THE SUSCEPTIBILITY OF ENVIRONMENTALLY STRESSED *AVENA* SPP TO SEQUENTIAL APPLICATIONS OF GIBBERELIC ACID AND POST-EMERGENCE HERBICIDES

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SUMMARY

Under controlled environment conditions, the susceptibility of drought stressed wild oat to fluazifop-butyl was increased when gibberellic acid (GA) was applied 2 days before the herbicide. Similarly, GA application was found to enhance glyphosate activity on cultivated oat, growing in low soil nitrogen under field conditions. Reasons for GA enhanced post-emergence herbicide performance against plants growing in low levels of water and nitrogen are discussed.

INTRODUCTION

Many post-emergence herbicides are less effective when used against stressed plants (Caseley and Coupland 1985; Caseley 1987; Dickson and Field 1987). In the laboratory, application of gibberellic acid (GA) 2 days prior to spraying nitrogen (N) stressed cultivated oat with glyphosate or the phenoxy propionate herbicides diclofop-methyl and fluazifop-butyl can result in increased activity of these herbicides (Dickson *et al* 1988; Andrews *et al* 1989).

Phenoxy-propionate herbicide activity is primarily due to membrane disruption (Hoppe 1985; Harwood *et al* 1987). It has been proposed that the likeliest cause of GA enhancement of diclofop-methyl and fluazifop-butyl activity is the increased rate of leaf expansion which will result in greater demand for membrane synthesis, increased strain on vulnerable membranes and thus, greater cellular disruption (Dickson *et al* 1988; Andrews *et al* 1989). The primary mode of action of glyphosate appears to be inhibition of aromatic amino acid biosynthesis, but this herbicide has been reported to also cause membrane damage (Campbell *et al* 1976). It is possible that GA enhancement of glyphosate activity is due to increased membrane damage, but increased uptake, translocation and/or metabolism of the herbicide cannot be discounted without further study (Tworkoski and Sterrett 1987).

Under field conditions, attempts to increase weed susceptibility to herbicides by using growth regulators have usually failed (Tworkoski and Sterrett 1987). Variable environmental conditions in the field and herbicide counteraction of growth regulator effects were thought to be the possible factors responsible for nullifying any potential benefits of the adjuvants on herbicide efficacy. In these studies, the growth regulator was usually mixed with the herbicide for application. Under low N conditions in the laboratory, a consistent increase in herbicide activity occurred only if GA was applied 2 days before spraying with herbicide (Dickson *et al* 1988; Andrews *et al* 1989).

This paper describes two experiments which investigated the potential of GA enhancement of post-emergence herbicide activity on environmentally stressed *Avena* spp. The first experiment investigated the efficacy of fluazifop-butyl on wild oat growing in varying levels of soil moisture under controlled environment conditions. The second experiment was a field trial which evaluated the ability of GA to enhance formulated glyphosate activity against N stressed cultivated oat.

MATERIALS AND METHODS

Experiment 1 investigated the effects of GA on the performance of fluazifop-butyl on wild oat (*Avena fatua*) grown in soil of different water content. The seed was

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Proc. 42nd N.Z. Weed and Pest Control Conf.

collected from plants growing in the 1987/88 summer season. All seeds had their glumes removed and their caryopses germinated as described in Dickson and Field (1987). Seedlings of uniform size were selected and transplanted into 200 ml polystyrene pots (1 per pot) filled with oven dried Rapaki silt loam soil brought to field capacity (soil moisture content, SMC = 36.9% w/w). The statistical design of this experiment was completely random with six replicates. The soil moisture treatments were FC = field capacity; 3/4 FC = three quarters field capacity (SMC = 27.6% w/w); PW = partial wilting (SMC = 23.9% w/w); CWP = close to wilting point (SMC = 20.2% w/w); WP = wilting point (SMC = 18.4% w/w). Plants in the PW, CWP and WP soil moisture treatments were transplanted 2 weeks before the FC or 3/4 FC soil moisture treatments, to ensure that all plants were at a similar stage of growth at spraying. Plants were grown in a controlled environment chamber as described in Dickson and Field (1987).

Soil moisture in all pots was maintained at FC until emergence of leaf 4. At this stage water was withheld from the 3/4 FC, PW, CWP and WP treatments. Leaf 4 of plants in all treatments was typically at mid expansion when the respective soil moisture levels were achieved. Five days later, plants had either 0 or 100 µg GA placed in the ligule/inner sheath area of each of leaves 2 and 3. Two days after applying GA, plants were sprayed with fluzifop-butyl at 0.25 kg/ha. At spraying, the leaf water potential of plants in their respective treatments was measured using a Wescor C-51 psychrometer (Savage and Cass 1985). Forty four days after fluzifop-butyl application, total shoot dry weight was determined.

Experiment 2 was conducted on a nitrogen depleted (approximately 1.0 mol/m³ NO₃⁻) Wakanui silt loam soil at Lincoln, between 6 November 1988 and 6 January 1989. The trial was a randomised complete block design with two GA (0, 0.21 kg/ha) and two herbicide (0, 0.18 kg/ha glyphosate (Roundup) treatments. The plots were 4 m² and each treatment was replicated six times. The seed of cultivated oat (*Avena sativa* L. cv Amuri) was sown at 70 kg/ha (15 cm row spacing) with an Oyjord cone seeder drill. All plots were regularly irrigated throughout the experiment to maintain soil moisture content at around FC. At the 3 leaf stage, GA treatments were applied 2 days prior to herbicide treatments. Thirty nine days after spraying, plants were harvested as described in Dickson *et al* 1988 and shoot dry weight, seed head number and individual seed head dry weight were determined.

In both experiments, herbicides and GA, were applied with a CO₂ powered sprayer fitted with Teejet 8001 nozzles which delivered 250 litres water/ha at a pressure of 275 kPa.

RESULTS AND DISCUSSION

Wild oat leaf water potential decreased as soil moisture content approached wilting point in Experiment 1 (Table 1). Leaf water potential is considered to be a satisfactory measure of plant water status (Kramer 1988) and thus, these data indicate that plant water stress was increasing with decreased soil moisture. As a result all facets of plant physiology, which are essential for herbicide activity, would have become progressively more dislocated (Price 1983).

Shoot dry weight of unsprayed plants grown in soil maintained at field capacity was 1.13 ± 0.09 g and 1.32 ± 0.02 g at 0 and 200 µg GA respectively. These data support previous findings that, in wild oat, the main effect of GA is on cell expansion

TABLE 1: Effect of soil moisture content on water potential of leaf 3 of wild oat as measured just prior to GA treatment. The soil was a Rapaki silt loam.

Soil moisture content (% w/w)	Plant water potential (mPa)
18.4	-2.3
20.2	-2.2
23.9	-1.7
27.6	-0.29
36.9	-0.29

rather than other aspects of plant growth (Dickson *et al* 1988). For wild oat plants sprayed with fluazifop-butyl, regardless of GA or water treatment, total plant dry weight at harvest was less than for unsprayed plants (Fig. 1). In the case of sprayed plants not treated with GA, shoot dry weight changed little with an increase in SMC from 18.4 to 23.9%, but decreased substantially when SMC increased from 23.9 to 27.6% then changed little with a further increase in SMC to 36.9% (Fig. 1). In contrast, values for plants given a GA pretreatment decreased fairly steadily with increasing soil moisture over the entire range used. At a soil moisture content of 23.9%, shoot dry weight was substantially lower for GA pre-treated plants than for plants sprayed with fluazifop-butyl alone. At all other soil moisture levels, GA had no effect on the susceptibility of wild oat to fluazifop-butyl.

Fig. 1: The effect of variable soil moisture on the dry weight of wild oat 44 days after spraying with fluazifop-butyl (0.25 kg/ha). Plants were treated with 0 or 200 μ g gibberellic acid two days prior to spraying.

Increased fluazifop-butyl efficacy with a GA pre-treatment at 23.9% w/w soil moisture is probably due to an increased rate of stem/leaf extension (Dickson *et al* 1988; Andrews *et al* 1989). It is thought that GA causes increased expansion growth in plants in two ways. Firstly, it lowers cell water potential which causes water to enter and secondly, it increases cell wall plasticity thus allowing cells to expand (Adams *et al* 1975; Jones 1980). At low soil moisture levels in the present study, GA may have been ineffective because it did not stimulate cell expansion as the biochemical (sucrose, mineral salts) and biophysical (water for turgor pressure) requirements for cell expansion (Dale 1988) would not have been satisfied. In addition, there may have been insufficient sucrose, mineral salts and water present to synthesize new cells. At high SMC, fluazifop-butyl alone caused rapid death of plants and so an effect from GA was not expected.

The use of growth regulators for improving the effectiveness of selective post emergence herbicides such as fluazifop-butyl may be limited under field conditions as the hormone adjuvant may have deleterious effects on the crop from which weeds are being removed. In the field experiment, formulated glyphosate was used as the test herbicide because GA enhancement of broad spectrum herbicides, such as glyphosate, may have greater practical application. Under field conditions, GA increased the rate of stem/leaf extension. Cultivated oat plants treated with GA in Experiment 2 were visibly taller and their stem/leaf sheaths paler green indicating dilution of chlorophyll. In the

TABLE 2: The effect of gibberellic acid and glyphosate on shoot dry weight, panicle number and mean panicle dry weight of cultivated oat grown in medium levels of soil nitrogen under field conditions. Plants were harvested 39 days after spraying.

Herbicide rate (kg ai/ha)	Gibberellic acid treatment (kg/ha)	Shoot dry weight (g/m ²)	Seed head number (g/m ²)	Individual seed-head dry weight (g)
0	0	61.6	89	0.33
	0.21	62.8	110	0.26
0.18	0	33.8	53	0.14
	0.21	0.0	0	0.00
SEM		5.3	6.0	0.01

field, as in the laboratory, GA had no effect on shoot or seed head dry weight (per plant) at harvest of plants not sprayed with herbicide (Table 2). However GA did cause an increase in seed head number/m² and a decrease in individual seed head dry weight (Table 2). The reasons(s) for these effects are unclear, but, as found for barley (Cottrell *et al* 1981), GA may have stimulated tiller growth and reduced the number and hence weight of spikelets per seed head.

Application of GA dramatically increased glyphosate activity against cultivated oats growing in low soil N in the field. At harvest, plots sprayed with GA plus glyphosate were completely devoid of oat plants.

It is concluded that GA can increase post-emergent herbicide activity against stressed *Avena* spp. if it is applied 2 days prior to the herbicide spray. The 2 day separation of GA and herbicide ensured that cells were expanding rapidly when the herbicide was applied which avoided any counteraction of hormone induced cell expansion by the herbicide.

ACKNOWLEDGEMENTS

The authors are grateful to Mrs B. Calder and Miss S. Hines for helping in the preparation of this manuscript and Mr D. Heffer for assistance in the field research. Thanks are extended to the New Zealand University Grants Committee for a Scholarship to the senior author.

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