SPRAYING HISTORY AND FITNESS OF NODDING THISTLE, *CARDUUS NUTANS*, POPULATIONS RESISTANT TO MCPA AND 2,4-D

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Summary: Populations of nodding thistle, *Carduus nutans* L., which can tolerate MCPA and 2,4-D have been found at many sites in Hawkes Bay and Waikato. The spraying history for seven resistant and seven susceptible populations was compared. Although all sites had been sprayed with 2,4-D or MCPA over the past 20 years, the resistant sites had been sprayed much more regularly. Results indicated that herbicide-resistant nodding thistle populations were as ecologically fit as susceptible populations. Implications of these findings are discussed.

INTRODUCTION

Although nodding thistle can normally be selectively removed from pastures with MCPA or 2,4-D (8), farmers in several parts of New Zealand have recently obtained poor results with these herbicides.

Seed has been collected from populations that are difficult to kill with these herbicides, and also from susceptible populations. When grown in the same glasshouse, the populations have retained their differential susceptibility to MCPA, with differences in tolerance ranging from 5-fold to 30-fold (5). When grown under the same field conditions, a 6-fold difference in susceptibility was measured (6).

A technique developed to differentiate between resistant and susceptible populations involved applying a single rate of MCPA (3.0 mg/plant) to glasshouse-grown plants (4) rather than producing dose-response curves for each population as in earlier work. Using this technique, 14 sites in Hawkes Bay and Waikato have been identified as having nodding thistle populations with significant levels of resistance to MCPA and 2,4-D.

Although intra-specific variation to phenoxy herbicides has been shown in the past (7), there has seldom been any indication as to whether biotypes have become resistant due to repeated exposure to the herbicide over many years. This paper describes the effect of spraying history on resistance to phenoxy herbicides in nodding thistle.

MCPA, 2,4-D and MCPB are all tolerated by these nodding thistle populations. Herbicides such as clopyralid, dicamba and glyphosate that are still effective against these populations (4) cannot be used selectively in legume-based pastures. The best chemical strategy available at present is to apply a mixture of MCPB and clopyralid while the plants are young and actively growing.

Competition exerted by pasture can help keep nodding thistle under control (1) whether herbicides are used for control or not. Biotypes which develop resistance to herbicides or other pesticides tend to be less competitive than susceptible biotypes of the same species (2). As this has obvious implications for the control of herbicide-tolerant nodding thistles in New Zealand, the present work was carried out to test the relative fitness of the nodding thistle populations.

METHODS

Trial 1. Nodding thistle seed was collected from properties located in several parts of New Zealand. The seeds were germinated in petri dishes in 0.2% solution of potassium nitrate. Vigorous seedlings were planted into individual 230 ml plastic pots with a peat/sand/pumice mix and placed in a glasshouse in which the daily temperature ranged from 15.3 $\pm$ 0.1°C (SEM) to 18.4 $\pm$ 0.1°C. The pots were supplied with slow-release fertilizer and were sub-irrigated daily. When they were 3 months old, 30 plants from each of the populations were individually sprayed with 5.0 ml of solution containing 3.0 mg MCPA using a specially designed sprayer described elsewhere (3). At treatment, plants had an average (with SEM)

crown diameter of 8.3 ± 0.2 mm (as measured just above ground level). The number of plants killed was recorded after 4 months, and differences were compared using an adjusted chi-square analysis.

From these results, seven susceptible and seven resistant sites were chosen for further study. Past and present managers or owners of the properties were contacted and interviewed about the spraying history of their nodding thistle populations.

Trial 2. Seed from two populations initially identified as being resistant (Argyll) or susceptible (Matapiro) to MCPA were germinated as in Trial 1 and transplanted into trays 42 cm x 30 cm x 7 cm deep filled with a peat/sand/pumice mix. Three trays were planted with 35 plants/tray with plants equidistant from each other and with Argyll plants alternating within and across rows with Matapiro plants. A further five trays were planted each with two Argyll plants and two Matapiro plants. The trays, placed in a glasshouse whose daily temperature ranged from 18.7 ± 0.2°C to 26.2 ± 0.3°C, were watered twice daily by an overhead sprinkler. No fertilizer was applied.

Ten weeks later, the shoot material of each plant was removed at ground level, dried at 80°C and weighed. A t-test was used to compare the high density with the low density plants. Separate F-tests (randomised complete block with sub-samples) were used for the low density and high density plants to compare the susceptible and tolerant biotype. Allowance was made (covariance adjustment) with the high density trays for plants, growing at the edge of each tray, which received less competition than plants in the middle of the tray.

RESULTS AND DISCUSSION

All of the populations whose spraying histories were investigated had a history of 2,4-D or MCPA application (Table 1). However, the seven resistant sites differed from the seven susceptible sites in that spraying had occurred more consistently over the past 10-20 years. The general policy for control of nodding thistle at the resistant sites was to spray the entire property at least once every year. In contrast, farmers at the susceptible sites only applied herbicide to their nodding thistle infestations in the years when plant density was particularly high, and then only to selected parts of the farm. Many of these farms had been sprayed more regularly in the past. Reasons for the reduction in spraying included economic factors, changes in ownership of properties, reduced pressure from Noxious Plant Officers to control the plants and disappointment at the lack of progress in reducing the numbers of seedlings germinating each year.

It was very difficult to obtain precise records of spraying history for any of the properties. Widespread use of 2,4-D and MCPA for controlling nodding thistle in these areas has been occurring since the late 1940's (9). Written records of spraying are almost non-existent. Over the past 40 years many of the farms have changed ownership several times and had many different managers. As a result, information presented in Table 1 is mainly for the last 15-20 years and where managers could remember spraying regimes. It seems very likely though that most of the properties were sprayed regularly during the 1950's and 1960's when herbicide was cheap, aerial spraying contractors readily available and pressure to eradicate this noxious weed intense. Therefore the main differences in spraying history between susceptible and resistant properties are probably those relating to the reduction in spraying in recent years.

It seems that many consecutive years of spraying are required for resistance to become apparent. All seven farmers at the resistant sites could recall when nodding thistle had become more difficult to control, and this had occurred within the last 10 years for all sites. There may have been up to thirty years of more or less successful control before resistance became apparent.

Table 1. Spraying history of seven susceptible and seven resistant nodding thistle populations.

Site	% Death*	Spraying History in Most Recent Years
Maungatautari	0 a	2,4-D annually for at least 15 years.
Waotu	0 a	2,4-D annually for at least 15 years.
Argyll	10 ab	2,4-D annually for at least 25 years.
Te Onepu	13 ab	2,4-D annually for 20 years.
Arohena	17 ab	2,4-D or MCPA annually for 17 years.
Glenalvon	20 b	2,4-D annually for 30 years.
Kia Ora	23 b	2,4-D annually for at least 20 years.
Mason Ridge	93 c	2,4-D or MCPA for 30 years but only when infestation severe, mowing the rest .
Limestone Downs	93 c	2,4-D for at least 10 years but only when infestation severe.
Maraekakaho	95 c	MCPA annually for 20 years, then only when infestation severe for 15 years.
Ohutu	97 c	2,4-D annually till 12 years ago, and very little since.
Matapiro	97 c	2,4-D annually, then only occasionally for 6 years.
Colyton	100 c	2,4-D annually for 10 years, then only occasionally for 10 years.
Hickey Road	100 c	2,4-D annually for 10 years, then only occasionally for 8 years.

*MCPA was applied at 3 mg/plant. Populations sharing the same letter do not differ in susceptibility at p = 0.05

If selection pressure applied by the phenoxy herbicides was responsible for an increase in resistance within these nodding thistle populations, it seems likely that the populations at some of the susceptible sites may have been approaching resistance at the time when selection pressure was reduced. Matapiro and Ohutu in particular were sprayed with 2,4-D through the 1960's and 1970's. However the managers of all the susceptible sites have never noticed poor control of their thistles by 2,4-D.

If resistant biotypes are less ecologically fit than susceptible biotypes, a reduction in selection pressure resulting from reduced herbicide application should lead to a lower proportion of resistant individuals (2). In Trial 2, substantial competitive pressure was applied to both susceptible and resistant individuals in the trays containing 35 plants each. The extent of this competition was shown by the much greater size of plants grown at the lower density despite being grown under the same growing conditions. Even under this competitive pressure, resistant plants were the same size as the susceptible plants after 10 weeks (Table 2).

These results do not conclusively prove a lack of difference in ecological fitness between the two biotypes. These results may have been changed under different growing conditions or at a different density. However, if there were differences in the fitness of the magnitude displayed by triazine-resistant biotypes of weeds (10), some indication of this might have been expected in the trial. The results were consistent with observations of the relative behaviour of these two biotypes in numerous herbicide susceptibility experiments.

Table 2: Average shoot dry weight of herbicide-resistant and herbicide-susceptible nodding thistle plants grown at two densities.

	Mean DW (mg)*	SEM
Resistant plants at high density	168.5 a	10.0
Susceptible plants at high density	169.2 a	9.6
Resistant plants at low density	876.3 b	52.9
Susceptible plants at low density	908.4 b	95.7

* Values with the same letter are not significantly different at the 5% level of probability

Continuous selection pressure from 2,4-D or MCPA applications can result in resistance to these herbicides developing within nodding thistle populations. A lower selection pressure may merely increase the time required for tolerance to appear. As the tolerant individuals appear to be no less competitive than susceptible individuals, the proportion of tolerant individuals in the population will not necessarily drop during times of low selection pressure from 2,4-D. If the intensity of spraying at the susceptible sites was to be increased in future, resistance could possibly develop quite rapidly.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the helpful advice given by Assoc Prof A.G. Robertson and Dr A.I. Popay, and also the financial assistance given by the Massey University Agricultural Research Fund and Ivon Watkins-Dow.

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