THE INFLUENCE OF THE ENVIRONMENT ON THE ACTIVITY OF CHLORSULFURON

D. Lemerle, A.R. Leys and C.R. Kidd
Agricultural Research Institute, Wagga Wagga N.S.W. 2650

Summary. The performance of herbicides is often variable under Australian conditions. This paper reviews the environmental factors (soil and weather) that influence the activity of chlorsulfuron. We outline research in southern N.S.W. which examines the effect of soil pH and seasonal conditions on the field responses of barley, wheat and annual ryegrass, *Lolium rigidum* Gaud., to chlorsulfuron. We also detail some field and controlled environment studies on the influence of weather (rainfall, soil moisture and temperature) on the tolerance barley to chlorsulfuron.

INTRODUCTION

Chlorsulfuron belongs to the sulfonylurea group of herbicides, a new and rapidly expanding group being developed for use in many crops at extremely low use rates (5-20 g a.i./ha). Chlorsulfuron was the first of these herbicides to be introduced into Australia and is already one of the major cereal herbicides.

Genetic and biochemical studies have shown that these herbicides work by inhibiting a key enzyme (acetohydroxyacid synthase) in the biosynthesis of two essential amino acids, valine and isoleucine (14). Selectivity depends on tolerant crops being able to metabolize chlorsulfuron to inactive products before it is able to exert its herbicidal effect (16).

It is essential that herbicide performance is optimized to meet the stringent environmental, economic and legislative requirememts placed on their use. This can only be achieved if we understand the factors which influence herbicide selectivity.

In this paper we will discuss some of the environmental factors (soil and weather) that can affect the bioactivity of chlorsulfuron, and the progress we have made in quantifying the effects of soil pH and weather on its activity.

VARIABLE SELECTIVITY

Wheat is more tolerant of chlorsulfuron than barley (5), although there is considerable variation within each species (7, 8, 9). We have found that differences in the environment can be just as important as genetic differences in the yield responses of barley to chlorsulfuron (Table 1). Differences as marked as these need to be explained. Growing conditions in the four years were very different; 1982 was a drought year, 1983 and 1984 were quite wet, while the growing conditions in 1985 were in-between these two extremes. General observations such as these are useful, but they are of limited value in providing information that will prevent such occurrences in the future. For instance, did the wetter conditions in 1983 and 1984 cause waterlogging and hence stress the plant to the extent that detoxification of chlorsulfuron by barley was reduced; or, did the high rainfall cause greater leaching of

Table 1. Grain yields (% of unsprayed controls) of weed-free barley cultivars sprayed with 14 g a.i./ha chlorsulfuron at ZGS 13 at Wagga Wagga 1982–1985.[a]

Cultivar	1982	1983	1984	1985
Bandulla	96	84*	70*	100
Clipper	97	75*	80*	104
Corvette	100	71*	60*	86*
Forrest	108	57*	64*	90
Galleon	102	78*	81*	102
Grimmett	97	92	87	104
Lara	105	95	88	104
Schooner	102	72*	66*	89*
Shannon	98	81*	102	95
Stirling	102	93	86	86*
Means	102	73	78	96

[a] Values followed by asterisks indicate a significant difference from the unsprayed control (P=0.05).

chlorsulfuron into the root zone; or, did it cause greater amounts of chlorsulfuron to remain in solution and hence be absorbed by the roots? The answer probably includes a combination of a number of interacting factors.

FACTORS AFFECTING BIOACTIVITY

To be effective chlorsulfuron must be absorbed and translocated to the site of action in sufficient quantity to exert its effect. The bioactivity of chlorsulfuron will be greatest when environmental conditions favouring availability and plant uptake are coupled with growing conditions that inhibit metabolism of the herbicide in the plant. Various soil and weather factors affect the availability of, and plant response to, chlorsulfuron.

Soil factors. The availability and bioactivity of chlorsulfuron has been shown to be influenced by soil pH. In absolute terms there is less chlorsulfuron available in acid soils; it is degraded more quickly, adsorbed to the soil in greater amounts and desorbed less, and is also less soluble (6). These latter two points mean that chlorsulfuron is also less mobile in acid soils. Thus, good rain after post-emergence applications of chlorsulfuron in alkaline soils means that the herbicide is leached into the root zone. Fredrickson and Shea (6) have shown that chlorsulfuron is more phytotoxic to sorghum, *Sorghum bicolor*, at pH 5.9 than at 7.5 (presumably measured in water). Mersie and Foy (10) found the reverse was true for corn, *Zea mays*; phytotoxicity increased with increasing pH, reaching a maximum at pH 6.9. Soil pH can also effect the uptake of chlorsulfuron by plant roots. The uptake of chlorsulfuron by wheat was 67–100% greater at pH 5.9 than at pH 7.5 (6).

Adsorbtion of chlorsulfuron to the soil also increases with increasing organic matter content (2, 10, 15). Little information is available on the effect of soil nutrients on chlorsulfuron activity. Bowan *et al.* (1) have shown that wheat (cv. Sonora) was more sensitive to chlorsulfuron as the levels of soil nitrogen and phosphorus increased.

Weather factors. The importance of variable weather conditions in causing unreliable herbicide performance is reviewed in detail by Caseley at this conference (4). The important factors which influence the activity of chlorsulfuron are: rainfall and soil water status (11, 12, 13); and temperature and relative humidity (1, 11, 12). Campion and Tichon (3) reported that the best weed control with chlorsulfuron during early evaluation trials in Australia was achieved in warm moist conditions, and that rainfall following post-emergence application also improved weed control. The manufacturers' recommendations on the label warns that the best weed control is achieved when rainfall or sprinkler irrigation wets the soil to a depth of 5-7.5 cm within four weeks of post-emergence application. The label also warns that damage may result if crops are stressed by severe weather conditions e.g. disease, frost, prolonged cold, waterlogged soil, drought or insect damage at, or after the time of application of chlorsulfuron. Chlorsulfuron was less phytotoxic to kochia, *Kochia scoparia*, and green foxtail, *Setaria viridus*, plants stressed for moisture after treatment than plants not stressed, or only stressed before treatment (11). Papalia *et al.* (13) have shown that the sensitivity of wheat to chlorsulfuron is increased in waterlogged soils. Nalewaja and Woznica (11) found that temperatures between 10 and 30°C had little effect on the phytotoxicity of chlorsulfuron or kochia on green foxtail. Bowran *et al.* (1) found that wheat cultivars were more sensitive to chlorsulfuron at soil temperatures of 13°C than at 20°C. Chlorsulfuron has been shown to be more phytotoxic at high than at low relative humidities (11). Some of the reports present conflicting results, but in general, chlorsulfuron is more phytotoxic to plants when soil moisture, soil nitrogen or relative humidity are high.

CURRENT RESEARCH

In 1986 field trials were set up at three locations in southern N.S.W. to determine the effect of soil pH and seasonal conditions on the responses of barley, wheat and annual ryegrass to chlorsulfuron. The sites were chosen to cover a wide range of environments (soil pH and rainfall). In addition to the natural variation in pH between sites (pH in $CaCl_2$ ranged from 4.5 at Ariah Park to 6.2 at Goolgowi), lime was applied to obtain two pH levels at each site. The experiments will be repeated for three years, and during this time detailed meteorological and soil parameters are being recorded by automatic weather stations.

At each site six rates of chlorsulfuron were applied post-emergence when the crop was at ZGS 13. Tolerant and susceptible wheat and barley cultivars, identified from earlier research at Wagga Wagga, were included in the experiments, along with the susceptible weed, annual ryegrass.

The results from the first season show that wheat is more tolerant of chlorsulfuron than barley, and the extent of grain yield losses differed between cultivars. The yield losses in the susceptible cultivars Corvette and Schooner were always greater than in the more tolerant cultivars, Lara and Grimmett. At one site (Ariah Park) the addition of lime reduced the extent of the yield losses caused by chlorsulfuron.

Pot trials in a glasshouse are examining, in greater detail, the effect of soil pH on the response of barley to chlorsulfuron. This work also includes some of the newer chlorsulfuron analogues (metsulfuron and CGA 131036).

The influence of the weather (rainfall, soil moisture and temperature) on the tolerance of barley to chlorsulfuron is being studied in an experiment that commenced this year. A field trial in a rain-out shelter aims to determine the effect of soil moisture (in the top 20 cm) at the time of, and shortly after post-emergence application of chlorsulfuron to barley cv. Schooner. As the effect of the weather on barley tolerance will be strongly influenced by the relative importance of shoot versus root uptake, controlled environment studies are examining mechanisms of chlorsulfuron uptake by barley.

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