CHLORSULFURON INDUCED NITRATE ACCUMULATION IN A SENSITIVE WHEAT CULTIVAR: CAUSE AND EFFECT

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SUMMARY

One day after spraying (DAS), chlorsulfuron (15 g/ha) caused an 80% decrease in acetolactate synthase (ALS) activity of wheat (*Triticum aestivum* L. cv. Rongotea) supplied low nitrate (NO_3^-). Acetolactate synthase activity of sprayed plants returned to normal 14-21 DAS. For sprayed plants transferred from low to high NO_3^- 7, 14 or 21 DAS, shoot dry weight 50 DAS increased with increased delay of transfer to high NO_3^- while shoot NO_3^- content decreased. Shoot NO_3^- content of sprayed plants transferred to high NO_3^- 7 or 14 DAS, was similar to that in unsprayed plants at applied NO_3^- concentrations which inhibited growth.

Keywords: *Triticum aestivum* L., sulfonyleurea herbicide, chlorsulfuron, acetolactate synthase, nitrate.

INTRODUCTION

Chlorsulfuron can reduce the ability of some wheat (*Triticum aestivum* L.) cultivars to respond to additional nitrogen (N) (Bowran and Backlow 1987; Dastgheib *et al.* 1992, 1993). The primary mode of action of the herbicide in a range of species is inhibition of acetolactate synthase (ALS), the enzyme which catalyses the first common reaction in the synthesis of the branched chain amino acids (BCAA) valine, leucine and isoleucine (Ray 1989; Dastgheib *et al.* 1993). For the chlorsulfuron sensitive cultivar Rongotea, during the first 7 days after spraying (DAS), decreases in leaf extension rate and shoot fresh weight, ALS activity and valine content were similar with 5 mol/m³ nitrate (NO_3^-) or 1 mol/m³ NO_3^- plus 4 mol/m³ BCAA as N source (Dastgheib *et al.* 1993). For sprayed plants in the longer term (28-45 DAS), shoot and root dry weight (DW) were substantially greater with BCAA than with NO_3^- , despite unsprayed plants showing similar growth on both N forms (Dastgheib *et al.* 1992, 1993). Chlorsulfuron caused substantial NO_3^- accumulation in plants supplied NO_3^- . In the present study, the relationship between ALS activity and NO_3^- content was examined in Rongotea wheat sprayed with chlorsulfuron. The possibility that NO_3^- accumulation can inhibit growth is assessed.

METHODS

Two experiments were carried out under controlled environment conditions (Dastgheib *et al.* 1992). In both experiments, seeds of Rongotea were germinated on moist paper towels in the growth cabinet. Seedlings with a shoot length of approximately 30 mm were transferred to pots 800 cm³ in volume (one plant/pot) containing a vermiculite/perlite (1:1, v/v) mixture soaked in basal nutrient solution (Andrews *et al.* 1989) containing the appropriate N treatment. Potassium concentration was made equal in all treatments by the addition of potassium sulphate as required. All pots were flushed with the appropriate nutrient solution every 2 days. Chlorsulfuron was applied at 0 or 15 g/ha at the three-leaf stage as described previously (Dastgheib *et al.* 1992). In Experiment 1, ALS activity of shoots 1, 7, 14 and 21 DAS was determined in plants supplied low (1 mol/m³) NO_3^- using the method described in Ray (1984) with minor modifications, and expressed on a protein (Bradford 1976) basis. Also, plants were transferred from low to high (5 mol/m³) NO_3^- 7, 14 and 21 DAS to determine if the

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inhibitory effect of chlorsulfuron on growth of *Rongotea* is a long term effect. Shoot DW and NO_3^- content were determined 50 DAS. In Experiment 2, plants were supplied 0.5, 1.0, 2.5, 5.0, 7.5, 10 or 15 mol/m^3 NO_3^- throughout. Plants were harvested 42 DAS and shoot DW and NO_3^- content determined (Dastgheib *et al.* 1992). In both experiments, the experimental design was a randomised complete block with five replicates. All measurements were carried out on all five replicates. Both experiments were done twice. An analysis of variance was carried out on all data. All effects discussed have a probability of $P < 0.01$ and were obtained in the repeat experiments.

Figure 1: Effect of chlorsulfuron on dry weight and nitrate (NO_3^-) content of shoots of *Rongotea* wheat transferred from low to high NO_3^- 7, 14 and 21 days after spraying (DAS). Vertical lines indicate 95% confidence intervals.

RESULTS AND DISCUSSION

In Experiment 1, chlorsulfuron caused an 80% decrease in ALS activity 1 DAS, as was found previously (Table 1; Dastgheib *et al.* 1993). Acetolactate synthase activity of sprayed plants increased with time and returned to normal 14-21 DAS. If inhibition of ALS activity is the primary mode of action of chlorsulfuron in *Rongotea* (Dastgheib *et al.* 1993), and the reason why sprayed plants can not respond to additional N, then shoot DW for sprayed plants relative to untreated plants should increase with time of transfer from low to high NO_3^- . This was found to be the case:

shoot DW for sprayed plants increased more than twofold with increased time of transfer to high NO_3^- (Fig. 1). Shoot DW was similar for untreated and sprayed plants transferred to high NO_3^- 21 DAS. If NO_3^- accumulation in sprayed plants is related to inhibition of ALS activity then shoot NO_3^- content should decrease with time of transfer from low to high NO_3^- . This was found to be the case (Fig. 1). Shoot NO_3^-

TABLE 1: Effect of chlorsulfuron on acetolactate synthase (ALS) activity in shoots 1, 7, 14 and 21 days after spraying (DAS) Rongotea wheat supplied low nitrate (NO_3^-) in Experiment 1.

Chlorsulfuron	ALS activity ($\mu\text{mol}/\text{mg protein}$)				
	1 DAS	4 DAS	7 DAS	14 DAS	21 DAS
Unsprayed	259	269	376	500	395
Sprayed	54	128	144	302	371
LSD	72	90	109	94	125

Figure 2: Effect of chlorsulfuron on dry weight and nitrate (NO_3^-) content of shoots 42 days after spraying Rongotea wheat supplied different concentrations of NO_3^- . Vertical lines indicate 95% confidence intervals.

content was 100 times greater in sprayed than in untreated plants transferred to high NO_3^- 1 DAS, but chlorsulfuron did not affect NO_3^- content of plants transferred 21 DAS.

In Experiment 2, shoot DW of control plants increased with increased applied NO_3^- concentration from 0.5 to 5.0 mol/m³ then decreased with increased NO_3^- supply to 15 mol/m³ (Fig. 2). For sprayed plants, shoot DW increased with increased NO_3^- supply from 0.5 to 2.5 mol/m³, then decreased with additional NO_3^- thereafter. The greatest reduction in shoot DW with chlorsulfuron occurred at 5 mol/m³ NO_3^- . Nitrate content of untreated plants was < 0.06 mg NO_3^- -N/g DW at applied NO_3^- concentrations from 0.5 to 5.0 mol/m³ but increased 100 fold approximately with additional NO_3^- from 5.0 to 7.5 mol/m³ (Fig. 2). For sprayed plants, NO_3^- content showed a similar increase with increased applied NO_3^- from 2.5 to 5.0 mol/m³. At 5 mol/m³ NO_3^- , NO_3^- content of shoots of sprayed plants was 80 times greater than that for controls and similar to that for untreated plants supplied 7.5 mol/m³ NO_3^- , an applied NO_3^- concentration which inhibited growth. It is concluded that chlorsulfuron induced NO_3^- accumulation is related to decreased ALS activity and that findings are consistent with the proposal that this NO_3^- accumulation inhibits growth of *Rongotea*.

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