DIFFERENCES IN SUSCEPTIBILITY OF NODDING THISTLE POPULATIONS TO PHENOXY HERBICIDES

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Summary. In a field trial in New Zealand, nodding thistle, *Carduus nutans* L., was less susceptible to 2,4-D and MCPA at one site than at a nearby site. Plants grown in a glasshouse from seed collected from these two areas were treated with several rates of MCPA. The results strongly suggest that differences in susceptibility between these two populations are due to differences in their genetic composition. One experiment indicated a 30-fold difference in susceptibility, while a second experiment indicated a 5-fold difference. The latter figure is probably the more accurate estimate though this needs to be confirmed in field experiments.

INTRODUCTION

Nodding thistle is a troublesome pasture weed in many parts of New Zealand (6). Control options for this species have been discussed by Popay (5), but most farmers apply MCPA, MCPB or 2,4-D to young plants in autumn or spring.

A farmer from central Hawkes Bay in New Zealand reported poor control of nodding thistle after applying 2,4-D at the recommended rate of 1.1 kg a.i./ha. This paper reports the results of field and glasshouse experiments that compare the response of two populations of nodding thistle (32 km apart) to MCPA and 2,4-D.

METHODS

Field trial. The trial site containing thistles apparently difficult to control was at Argyll (176°32'E 39°54'S). The paddock has a slight north-east aspect with a pasture cover dominated by perennial ryegrass, *Lolium perenne* L., crested dogstail, *Cynosurus cristatus* L., soft brome, *Bromus hordeaceus* L., sweet vernal, *Anthoxanthum odoratum* L. and white clover, *Trifolium repens* L. The other trial site at Matapiro (176°37'E 39°36'S) has a northerly aspect and a pasture dominated by perennial ryegrass and white clover. The soil type at both sites is a Matapiro silt loam. The annual rainfall in 1981 was 899 mm at Argyll, and 995 mm at Matapiro.

Individual nodding thistle rosettes were pegged at both sites and treated with either MCPA (potassium salt), or 2,4-D (butyl ester). Both herbicides were applied at a rate of 20 mg a.e./plant in 10 ml of solution from a modified drench gun fitted with a solid cone nozzle. These treatments were repeated six times during 1981 (Table 1). Each treatment was applied each time to eight plants, giving a total of 192 plants treated in the trial. The plants had an average diameter of 24±10 cm at treatment. The effectiveness of the herbicides was determined by recording the proportion of plants that died for each treatment. An F-test was used to separate treatment means.

Glasshouse experiments. Seed was collected from plants at both sites, and planted in 230 ml pots in a glasshouse at Massey University. The pots, containing a potting mix of sand and slow-release fertilizer, were sub-irrigated once every day and were never moisture stressed.

In experiment 1, MCPA was applied at six rates (0.75, 1.5, 3, 6, 12 and 24 mg a.e./plant) in 5 ml of water using a pot sprayer described elsewhere (2).

Each rate was applied to 25 plants of each population. Although the above doses of herbicide were sprayed at each plant, only about 40% was intercepted by the plant. At the time of spraying, the plants were four months old and had an average shoot dry weight of 2.5±0.7 g. The number of plants killed was recorded.

Experiment 2 was very similar to Experiment 1 except that there were only four application rates (0.19, 0.75, 3 and 12 mg a.e./plant) and only ten plants per treatment. The plants were six weeks old when sprayed and had an average shoot dry weight of 0.12±0.07 g.

Conditions in the glasshouse were not recorded for Experiment 1. In Experiment 2, they ranged from a maximum temperature of 25±2°C and minimum RH of 33±9% during the day, to 19±2°C and 89±8% RH at night.

RESULTS AND DISCUSSION

The results of the field trial show that both MCPA and 2,4-D were significantly less effective at Matapiro than at Argyll (Table 1). Note that a few of the plants were lost after stock knocked over pegs, so figures are expressed as percentage of plants found, not as percentage of plants initially treated.

Table 1. Effect of MCPA and 2,4-D on the control of nodding thistle (%) grown at Argyll and Matapiro[a]

Time of application	MCPA		2,4-D	
	Argyll	Matapiro	Argyll	Matapiro
March	40	100	38	100
April	43	100	21	100
May	88	100	43	88
June	50	100	14	63
July	50	75	0	88
September	20	100	0	100
Mean	48.5 b	95.8 c	19.3 a	89.8 c

[a]Treatment means followed by the same letter are not significantly different (P = 0.01) using an F-test.

MCPA gave significantly better control than 2,4-D at Argyll, although the increase in control obtained at Matapiro was not significant (P = 0.05). Such differences are best shown when near the LD_{50}. The 20 mg/plant dose used in this trial was near the LD_{50} for the Argyll population but was apparently above the LD_{50} for Matapiro.

Hurrell *et al.* (3) found nodding thistle is more effectively controlled in autumn and spring than in winter. This would explain some of the variability in results for different times of treatment.

The lower susceptibility of the Argyll plants to the herbicides could be due to genetic, or environmental differences. Muzik (4) has reviewed ways in which environmental factors can have marked effects on herbicide activity in plants. The glasshouse experiments were an attempt to eliminate the environmental differences, leaving the genetic differences to express

themselves if present.

Results from both glasshouse experiments presented in Fig. 1 show a major difference in susceptibility between the two populations under the same environmental conditions, which suggests genetic differences. The vertical distance between curves for any particular dose gives a comparison similar to the field experiment (i.e. the difference in proportion of plants killed at any dose). The horizontal distance between curves indicates how much more herbicide is required to kill the same proportion of plants from the second population. This comparison normally uses the LD_{50} of each population.

According to the theory of dose response curves discussed by Finney (1), the change in proportion of the population dying with the logarithmic increase in herbicide dose can be described best by a sigmoid curve, and the most appropriate sigmoid curve for a particular set of data can be determined using probit analysis. The data presented in Fig. 1 for Experiment 2 was analysed in this way by computer and fitted to the curves shown in Fig. 2.

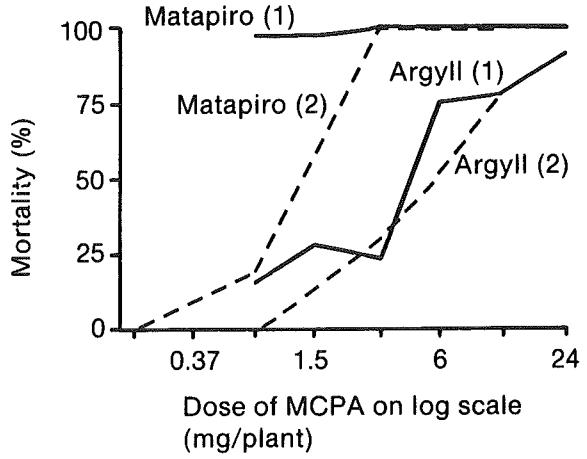

Figure 1. Effect of MCPA on plants from Argyll and Matapiro for Experiments 1 (unbroken line) and 2 (broken line).

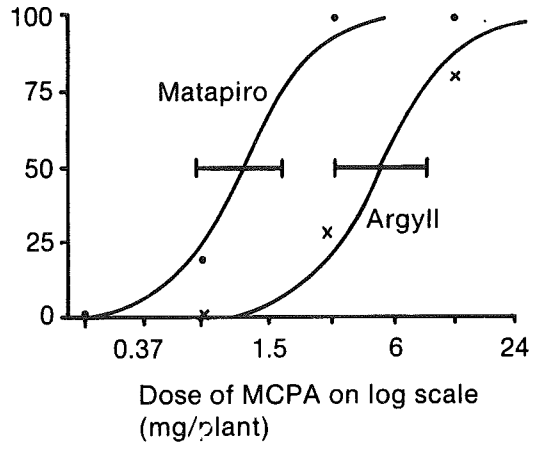

Figure 2. Dose response curves for MCPA from Experiment 2 fitted using probit analysis. The bars show the 95% confidence limits.

The results obtained in Experiment 1 clearly show a difference exists between the Argyll and Matapiro plants in their susceptibility to MCPA. Unfortunately sufficiently low doses were not used at Matapiro to obtain a good horizontal comparison between the curves. However, by comparing the proportion of plants killed in this experiment from the Argyll population at 24 mg/plant (92%) with that killed by 0.75 mg/plant in the Matapiro population (96%), the data indicates that the Argyll plants can tolerate at least 32 times more MCPA than the Matapiro plants.

A small number of untreated plants were included in the design of the experiment to monitor whether any natural mortality was occurring within the populations. Of the nine untreated Argyll plants, two died during the experiment, though none of the seven untreated Matapiro plants died. This 22% mortality of the untreated Argyll plants casts suspicion on the results obtained for the Argyll population at 0.75, 1.5 and 3 mg/plant.

The results obtained in Experiment 2 give more reliable information than

Experiment 1 despite having fewer plants treated because the Matapiro response curve is more clearly defined. Also none of the ten untreated Argyll, nor the ten untreated Matapiro plants died. The main difference between the results obtained in the two experiments is the much smaller horizontal distance between the two populations in Experiment 2. This experiment shows the Argyll plants to be only 4.8 times more tolerant of MCPA than the Matapiro plants, though the 95% confidence limits show this difference to be significant.

The plants in Experiment 2 were much smaller and younger than those in Experiment 1 at treatment, yet the Argyll plants in both experiments showed very similar responses to the MCPA. So the difference between the experiments is due to the younger Matapiro plants being more tolerant of the MCPA than the older Matapiro plants. This is unusual as one would normally expect older plants to be more tolerant than younger ones. Therefore, it seems likely that the Matapiro plants in Experiment 1 were abnormally sensitive to the herbicide, possible because of stress resulting from the small size of the pots in which they were grown.

In conclusion, the nodding thistle population at Argyll can tolerate higher rates of MCPA or 2,4-D than the population at Matapiro because of differences in their genotype. However plants from the two populations will need to be grown together under field conditions, rather than the artificial conditions experienced in the glasshouse, to obtain a more accurate estimate of the size of this difference in tolerance. Such an experiment is presently being conducted at Massey University.

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