DIFFERENTIAL RESPONSE OF WHEAT CULTIVARS TO CHLORSULFURON

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SUMMARY

Tolerance of 13 wheat (*Triticum aestivum* L.) cultivars to foliar applications of the herbicide chlorsulfuron were tested. Growth was reduced in the cultivars Rongotea and Lancer. In a further experiment, two methods of application, one to foliage plus soil and the other to foliage only, were used to determine the effect of soil activity on the efficacy of the herbicide. Cultivars Rongotea and Lancer were the most sensitive, based on reductions in shoot dry weight. The highest sensitivity was shown where the herbicide was allowed to reach the soil as well as the foliage. The results are discussed in relation to the soil persistence of chlorsulfuron.

INTRODUCTION

Chlorsulfuron is recommended for broad spectrum weed control in cereals at rates less than 20 g/ha (Cornwell and Lane 1981). Reports about the response of cereal cultivars to chlorsulfuron are contradictory. Hageman and Behrens (1981) found no differences in response of spring and durum wheat, barley (*Hordeum vulgare* L.) and oat (*Avena sativa* L.) cultivars to chlorsulfuron at 125 g/ha in the field. Cornwell and Lane (1981) reported that there were no yield differences amongst several wheat cultivars for rates of chlorsulfuron up to 75 g/ha. In contrast Wicks *et al* (1987) tested 13 winter wheat cultivars and found three showed yield reductions when sprayed with 70 g/ha chlorsulfuron. Genotype by environment interactions have been reported for wheat (Blacklow and Pheloung 1987; Bowran and Blacklow 1987) and for barley (Lemerle *et al* 1987) cultivars. Chlorsulfuron is reported to be a persistent herbicide having a soil half life ranging from 63 to 229 days depending on the temperature (Thirunaryan *et al* 1985). Other environmental factors such as soil pH, organic matter content and water level also play an important role in chlorsulfuron persistence (Anderson and Barrett 1985).

The purpose of this research was to evaluate some of the wheat cultivars grown in New Zealand for their response to chlorsulfuron. Because in normal spraying practice the soil receives an appreciable amount of herbicide, an attempt was made to separate the effect of root and shoot uptake.

MATERIALS AND METHODS

In all experiments, chlorsulfuron (Glean) was applied with a CO₂ pressurized sprayer fitted with Teejet 8001 nozzles which delivered 250 litres water/ha at 275 kPa. Citowett at 0.025% was added to the spray tank. All experiments were factorials and arranged in randomized complete block designs with five replicates.

Experiment 1

Thirteen cultivars of wheat (*Triticum aestivum* L.) were selected for initial screening (Table 1). Uniform 10-day old seedlings of all cultivars were planted individually into 15 cm diameter plastic pots filled with Templeton silt loam. These were maintained in a glasshouse with a min./max. temperature of 16/30°C during the growing period. Artificial lighting extended the daylength to 14 h. When the plants reached the three leaf stage, an over the top application of chlorsulfuron was made at 0, 30, 60 and 90 g/ha. Shoot dry weights were measured at maturity, approximately 80 to 130 days after spraying.

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TABLE 1: Effect of chlorsulfuron on shoot dry weight of wheat cultivars. Data are percent of unsprayed controls.

Cultivar	Chlorsulfuron rate (g ai/ha)		
	30	60	90
Abele	104.5	115.2	118.8
Advantage	125.5	117.9	87.7
Crossbow	88.7	82.3	88.7
Dartagnan	106.3	100.8	65.9
Jasper	91.9	64.9	73.9
Karamu	77.7	74.8	65.0
Kotare	61.2	64.2	68.5
Lancer	64.9	51.9*	54.1*
Norseman	90.7	88.9	70.4
Oroua	89.5	70.3	67.4
Otane	86.3	66.9	54.3
Pegasus	94.8	74.7	55.7
Rongotea	73.1	37.7*	57.1*

* An asterisk indicates significant reduction in shoot dry weight compared to the control based on LSD.₀₅.

Experiment 2

Seeds of Abele, Jasper, Kotare, Lancer and Rongotea were sown on 10 July 1989 into black plastic (planter) bags (20 cm diameter) containing about 9 kg of Templeton silt loam, held at field capacity. All pots were thinned to a final stand of five plants per pot. On 12 August 1989 when plants had reached the 3-4 leaf stage, they received an over the top spray of chlorsulfuron at 0, 15 or 60 g/ha. The soil surface of half the pots was temporarily covered with 5 mm of vermiculite to prevent the herbicide from reaching the soil. Pots were maintained outdoors and three harvests were made; 43, 62 and 161 days after spraying. One or two plants were hand-clipped at the soil surface at each harvest and their dry weights determined. At the final harvest (maturity), seed heads were clipped and grain yield determined.

Experiment 3

The aim of this experiment was to determine the residual activity of chlorsulfuron in the soil. Soil samples were collected from the top 30 mm of each pot in Experiment 2 on 1 March 1990 (203 days after spraying). Soil from different cultivars but receiving a similar spraying treatment was mixed and a composite sample of 260 g was put into 9 cm diameter plastic pots. Chlorsulfuron residues were determined by a maize (*Zea mays* L.) bioassay technique (Groves and Foster 1985). Standard concentrations of chlorsulfuron were made by mixing chlorsulfuron with unsprayed soil to give concentrations of 0, 0.25, 0.50 and 1.0 ppb in the soil. Two pre-germinated maize seedlings (PX 9199 hybrid variety) were placed into each pot and their root lengths measured after 7 days. Percent inhibition of root growth was calculated and compared with the standard curve to estimate the level of chlorsulfuron residues in the soil.

RESULTS AND DISCUSSION

In Experiment 1, significant reductions in dry weight occurred for cultivars Lancer and Rongotea when sprayed with 60 or 90 g/ha chlorsulfuron (Table 1).

In Experiment 2, all cultivars showed significant reductions in dry weight at the first harvest when sprayed with 60 g/ha chlorsulfuron irrespective of spraying technique (Table 2). However, some of the cultivars showed recovery in the succeeding harvests. In the second harvest (data not presented) dry weight reductions were significant only for cultivars Lancer and Rongotea when both foliage and soil surface were sprayed at 60 g/ha chlorsulfuron. At the final harvest the only cultivar with a significant reduction in dry weight was Rongotea which showed more than 18% reduction when foliage and soil had been sprayed with either 15 or 60 g/ha chlorsulfuron. This cultivar also showed

TABLE 2: Effect of chlorsulfuron applied to foliage alone (F) or to foliage and soil surface (F+S) on shoot dry weight of wheat cultivars at different harvests. Data are percent of unsprayed controls.

Cultivar	Chlorsulfuron rate (g ai/ha)	First harvest		Final harvest	
		F	F + S	F	F + S
Abele	15	75.0*	75.0*	86.8	90.1
	60	78.1*	63.5*	101.2	104.5
Jasper	15	86.8	84.9	100.4	122.5
	60	73.6*	58.5*	81.1	93.4
Kotare	15	75.2*	83.8	94.7	116.6
	60	82.1*	72.6*	111.7	105.7
Lancer	15	95.1	94.1	95.4	102.8
	60	75.5*	59.8*	96.4	85.7
Rongotea	15	83.0	72.3*	93.2	81.7*
	60	73.4*	47.9*	88.5	81.2*

* An asterisk indicates significant reduction in shoot dry weight compared to the control based on LSD_{0.05}.

detachment of leaf 4 when sprayed with 60 g/ha chlorsulfuron without the soil cover. Reductions in grain yield (data not presented) were significant only for Lancer when exposed to 60 g/ha chlorsulfuron applied to the foliage and soil surface (77.1% of control).

When the soil surface received chlorsulfuron spray, consistently higher reductions in growth were obtained, compared to when only the foliage was sprayed (Table 2). There was apparently residual activity of chlorsulfuron in the soil and probably continuous root uptake throughout the growing season.

Several bioassay techniques have been developed to determine the amount of chlorsulfuron in the soil (Hsiao and Smith 1983; Morishita *et al* 1985). The method based on inhibition of root growth in maize seedlings described by Groves and Foster (1985) which was used in this work, is reported to be the most sensitive. Table 3 shows that 7 months after spraying at 60 g/ha residues of chlorsulfuron could be detected at 0.47 ppb in the soil and this level caused 43.8% inhibition in root growth of maize. In normal field applications of foliar herbicides, the soil surface usually receives significant spray coverage. If a herbicide is soil active, as is the case with chlorsulfuron (Thirunarayan *et al* 1985), the root uptake should be considered in evaluating and interpreting phytotoxicity data.

It is concluded that among the cultivars tested, Lancer and Rongotea were the most sensitive to chlorsulfuron and the effect was partially associated with root uptake of the herbicide. The results for the cultivars Jasper and Kotare in the first and second

TABLE 3: Percent inhibition of maize root length following growth in soil samples 7 months after chlorsulfuron treatments had been applied to foliage alone (F) or to foliage and soil surface (F+S) (Experiment 2). Figures in brackets are estimated chlorsulfuron residues (ppb) derived from a standard curve.

Initial chlorsulfuron rate (g ai/ha)	Application method	
	F	F + S
0	0.0 (nil)	0.0 (nil)
15	18.8 (<0.25)†	38.9* (0.39)
60	16.0 (<0.25)†	43.8* (0.47)

† Residual concentrations smaller than the lowest standard concentration (0.25 ppb) were regarded as negligible.

* Significant reductions in root length compared to the control based on an LSD_{0.05} test.

experiments (Tables 1 and 2) are different and any conclusion about the behaviour of these cultivars requires further work. Such variations in chlorsulfuron phytotoxicity were observed by Lemerle *et al* (1987) who reported that several cultivars of barley showed reductions in grain yield due to chlorsulfuron in one year but not in another. They related the variation to fluctuating environmental conditions. The importance of soil nitrogen in the magnitude of the response of wheat to chlorsulfuron has also been shown (Dastgheib *et al* 1989).

One critical finding is that early plant damage associated with chlorsulfuron may not carry over to final crop maturity. Cultivars Abele, Jasper and Kotare (Table 2) showed significant early damage that was not apparent as either a reduction in shoot weight or grain yield at the final harvest. One implication is that early damage symptoms may be misleading and not necessarily indicative of subsequent yield loss, although this is dependent upon cultivar.

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