EVALUATION OF HERBICIDE ACTIVITY AFTER ROOT UPTAKE BY GORSE AND RADIATA PINE SEEDLINGS GROWN HYDROPONICALLY

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Summary

Seedlings of gorse (*Ulex europaeus*) and radiata pine (*Pinus radiata*) were germinated and grown in water culture with added herbicidal chemicals. The effects of 27 phenoxy compounds and 17 commercial herbicides at 0.5, 1.0 and 2.0 x 10⁻⁵ Molar concentration of herbicide were assessed after 60 days. None of the phenoxy compounds caused significant mortality of gorse seedlings, but radiata pine seedlings were affected in some cases. Conversely, several commercial herbicides showed a pronounced toxicity to gorse but not to radiata. The results indicated that triazine-type herbicides would be best at controlling gorse seedling regrowth if applied 'pre-emergence'.

INTRODUCTION

Much effort has gone into the screening and evaluation of potential herbicide formulations and chemicals for the control of gorse. The vast majority have been applied onto mature gorse: more recently (Ivens 1977 1978) attention has been directed at controlling it at the juvenile to 'young mature' stages i.e. with juvenile foliage or unhardened mature foliage. However, in all cases the approach has been to use foliage absorbed herbicides in the expectation that there would be either complete coverage of the plant or alternatively sufficient translocation to kill the whole plant. Only rarely (Bell 1961; Patterson 1965) has an attempt been made to kill gorse plants by the use of soil applied herbicides. This approach has obvious limitations and difficulties when applied to mature plants, but could be much more effective on seedling gorse. It has been found that there is very pronounced germination of gorse seed after a burn-off and during the subsequent natural spring flush (Zabkiewicz and Gaskin unpublished). Hence the potential exists of killing this regrowth by the use of a 'pre-emergence' herbicide, applied principally for the purpose of long-term control, rather than for a single rapid 'knock-down' effect.

No information was available on the relative susceptibilities of radiata pine and gorse seedlings to root uptake of different herbicides. The application of hydroponics to trees in general and pines specifically has been known for a long time (Olson 1944); it has also been used for germination tests of gorse seed (Zabkiewicz and Gaskin 1978) and subsequently extended to gorse seedlings. To avoid a massive and prolonged series of pot or field plot trials, a simple bioassay was developed that depended on the incorporation of the herbicide into the aqueous nutrient solution that the seedlings were grown in. The method developed allowed a fast and simple initial screening of a large number of actual and potential herbicides on radiata pine and gorse seedlings.

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MATERIALS AND METHODS

Seed source and preparation.

Gorse seed was extracted from litter under bushes soon after the pods had ripened and shed the seed; 100% germination was obtained in a standard assay (Zabkiewicz and Gaskin 1978).

Seed was soaked in water at 60°-80° for 15 minutes, then left in water at room temperature overnight: after treatment with thiram dust in latex to prevent fungal infection it was then distributed evenly over several polystyrene bead 'rafts' (each approx. 30 x 30 cm) floating in shallow trays filled with water. The seeds were then germinated at 16°-17° under fluorescent light (16 h day-length). After 12 days those that had both cotyledons fully expanded and a radicle approximately 1 cm long were selected for use in the assay.

Radiata pine seed was obtained from Rotorua Conservancy. After cold stratification it was also coated in thiram/latex and set up on rafts as above, but at 20°-26°. After 13 days, seeds that had radicles 1-2 cm long were selected for the assay.

Assay methods.

Initially the testing of phenoxy chemicals on radiata seedlings was done under low light levels and in glass dishes with black paper around them to reduce root illumination. Opaque plastic dishes and higher light levels were used in all subsequent work as described herein. Small polystyrene bead rafts were used in the assays (modified from the system described by Knight *et al* 1969) with 10 seedlings/raft, and each raft floating in an aqueous herbicide solution held in a polystyrene dish of approximately 300 ml capacity. Two rafts were used per treatment; assessments were made of the survival and general conditions of the seedlings over a period of 60 days. Dead seedlings were removed regularly. Diluted nutrient solution (2 ml of modified Hoagland) was supplied to each dish after 7, 22, 36 and 50 days from the start. All assays were conducted at 20°-26° under a bank of fluorescent and incandescent lamps (light intensity of 190 lumens).

Herbicide solutions.

Previous trials had shown that in general the borderline between insignificant and obvious toxicity symptoms for seedlings grown hydroponically lay over a concentration range of 0.5 to 2.0 x 10⁻⁵ Molar. This in turn coincided reasonably with field equivalents of the order of 0.5 to 2.0 kg/ha active ingredient.

Rafts supporting 10 seedlings were each placed at Day 0 in 270 ml of solution of weedicide (at concentrations of 0.5, 1.0 and 2.0 x 10⁻⁵ M a.i.). This solution was thereafter only topped up with distilled water or small volumes of nutrient solution.

All the phenoxy acids were available pure and solutions were made up via their sodium salts. Other herbicides which could not be dissolved directly in the distilled water required salt formation, or the addition of detergent (Tween 80), warming, ultrasonic treatment or a combination thereof. No allowance was made for the possible effects of these or commercial additives.

Assessment.

Assessment after 60 days was by counting the surviving seedlings scoring for root and shoot characteristics and photographing representative examples.

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RESULTS AND DISCUSSION

All treatment results are quoted as percentage survival of seedlings after 60 days.

Initially representative compounds were tested from a series of phenoxy acids including 2-chloro, 4-chloro, 2,4-dichloro, 2,4,5-trichloro and 2-methyl,4-chloro ring substitution and side-chain lengths of acetic to caproic acids, either normal or branched. Regardless of the phenoxy acid used, a conspicuous feature was that survival of gorse seedlings never dropped below 90%, even at the highest phenoxy acid concentration. In contrast, several of these phenoxy compounds, notably 2,4,5-T, fenoprop, 2-(2,4,5-trichlorophenoxy) butyric acid, 2-(2-chlorophenoxy) butyric acid, 2,4-D, 2-(2,4-dichlorophenoxy) propionic acid, MCPA, MCPB and 2-(2-methyl, 4-chlorophenoxy) propionic acid had a pronounced toxic effect on radiata pine seedlings.

A greater variation in seedling survival is shown by both species from exposure to the mostly commercial weedicides listed in Table 1. In a few cases, such as for linuron and atrazine, there is little sign of chemical selectivity to either species. In contrast, hexazinone, prometryn, GS 13528 and terbutylazine show a clear herbicidal effect on the gorse but not on the radiata pine seedlings. Less marked, but potentially useful selectivities are shown by Dowco 290, picloram and propazine.

Although it is difficult to equate the conditions used in this assay with those in field trials, it is clear that some of the chemicals, when absorbed via the roots, more toxic to gorse than many other currently used ones (such as the phenoxy acids). Although the phenoxy herbicides are normally formulated as their esters, it is well known (Loos 1969) that they hydrolyse readily under field conditions, so that the free acid forms as tested here have biological relevance. This facile hydrolysis may also contribute to a more rapid immobilisation on the soil surface, so that more

Table 1. Percentage survival after 60 days of radiata and gorse seedlings grown in 0.5, 1.0 and 2.0 x 10⁻⁵ Molar concentrations (a.i.) of different weedicides.

Chemical	Percentage survival and solution concentration					
	0.5 x 10 ⁻⁵ M		1.0 x 10 ⁻⁵ M		2.0 x 10 ⁻⁵ M	
	pine	gorse	pine	gorse	pine	gorse
triclopyr	100	100	90	100	85	90
Dowco 290	100	75	100	55	100	45
picloram	100	55	100	40	100	20
hexazinone	95	15	100	0	60	0
nitrofen	100	100	80	100	100	100
chlorthal*	100	100	85	100	85	100
chlorthiamid*	90	100	5	100	20	100
dichlobenil*	100	100	80	100	75	90
linuron*	25	55	15	30	0	10
diphenamid*	100	100	100	100	95	100
atrazine	95	85	10	25	0	0
propazine	95	95	100	85	90	55
simazine	70	90	40	100	0	85
prometryn*	95	65	100	45	70	5
terbutylazine	100	65	100	10	100	0
GS 13528*	95	90	95	60	95	0
2,2-DPA + amitrole T	90	95	100	100	60	95
control survival	100%					

* Indicates commercial formulations.

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neutral structures, such as the triazines, may be a better choice for this reason as well as having greater selectivity and toxicity to gorse.

It should also be stated that in certain cases, despite high survival percentages, quite obvious damage had occurred to either the root or shoot systems. These morphological abnormalities would probably prevent seedlings surviving under field conditions. Since these effects varied with the chemical under test, it was difficult to assess or score them uniformly, so a representative photographic record was made as well. The symptoms were generally root stunting, root tip die-back, with or without lateral root development and needle or stem distortions.

Hydroponics eliminates soil and environmental interactions, so the results obtained should only be taken as an indicator of potential activity. Furthermore, the root systems for both species are somewhat atypical in their form when grown in water, as well as lacking a mycorrhizal or a bacterial nodule component. Normal root systems would be more finely branched; perhaps they would absorb weedicides even more efficiently to compensate for reduced amounts reaching them in a soil environment. Ultimately herbicidal activity could be similar in field conditions. This concept will be evaluated in field plot trials with selected compounds in the near future; pot trials of various soil incorporated herbicides, including some of those tested here, have already shown similar activity and selectivity towards gorse (Turner and Richardson 1978).

CONCLUSIONS

It has been shown that both radiata pine and gorse seedlings can be grown hydroponically from germination for extended periods. If the culture solutions also contain herbicides, then this system can be used as an assay to test for relative toxicities to either species of plant.

Using this method it is evident that when taken up through the roots the phenoxy acid herbicides have little or no effect on gorse seedlings while the triazine chemical class is much more toxic. This result suggests that if regrowth of seedling gorse is to be controlled then the triazine class of herbicide shows the most promise for selective long term control.

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REFERENCES

- Bell, J. E., 1961. Control of gorse. *Proc. 14th NZ Weed and Pest Control Conf.*: 127-132.
- Ivens, G. W., 1977. Susceptibility of seedling gorse to herbicides. *Proc. 30th NZ Weed and Pest Control Conf.*: 61-65.
- Ivens, G. W., 1978. Further herbicide studies on gorse seedlings. *Proc. 31st NZ Weed and Pest Control Conf.*: 44-46.
- Knight, B. E. A., Taylor, H. F. and Wain, R. L., 1969. Studies on plant growth regulating substances XXIX. *Ann. Appl. Biol.*: 63, 211-223.
- Loos, M. A., 1969. The phenoxyalkanoic acids, p. 41 in *Degradation of herbicides*, by Kearney P. C. and Kaufman D. D. (Eds) Marcel

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- Dekker, New York.
- Olson, R. V., 1944. The use of hydroponics in the practice of forestry. *J. Forestry.*: 42, 264-268.
- Patterson, T. M., 1965. Departmental trials with picloram. *Proc. 18th NZ Weed and Pest Control Conf.*: 24-31.
- Turner, D. J. and Richardson, W. G., 1978. Pot experiments at the Weed Research Organisation with forest crop and weed species. *Technical Report Agricultural Research Council Weed Research Organisation*, No. 46.
- Zabkiewicz, J. A. and Gaskin, R. E., 1978. Effect of fire on gorse seeds. *Proc. 31st NZ Weed and Pest Control Conf.*: 47-52.