	395 abA	830 aA	5052 aAB
control	350 bB	115 bBC	165 aA	560 bB	546 cC	148 bC	45 cB	233 bcB	2177 cC
CV%	36	58	59	30	29	39	41	39	17
Main Effects									
no paraquat	485 aA	215 aA	185 aA	900 aA	1095 aA	260 a	230 a	605 aA	3985 aA
paraquat	140 bB	5 bB	0 bB	430 bB	860 bA	285 a	290 a	445 bA	2470 bB
no carbofuran	215 bB	80 bB	—	340 bB	540 bB	160 bB	65 bB	280 bB	1795 bB
carbofuran	410 aA	155 aA	—	1000 aA	1415 aA	385 aA	455 aA	770 aA	4660 aA
interaction	1%			N.S.	N.S.	N.S.	5%	N.S.	5%
Weed species in order of importance:	Cerastium sp Rumex Obruifolius, R. acetosella			Taraxacum officinale Plantago lanceolata					

DISCUSSION

Research in New Zealand has investigated three main techniques for the control of soldier fly, these are:

- (a) Pasture trampling under heavy winter stocking rates which was found to be only partially effective (Wilcocks 1971).
- (b) Cultivation: (Wilcocks and Hewitt 1971) showed that 13 cultivations in the autumn caused a 95% reduction in larvae numbers, whilst a continuous cultivation treatment (between February and May) reduced larval number by (75-90%) and increased dry matter production (Cumberland, 1973).
- (c) Chemical.

At current agricultural contracting rates of \$10 per hour, the cost of cultivation is approximately \$90 per hectare for a total of nine cultivations, compared with thirteen cultivations described by Wilcocks and Hewitt (1971). These costs do not take into account the interim loss of dry matter production during the establishment period required for new pasture.

Cultivation also destroys the clover component of the original pasture, resulting in a reduction of available nitrogen to the developing sward.

The experimental evidence presented in this paper has shown that undersowing carbofuran into land infested with soldier fly caused a significant reduction in the larvae population and increase in dry matter production. Measurements of these responses, which have persisted for a year after treatment, are being continued.

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In practice the results obtained in the trials may be applied in a number of ways. If the larvae infestation is relatively light (3000-6000/m²) one of the first indications of an insect problem is a noticeable loss of ryegrass from the sward. In this situation undersowing with 2 kg/ha of carbofuran can reduce the number of larvae present in the soil for more than 12 months. A substantial dry matter production increase has been shown to result from this treatment. If however, the pasture has deteriorated to the stage where the ryegrass is almost absent from the sward, undersowing with seed and carbofuran can reduce larvae numbers and increase pasture production. In land which is so heavily infested with soldier fly, (10,000-13,000/m²) that all grass has been lost from the sward, leaving only weed species and clover, the use of paraquat as a pre-sowing spray prior to under-drilling with seed and carbofuran may be recommended. The combined effect of paraquat and carbofuran on the larvae of soldier fly both on and between the drilled row indicates that the paraquat treatment which effectively kills the existing pasture sward, may encourage larvae movement towards a new food source, i.e. the developing ryegrass seedlings (Fig. 1). The fact that this treatment resulted in the greatest reduction in larvae numbers warrants further research.

Seedling emergence was not significantly affected by the soldierfly larvae. Dixon (pers. comm.) in small pot work has confirmed this effect by germinating ryegrass in the presence of high populations of soldier fly. The significant differences in ryegrass production which were measured suggest that the soldier fly larvae may affect plant vigour reducing the future tillering capacity of the seedling ryegrass.

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(Chairman's Summary continued)

no critical work had been done. In reply to a question from Mr Lynch as to what he meant by a "normal pasture mix" Mr Farrell stated that it would be more correct to say that the same seeds mixture had been used in all trial work.

Carbofuran appeared to be the most promising chemical for control of soldier fly and questions were raised as to its possible effects on earthworms. This aspect was receiving attention but had not yet been completed. In reply to a question as to whether some of the effect on pasture growth could be due to factors other than effects on soldier fly larvae, Dr Parle stated that Mr Dixon had been unable to produce any plant growth effects in the absence of soldier fly in pot experiments. Mr Proude pointed out that the few promising insecticides against soldier fly were in fact all systematic nematocides. This could be significant.

Sowing insecticides in with seed evidently improved effectiveness and the question arose as to whether larvae were attracted to the roots of plants or whether the chemicals themselves might be attractive. It was stated that soldier fly larvae did appear to be attracted and that they might be more mobile than originally believed.

Mr King's paper on black beetle reported considerably improved effectiveness of certain insecticides in peat soils when drilled into the pasture surface compared to surface broadcast. The drilling procedure however caused some mechanical damage. It was suggested that the Duncan Multi-seeder might be considered as a possible implement as it caused very little pasture damage. Mr Leonard commented that there could be other advantages in putting insecticide beneath the pasture surface besides improved performance, such as reduced hazard to birds.

Mr King stated that it seemed that unlike grass grub, black beetle larvae were not selective feeders and were not attracted to the roots of particular plants. Effects of narrow band treatment with insecticide were thought to be produced by random movement of larvae.

In closing the session the Chairman commented that the papers presented illustrated well the procedures involved in evaluation of new chemicals for pasture pest control; initial screening to detect the most active materials for the pest in question, investigation of formulation and methods of application for optimum effect, and integration of chemical controls together with other pasture manipulation procedures.

Proc. 27th N.Z. Weed and Pest Control Conf.