EFFECT OF NITRATE CONCENTRATIONS AND ADDITIONAL AMINO ACIDS ON THE SUSCEPTIBILITY OF WHEAT TO CHLORSULFURON

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SUMMARY

The response of wheat (*Triticum aestivum* L. cv. Rongotea) to chlorsulfuron at 15 and 60 g/ha was evaluated under external nitrate concentrations ranging from 1 to 50 mol/m³. Maximum growth of sprayed and unsprayed plants occurred at 5 mol/m³ nitrate. The greatest reduction in growth caused by chlorsulfuron also occurred at 5 mol/m³ nitrate. Addition of the branched chain amino acids valine, leucine and isoleucine, that are associated with chlorsulfuron mode of action, partially overcame chlorsulfuron damage. It is concluded that chlorsulfuron limited the capacity of wheat to respond to nitrate, and chlorsulfuron damage to wheat may involve mechanisms in addition to inhibition of the biosynthesis of branched chain amino acids.

INTRODUCTION

Chlorsulfuron is a very potent sulfonylurea herbicide with excellent selectivity characteristics in cereals. However, damage to wheat has been reported in soils rich in nitrogen and phosphorous (Bowran *et al* 1984). An increase in soil (presumably interstitial water) nitrogen level from 20 to 140 ppm increased the phytotoxicity of chlorsulfuron to green foxtail (Nalewaja and Woznica 1985). No explanation for this increase in phytotoxicity is available in the literature. Chlorsulfuron inhibits cell division and its site of action is reported to be the enzyme acetohydroxyacid synthase, the key enzyme in the biosynthesis of the branched chain amino acids valine, leucine and isoleucine (Chaleff and Mauvais 1984; Ray 1984).

The work described here was undertaken to establish the relationship between external nitrate concentration (over a wide range) and the level of chlorsulfuron damage in wheat and to determine if addition of the amino acids valine, leucine and isoleucine can overcome this damage.

MATERIALS AND METHODS

In all experiments, chlorsulfuron (Glean) was applied with a portable sprayer fitted with Teejet 8001 nozzles which delivered 300 litres water/ha at 275 kPa. Citowett at 0.025% was added to the spray tank. All experiments were factorial and arranged in randomized complete block designs. Experiments 1 and 3 had five replicates and Experiment 2 had four replicates.

Experiment 1

Uniform seedlings of wheat (*Triticum aestivum* L. cv. Rongotea) were planted into 14 cm diameter pots filled with vermiculite/perlite mixture (1:1, V:V) and irrigated regularly with a basal nutrient solution containing 1, 5, 10, 25 or 50 mol/m³ potassium nitrate (Andrews *et al* 1989). Plants were maintained in a glasshouse with max/min. temperatures of 30/15 °C at 14 h daylength. When plants reached the three leaf stage, two rates of chlorsulfuron were applied (15 and 60 g/ha) and there was an untreated control. Plants were harvested at maturity (135 days after spraying) and seedhead and total shoot dry weight determined.

Experiment 2

Plants were maintained in a controlled environment cabinet at 12 h daylength and day/night temperatures of 15/9 °C. There were six nitrogen treatments; low and high

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nitrate (1 and 5 mol/m³), plus and minus amino acids (valine, leucine and isoleucine) added every other day either as a drench with each irrigation or injected into the sheaths of leaves one-three (Table 2). Each of the amino acids was at a concentration of 1 mol/m³ in the drench and 10 mol/m³ when injected (a total of 400 µl/plant each time). Plants were either unsprayed or sprayed with 15 or 60 g/ha of chlorsulfuron at the three leaf stage. They were harvested 28 days after spraying for shoot dry weight determination.

Experiment 3

Growth conditions and nitrate treatments were as in Experiment 2. At low and high nitrate, amino acids valine, leucine and isoleucine were added to the plants as a drench treatment with each irrigation at 0, 1 or 3 mol/m³ each. Chlorsulfuron was applied at the three leaf stage and plants harvested 45 days after spraying for shoot dry weight determination.

RESULTS AND DISCUSSION

Chlorsulfuron and nitrate

For unsprayed plants in Experiment 1, shoot dry weight at harvest increased as applied nitrate increased from 1 to 5 mol/m³, then decreased with further increases in applied nitrate over the range used (Table 1). The same pattern was observed at both rates of chlorsulfuron. Chlorsulfuron at 15 g/ha caused significant reductions in shoot dry weight at nitrate concentrations in the range 5 to 25 mol/m³. At 60 g/ha, chlorsulfuron caused a reduction in shoot dry weight at all nitrate concentrations. The difference between unsprayed and sprayed plants was greatest at 5 mol/m³ nitrate, the concentrations which gave greatest growth. Seed head dry weight showed similar results. These data indicate that chlorsulfuron reduced the capacity of wheat to respond to increased external nitrate concentration.

TABLE 1: Effect of nitrate concentrations on shoot dry weight (g) of wheat sprayed with chlorsulfuron.

Chlorsulfuron rate (g ai/ha)	Nitrate concentration (mol/m ³)				
	1	5	10	25	50
0	4.04	12.72	8.75	6.84	4.68
15	4.05	8.97	7.18	5.16	4.77
60	2.43	4.68	4.13	3.25	1.72
SEM			0.49		

Chlorsulfuron and amino acids

In Experiment 2, chlorsulfuron again reduced the capacity of wheat to respond to nitrate. Shoot dry weight of unsprayed plants grown in the absence of amino acids was twice as great at high nitrate as at low nitrate but values for sprayed plants were unaffected by nitrate (Table 2). Application of amino acids through the leaf sheath did not increase the shoot dry weight at either rate of chlorsulfuron. As a root drench at both levels of nitrate, amino acids caused a significant increase in shoot dry weight of unsprayed plants. At 60 g/ha chlorsulfuron, shoot dry weight was unaffected by nitrogen treatment. At 15 g/ha chlorsulfuron, although plants did not respond to increased level of nitrate, shoot dry weight almost doubled when amino acids were added at low nitrate. At this herbicide rate, shoot dry weight of plants given low nitrate plus amino acids was approximately 80% that of comparable unsprayed plants and almost 85% that of unsprayed plants given high nitrate alone. At 15 g/ha chlorsulfuron plants given high nitrate also responded to additional amino acids but their shoot dry weight was similar to that for plants given low nitrate plus amino acids.

At 15 g/ha chlorsulfuron in Experiment 3, shoot dry weight was greater at high nitrate than low nitrate (Table 3). This increase with nitrate however, was much less than the increase obtained for unsprayed plants with nitrate or for sprayed plants with the addition of 1 mol/m³ amino acids at low nitrate. As in Experiment 2, addition of 1

TABLE 2: Effect of amino acids supplied through leaf sheath or roots on shoot dry weight (g) of wheat sprayed with chlorsulfuron at low (L) and high (H) nitrate.

Chlorsulfuron rate (g ai/ha)	Amino acid treatment					
	None		Leaf sheath		Roots	
	L	H	L	H	L	H
0	0.79	1.81	0.88	1.33	1.92	2.37
15	0.76	0.87	0.68	0.56	1.51	1.21
60	0.45	0.35	0.37	0.44	0.51	0.45
SEM	0.09					

TABLE 3: Effect of different concentrations of amino acids supplied through roots on shoot dry weight (g) of wheat sprayed with chlorsulfuron at low (L) and high (H) nitrate.

Chlorsulfuron rate (g ai/ha)	Amino acid concentration (mol/m ³)					
	0		1		3	
	L	H	L	H	L	H
0	1.09	3.00	3.20	4.91	4.47	0.43
15	0.67	1.33	2.47	2.37	3.45	0.35
SEM	0.17					

mol/m³ amino acids resulted in increased growth of sprayed plants at high nitrate but their shoot dry weight was not greater than that of plants given 1 mol/m³ amino acids at low nitrate. When the concentration of amino acids was increased to 3 mol/m³, shoot dry weight of sprayed plants showed a further increase at low nitrate but at high nitrate it decreased dramatically. As in Experiment 2, shoot dry weight of sprayed plants given low nitrate plus amino acids (1 and 3 mol/m³) was approximately 80% that of unsprayed plants.

There is good evidence that chlorsulfuron inhibits acetohydroxyacid synthase, an enzyme central to the biosynthesis of the branched chain amino acids valine, leucine and isoleucine (Ray 1984; Chaleff and Mauvais 1984). Previous reports on the effect of branched chain amino acids on the recovery of plants from chlorsulfuron injury are contradictory. Positive effects were reported for whole pea plants and soybean and bacteria cell suspension cultures (Ray 1984; Rost and Reynolds 1985; Scheel and Casida 1985). However, in other studies amino acids were found to have no effect on chlorsulfuron damage to pea and maize and the possibility that the herbicide has more than one site of action was proposed (Rubin and Casida 1985; Giardina *et al* 1987). The data obtained in the present study (Tables 1-3) indicate that chlorsulfuron limits the capacity of wheat to respond to nitrate. At field rate, but not four times field rate, addition of amino acids can partially overcome herbicide damage. It is concluded that chlorsulfuron damage to wheat is likely to be related to inhibition of branched chain amino acid synthesis but other factors appear to be involved.

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