LEAF EXPANSION EFFECTS ON POST-EMERGENCE HERBICIDE PERFORMANCE

ROSS L. DICKSON, MITCHELL ANDREWS
and ROGER J. FIELD

Plant Science Department, Lincoln College, Canterbury

SUMMARY

The post-emergence efficacy of diclofop-methyl and fluazifop-butyl against *Avena sativa* L. cv. Amuri was reduced under a range of environmental stresses. In all cases examined in which the plant had increased tolerance of the herbicides, leaf expansion rate was low. It is argued that this decreased expansion rate was more important than other aspects of decreased growth rate in determining the degree of resistance to these herbicides. A mechanism is proposed to explain the relationship between leaf expansion rate and degree of tolerance of the herbicides.

INTRODUCTION

Plant and environmental factors can cause inconsistency in the performance of herbicides resulting either in inadequate control of weeds or crop damage. There are many reports of reduced herbicide efficacy with increasing plant age and environmental stresses (Caseley and Coupland 1985). The common explanation for this reduced herbicide performance is decreased herbicide absorption and translocation due to decreased plant growth (Moosavi-Nia and Dore 1979). Uptake and translocation of glyphosate have been shown to be reduced in older plants and under a range of stresses (Whitwell and Santelmann 1978; Dickson and Field 1987). However, this explanation does not hold for the reduced performance of the phenoxy-propionate herbicides diclofop-methyl and fluazifop-butyl on plants under drought stress (Akey and Morrison 1983; Kells *et al* 1984).

This paper presents data from a series of experiments in which the efficacy of diclofop-methyl and fluazifop-butyl against *Avena sativa* was examined under a range of conditions.

METHODS

Oats (*Avena sativa* L. cv. Amuri) were used in all four experiments. The first experiment was a field study carried out in a drought susceptible Waimakariri silt loam soil in North Canterbury between 22 October 1987 and 13 February 1988. Plots were 6 m² and each treatment was replicated five times. Upon seedling emergence, half the plots were irrigated to maintain soil moisture at field capacity (20.0% w/w). The other plots were rainfed only and quickly approached wilting point (7.1% w/w). The extension rate of the youngest lamina (leaf 5) of droughted and irrigated plants was measured for 5 days prior to spraying with herbicides (Table 1). Fourteen days after spraying, droughted plots were brought to field capacity and thereafter treated as irrigated plots. Forty-five days after spraying, seed head dry weight was determined by taking a 0.4 m² quadrat sample from each plot.

A second field trial was carried out on a nitrogen depleted Templeton silt loam soil at Lincoln College. Plots were 4 m² and each treatment was replicated three times. Upon seedling emergence, half the plots were given 250 kg N/ha in the form of calcium ammonium nitrate. No nitrogen was applied to the other plots. The extension rate of the youngest lamina (leaf 5) of plants from both treatments was measured for 5 days prior to spraying with herbicides (Table 2). Forty-nine days after spraying, seedhead dry weight was measured as above.

In a controlled environment study, plants supplied with 10 mol/m³ nitrate were

Proc. 41st N.Z. Weed and Pest Control Conf.

sprayed with diclofop-methyl at the three leaf stage. The extension rate of all laminae was determined during the 2 days prior to spraying. Chlorophyll concentration was measured in individual leaves 8 days after spraying.

In another experiment, plants were supplied with 1 mol/m³ nitrate. At the three leaf stage, plants either had 0 or 100 µg gibberellic acid (GA) placed in the ligule/inner sheath area of each of leaves 1 and 2. Two days after applying GA, plants were sprayed with herbicide (Table 4). The extension rate of the youngest sheath (leaf 3) of each plant was determined during the 2 days prior to spraying and total plant dry weight was recorded 44 days later.

All herbicides in these experiments were applied with a portable sprayer fitted with Teejet 8001 nozzles which delivered 250 litres water/ha at 275 kPa.

RESULTS AND DISCUSSION

Leaf expansion and stress

Diclofop-methyl and fluazifop-butyl are less effective against plants growing in droughted soils than against plants in moist soils (Akey and Morrison 1983; Coupland, 1986) although the amount of herbicide taken up and translocated to meristems has been found to be similar for stressed and non-stressed plants (Akey and Morrison 1983; Kells *et al* 1984). Data in Table 1 show the resistance drought-stressed plants have to diclofop-methyl and fluazifop-butyl. For droughted plants, application of herbicide had little effect on seedhead dry weight. In contrast, diclofop-methyl dramatically decreased seedhead production completely. During the week prior to spraying, the lamina extension rate was much lower for droughted plants than for watered plants (Table 1).

TABLE 1: Extension rate of the youngest lamina during the 5 days prior to spraying and seedhead dry weight 45 days after spraying water-stressed and irrigated *Avena sativa* with either 2.0 kg ai/ha diclofop-methyl or 0.25 kg ai/ha fluazifop-butyl.

Soil moisture content	Lamina extension rate (mm/day)	Seedhead dry weight (g/m ²)		
		Unsprayed	Diclofop-methyl	Fluazifop-butyl
Wilting point	0.0- 3.0	113.0	104.5	97.7
Field capacity	26.0-30.0	327.5	38.5	00.0
SEM			11.4	

As under drought, plants growing in low soil nitrogen had resistance to diclofop-methyl and fluazifop-butyl (Table 2). Sprayed plants produced a significantly higher seedhead dry weight/m² in low soil nitrogen than in high soil nitrogen. The converse was found for unsprayed plants. Plants had a lower rate of lamina extension at the low nitrogen levels than at high nitrogen levels (Table 2).

TABLE 2: Extension rate of the youngest lamina during the 5 days prior to spraying and seedhead dry weight 49 days after spraying nitrogen fertilised and non-fertilised *Avena sativa* with either 1.0 kg ai/ha diclofop-methyl or 0.25 kg ai/ha fluazifop-butyl.

Additional nitrogen (kg/ha)	Lamina extension rate (mm/day)	Seedhead dry weight (g/m ²)		
		Unsprayed	Diclofop-methyl	Fluazifop-butyl
0	15-20	113.0	111.5	59.5
200	35-40	154.2	70.1	00.0
SEM			4.05	

Leaf age

If a slower rate of leaf expansion decreases plant susceptibility to diclofop-methyl and fluazifop-butyl, then mature non-expanding leaves should be more resistant to the herbicides than young rapidly expanding leaves. As shown in Table 3, chlorophyll breakdown following diclofop-methyl treatment was substantially greater in the rapidly expanding leaf 3 than the fully expanded leaf 1.

TABLE 3: Extension rate of individual laminae during the 2 days prior to spraying and total chlorophyll concentration 8 days after spraying *Avena sativa* with 1.0 kg ai/ha diclofop-methyl.

Leaf number	Lamina extension rate (mm/day)	Total chlorophyll concentration (mg chl/g dry weight)	
		Unsprayed	Diclofop-methyl
1	0.0- 3.0	12.6	8.1
2	21.0-27.0	11.9	4.9
3	26.0-30.0	10.9	3.0
SEM		0.73	

Plant growth regulators

Gibberellic acid can rapidly increase cell expansion rate with little effect on plant dry weight (Table 4). If increased cell expansion rate, as opposed to some other aspect of growth, increases plant susceptibility to diclofop-methyl and fluazifop-butyl then GA should increase the susceptibility of plants to these herbicides. This was found to be the case (Table 4). Plants treated with GA had a higher sheath and lamina extension rate than untreated plants. For unsprayed plants, application of GA had little effect on total plant dry weight. However, for sprayed plants, application of GA caused a significant reduction in total plant dry weight.

TABLE 4: Extension rate of the youngest leaf sheath during the 2 days prior to spraying and plant dry weight 44 days after spraying gibberellic acid treated and untreated *Avena sativa* with either 1.0 kg ai/ha diclofop-methyl or 0.25 kg ai/ha fluazifop-butyl.

Gibberellic acid application (μ g/leaf)	Sheath extension rate (mm/day)	Plant dry weight (g)		
		Unsprayed	Diclofop-methyl	Fluazifop-butyl
0	10-15	2.72	1.26	1.70
100	55-60	2.41	0.36	0.53
SEM			0.30	

Mechanism

Diclofop-methyl is thought to affect plant cell membrane integrity whereas the mode of action of fluazifop-butyl is unknown (Chandrasena and Sagar 1987; Wright and Shimabukuro 1987). Considering the similarities in symptoms of plant damage caused by fluazifop-butyl and diclofop-methyl, fluazifop-butyl may also affect plant cell membranes. The diclofop-methyl protection afforded to *Avena sativa* by abscisic acid (Foreman and Field 1986) and by drought or low temperatures has been attributed to membrane hardening (Foreman *et al* 1987). However, the rapid induction and loss of herbicide tolerance is inconsistent with the slow changes in membrane hardening associated with low temperature acclimation (Oquist 1983). Leaf expansion rate, by contrast, responds rapidly to abscisic acid, water stress or temperature. In all cases described above in which plants have shown resistance to both herbicides, leaf expansion rates were low. It is proposed that when the rate of leaf expansion is low, there is less strain on cell membranes damaged by the herbicides and thus less cellular disruption occurs (Andrews *et al* 1989).

REFERENCES

- Akey, W.C. and Morrison, I.N., 1983. Effect of moisture stress on wild oat (*Avena fatua*) response to diclofop. *Weed Sci.* 31: 247-253.
- Andrews, M., Dickson, R.L., Foreman, M.H., Dastgheib, F. and Field, R.J., 1989. The effect of different external nitrate concentrations on growth of *Avena sativa* L. cv. Amuri treated with diclofop-methyl. *Ann. of Appl. Biol.* (In Press).
- Caseley, J.C. and Coupland, D., 1985. Environmental and plant factors affecting glyphosate uptake, movement and activity. In: E. Grossbard and D. Atkinson (eds). *The Herbicide Glyphosate*, London, Butterworths: 92-123.
- Chandrasena, J.P.N.R. and Sagar, G.R., 1987. Effect of fluazifop-butyl on the chlorophyll content, fluorescence and chloroplast ultrastructure of *Elymus repens* (L.) Gould. leaves. *Weed Research* 27: 103-112.
- Coupland, D., 1986. The effects of environmental factors on the performance of fluazifop-butyl against *Elymus repens*. *Ann. of Appl. Biol.* 108: 353-363.
- Dickson, R.L. and Field, R.J., 1987. Uptake and translocation of glyphosate in oats after droughting. *Proc. 40th NZ Weed and Pest Control Conf.*: 182-185.
- Foreman, M.H. and Field, R.J., 1986. Drought induced tolerance to diclofop-methyl in cultivated oat. *Proc. 39th NZ Weed and Pest Control Conf.*: 267-271.
- Foreman, M.H., Field, R.J. and Buick, R.D., 1987. Absciscic acid protection against diclofop-methyl damage in cultivated oat. *Proc. of the 8th Aust. Weeds Conf.*: 407-410.
- Kells, J.J., Meggitt, W.F. and Penner, D., 1984. Absorption, translocation and activity of fluazifop-butyl as influenced by plant growth stage and environment. *Weed Sci.* 32: 143-149.
- Moosavi-Nia, H. and Dore, J., 1979. Factors affecting glyphosate activity in *Imperata cylindrica* (L.) Beau and *Cyperus rotundus* L. I. Effect of soil moisture, *Weed Res.* 19: 137-143.
- Oquist, G., 1983. Effects of low temperature on photosynthesis. *Plant, Cell and Environment* 6: 281-300.
- Whitwell, T. and Santelmann, P.W., 1978. Influence of growth stage and soil conditions on bermudagrass susceptibility to glyphosate. *Agronomy Journal* 70: 653-656.
- Wright, J.P. and Shimabukuro, R.H., 1987. Effects of diclofop and diclofop-methyl on the membrane potentials of wheat and oat coleoptiles. *Plant Physiology* 85: 188-193.