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ASPECTS OF RESISTANCE TO PHENOXY HERBICIDES

IN NODDING THISTLE (CARDUUS NUTANS L.)

A thesis
presented in partial fulfilment
of the requirements
for the degree of
Doctor of Philosophy
at
Massey University

Kerry Charles Harrington

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A nodding thistle (*Carduus nutans* L.) population had been reported from Argyll in Hawkes Bay, New Zealand, which had poor susceptibility to MCPA and 2,4-D. Plants from the Argyll population were grown beside another Hawkes Bay nodding thistle population in a glasshouse and their dose response curves for MCPA were compared in three separate experiments. The Argyll population was significantly less susceptible to MCPA in all experiments, though the magnitude of resistance varied between experiments from 5-fold to 14-fold. When grown beside each other in the field, the Argyll population was 7 times more resistant to MCPA than the other population.

A range of other herbicides was applied to the Argyll nodding thistle population. Cross-resistance was detected for 2,4-D and MCPB, but no significant decreases in susceptibility were detected with mecoprop, clopyralid, picloram, dicamba, paraquat/diquat or glyphosate. A significant reduction in susceptibility to tribenuron-methyl was measured in a field experiment, but this difference was not apparent when the experiment was repeated in a glasshouse. The cross-resistance to MCPA, MCPB and 2,4-D meant selective control of nodding thistle at Argyll in clover-based pastures was now very difficult to achieve.

Nodding thistle populations from 20 Hawkes Bay and 7 Waikato properties were tested for resistance to MCPA, and significant levels of resistance were detected in 14 of these populations. Interviews of property owners indicated that resistance had developed where 2,4-D or MCPA had been applied annually for many years, whereas properties without resistance had been sprayed less regularly.

Resistant and susceptible nodding thistle seedlings were grown together at a 1:1 ratio under conditions of nutrient stress to determine whether herbicide-resistant nodding thistle plants are less competitive than normal. No difference was detected between the resistant and susceptible biotypes used.

Under some conditions, susceptible plants were more likely to have high trichome densities on their leaves, but this trait was found to be too variable and not correlated closely enough with herbicide susceptibility to be useful in distinguishing between resistant and susceptible biotypes.

Significant differences in susceptibility to MCPA were maintained between resistant
and susceptible biotypes even when leaf surfaces were damaged to allow better foliar penetration of the herbicide, or when herbicide was applied to plants via the root system. Thus the mode of resistance did not appear to involve difficulties with foliar uptake.

Studies with radiolabelled 2,4-D confirmed that resistance did not relate to poor leaf penetration. These experiments indicated that 2,4-D was broken down more rapidly in resistant plants. Other findings were that 2,4-D or its metabolites were released in greater quantities from the root systems of susceptible plants, and that herbicide molecules were more difficult to extract from the interior of susceptible plants, possibly due to increased binding.

Reasons why resistance to phenoxy herbicides has developed in nodding thistle are discussed, and techniques for controlling resistant populations selectively in pastures and preventing further resistance from developing are also analysed.
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- bentazon: 3-isopropyl-2,1,3-benzothiadiazin-4-one 2,2-dioxide
- bromofenoxim: 3,5-dibromo-4-hydroxybenzaldehyde 2,4-dinitrophenyloxime
- bromoxynil: 3,5-dibromo-4-hydroxybenzonitrile
- chlorsulfuron: \( N'-(2\text{-chlorobenzenesulfonyl})-N-(4\text{-methoxy}-6\text{-methyl-1,3,5-triazin-1-yl})\text{urea} \)
- clopyralid: 3,6-dichloropyridine-2-carboxylic acid
- cyanazine: 2-chloro-4-(1-cyano-1-methylethylamino)-6-ethylamino-1,3,5-triazine
- 2,4-D: 2,4-dichlorophenoxyacetic acid
- dicamba: 3,6-dichloro-2-methoxybenzoic acid
- dichlorprop: \((\pm)-2\text{-}(2,4\text{-dichlorophenoxy})\text{propionic acid}\)
- dinoseb: 2-(1-methylpropyl)-4,6-dinitrophenol
- diquat: 9,10-dihydro-8a,10a-diazaionaphthanthrene
- DNOC: 2-methyl-4,6-dinitrophenol
- etridiazole: 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole
- glyphosate: \( N\text{-}(\text{phosphonomethyl})\text{glycine} \)
- ioxynil: 4-hydroxy-3,5-di-iiodobenzenitrile
- MCPA: 4-chloro-2-methylphenoxyacetic acid
- MCPB: 4-(4-chloro-2-methylphenoxy)propionic acid
- mecoprop: \((\pm)-2\text{-}(4\text{-chloro}-2\text{-methylphenoxy})\text{propionic acid}\)
- metsulfuron: 2-[3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)ureidosulfonyl]benzoic acid
- paclobutrazol: \((2\text{R, S} 3\text{R, S})\text{-1}\text{-(4\text{-chlorophenyl})-4,4\text{-dimethyl-2\text{-}(1H-1,2,4-triazol-1-yl)pentan-3-ol}}\)
- paraquat: 1,1'-dimethyl-4,4'-bipyridylium
- picloram: 4-amino-3,5,6-trichloropicolinic acid
- simazine: 2-chloro-4,6-bisethylamino-1,3,5-triazine
- tribenuron: 2-[4-methoxy-6-methyl-1,3,5-triazin-2-yl(methyl)carbamoylsulfamoyl]benzoic acid
- trifluralin: 2,6-dinitro-\( N\text{-}N\text{-dipropyl-4\text{-trifluoromethylaniline}} \)