HERBICIDE TOXICITY AND BIOLOGICAL CONTROL AGENTS

A.D. Wright and L. Skilling
CSIRO Division of Entomology, Long Pocket Laboratories,
Private Bag No. 3, Indooroopilly Qld. 4068

Summary. It may sometimes be desirable to apply herbicides to weeds even when insect biological control agents are present. This could occur where eradication rather than control is desired, or where speed of control is more important than expense. Herbicides differ in toxicity to insects. For example, 2,4-D was found to be virtually non-toxic to the weevil, *Neochetina eichhorniae*, the prime biological control agent of water hyacinth, whereas some other herbicides tested were significantly more toxic. Long-term benefits can be expected by using herbicides not harmful to populations of biological control agents.

INTRODUCTION

Liberation of biological control agents on a particular weed species need not be followed by cessation of all herbicide use on the weed. Firstly, the biological control agents may not be efficient over the whole of the environmental range of the weed. Secondly, biological control usually takes time to work, perhaps taking 10 years or more to achieve successful control (see review paper by Harley and Wright, this conference). Thirdly, biological control can never be expected to result in eradication of target weeds, and at sites where levels of control higher than those attainable with biological control are required, use of herbicides may continue indefinitely.

One attraction of biological control over chemical and mechanical weed control methods, is the prospect of long-term cost savings. In 1977 the cost of controlling aquatic weeds in Australia, by chemical and mechanical means, was estimated at between $1.5 and $4m annually (2), however an Australian Weeds Committee Working Party claimed that the total costs, including overheads, were far higher (1).

Biological control of aquatic weeds could be expected to reduce this expenditure appreciably, but it is not known if continued use of herbicides will jeopardise the effects of biological control agents. In order to provide a partial answer to this question, two experiments were undertaken to determine the toxicity of some herbicides and wetting agents to weevils the principal control agent for water hyacinth.

METHODS

Experiment 1. Five herbicides, amitrole (Amitrole T[R]), dichlorprop and surfactant (AF302[R]), dichlorprop (DF600[R]), two 2,4-D amines (Amicide-Lo[R] and Farmco D500[R]) and two surfactants (Chem 100[R] and Nufarm Surfactant[R]) were applied topically to the weevil. The application rates (% v/v) were: amitrole 2.5%; dichlorprop with surfactant 1%; dichlorprop 0.5%; 2,4-D amines 0.4%; and surfactants 0.1%.

Two hundred and forty adult weevils (sex ratio 1:1) were field collected and placed into 24 plastic food containers, each holding five males and five females. The containers of weevils were arranged into eight groups of three. On day 0 of the experiment, insects were dipped into the test solutions prepared to recommended dilutions for spraying water hyacinth; group 1 weevils into amitrole, group 2 into dichlorprop with surfactant (AF302[R]), group 3 into 2,4-D (Amicide-Lo[R]), group 4 into 2,4-D (Farmco D500[R]), group 5 into dichlorprop, group 6 into surfactant (Chem 100R), group 7 into surfactant (Nufarm SurfactantR), and group 8 into water. Laminae from age positions 1 to 5, the youngest five leaves, on insect-free water hyacinth plants which had been sprayed only with water were placed in each container on day 0 and replaced with fresh laminae on days 2, 6, 9, 13, 16, 20, 23, 27 and 30. the mortality was recorded each time leaves were replaced.

Experiment 2. The 2,4-D amine formulation Farmco D500R was further tested for toxicity to weevils. Since 2,4-D is often applied with surfactant added, the combined toxicity of 2,4-D and Chem 100R was also tested. In this experiment weevils were dipped into the treatment mixtures and also fed leaves sprayed with them.

On day 0 of the experiment, water hyacinth plants were sprayed with either 1% 2,4-D at a rate equivalent to 2 kg/ha, or the same volume and concentration of herbicide but with 0.1% added surfactant, or with deionised water.

Two hundred and ten adult weevils (sex ration 1:1) were field collected and placed into 21 containers each holding 5 males and 5 females. The containers were arranged into three groups. Insects in group A (6 containers) were dipped into the 2,4-D mixture and fed leaves sprayed either with 2,4-D or water; insects in group B (6 containers) were dipped into 2,4-D + surfactant and fed leaves sprayed with water or 2,4-D + surfactant; and insects in group C (9 containers) were dipped into deionised water and fed leaves sprayed with water, 2,4-D, or 2,4-D + surfactant. The insects were provided with new laminae twice weekly. The experiment was terminated after four weeks, when herbicide-treated laminae were dead. The mortality of weevils was noted each time new leaves were provided (days 3, 7, 10, 14, 17, 21, 24, 28 and 31).

Table 1. Experiment 1. The effect of herbicides and surfactants on mortality of adult weevils in experiment 1

Herbicide dip	Treat.	Males Dead	Females Dead	Total	Mortality (%)
Amitrole (Amitrole TR)	1	4	4	8	26.7 a
Dichlorprop with surfactant (AF302R)	2	4	4	8	26.7 a
2,4-D amine (Amicide-LoR)	3	0	2	2	6.7 b
2,4-D amine (Farmco D500R)	4	0	0	0	0.0 b
Dichlorprop (DP600R)	5	3	2	5	16.7 ab
Surfactant (Chem 100R)	6	0	2	2	6.7 b
Surfactant (Nufarm SurfactantR)	7	0	1	1	3.3 b
Water	8	3	1	0	13.3

Values followed by the same letter are not significantly different.

RESULTS AND DISCUSSION

Experiment 1. Values for weevil mortality after 30 days are given in Table 1. Analysis of variance of transformed data showed a significant difference (P =0.01) in mortality resulting from the treatments. Differences in means were tested using the protected l.s.d. at the 0.05 level. Amitrole and dichlorprop and surfactant (treatments 1 and 2) produced significantly greater mortality than either of the 2,4-D formulations (treatments 3 and 4). Results of treatments 3 and 4, treatment 8 (water) or treatments 6 and 7 (the two surfactants) were not significantly different. Dichlorprop (treatment 5) had a toxicity intermediate between amitrole and dichlorprop with surfactant and the 2,4-D formulations but was not significantly different from any of the other treatments.

Experiment 2. Values for weevil mortality after 31 days are given in Table 2. Data showed there was no additive effect when weevils had been dipped in herbicide, or herbicide plus surfactant, and fed laminae sprayed with the same mixtures. There was also no indication of differences resulting from treatment by dipping, or by ingestion of treated laminae. Analysis of variance of transformed data showed a significant difference (P = 0.05) in mortality resulting from treatments. Differences in estimates were tested for significance with the protected l.s.d. at the 0.05 level. There was no significant difference between mortality resulting from the application of water or 2,4-D. However there was a significant difference with the addition of surfactant to the 2,4-D, although the mortality was still low.

Table 2. Mortality of adult weevils in Experiment 2

Group	Herbicide dip	Leaf Spray	Males Dead	Females Dead	Total	Mortality (%)
A	2,4-D	2,4-D	0	1	1	3.3 ab
	2,4-D	water	0	2	2	6.7 ab
B	2,4-D + surfactant	2,4-D + surfactant	2	2	4	13.3 b
	2,4-D + surfactant	water	2	2	3	13.3 b
C	water	2,4-D	2	1	3	10.0 ab
	water	2,4-D + surfactant	2	3	5	16.7 b
	water	water	0	0	0	0.0 a

Values followed by the same letter are not significantly different.

Results indicate that spraying water hyacinth infestations with 2,4-D is likely to have little effect on adult weevils in the time it takes for the plants to die. Adults may migrate as plant quality declines but we did not investigate whether longevity or reproductive success of the insects was affected by exposure to the chemicals. Larvae of the weevils remain within the plant tissues until pupation and would undoubtedly die with the plants following application of herbicide.

The surfactants by themselves and 2,4-D alone were not significantly more toxic than water, but the combination of 2,4-D and surfactant was. This indicates that a synergistic effect may occur between herbicide and surfactant and may explain why dichlorprop used with surfactant (AF302[R]) resulted in greater mortality than dichlorprop used alone (DP600[R]).

For water hyacinth control, 2,4-D has been the most commonly used herbicide worldwide (3), although its use has decreased in Australia over recent years. Public pressure resulting from adverse publicity given to 2,4,5-T may have been partly responsible for this. We suggest that when insects of the prospective replacement should certainly be one of the selection criteria.

For any weed on which insect biological control agents are present, use of herbicides having low toxicity to insects should minimise deleterious effects on populations of biological control agents provided the agents are sufficiently mobile to find a new source of food. Low-toxicity herbicides should allow biological control agents to maintain higher population levels than they would otherwise thus increasing their contribution to control of the weed and resulting in long-term cost savings.

ACKNOWLEDGMENT

We thank Mr Tom Anderson, Queensland Lands Department, Alan Fletcher Research Station, for selecting and supplying the herbicides and advising on their application rates for control of water hyacinth, and Mrs Anne Bourne, CSIRO Division of Mathematics and Statistics, for statistical analyses.

REFERENCES

1. Harley, K.L.S., Forno, I.W. and Julien, M.H. 1978. Proc. 1st Conf. Counc. Aust. Weed Sci. Soc. Melbourne. pp. 113-8.
2. Mitchell, D.S. 1978. Aquatic Weeds in Australian Inland Waters. (Australian Government Publishing Service: Canberra) 189 pp.
3. Pieterse, A.H. 1978. Abst. on Trop. Agric. 4, 9.