# CROPPING OPTIONS FOLLOWING WINTER APPLIED RESIDUAL HERBICIDES IN SOUTHERN QUEENSLAND

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**Summary** Residual herbicides used in winter cereals and legumes play an important role in weed control in the northern cropping region of Australia. Current recommendations for re-cropping intervals restrict the choice of the following summer crop. We are reassessing these for the different soil types and climatic conditions of southern Queensland. Summer crops were sown at three sites over two seasons (pH 5.5 to 8.6) previously treated with chlorsulfuron (15 g a.i. $ha^{-1}$), triasulfuron (26 g a.i. $ha^{-1}$), metsulfuron methyl (4 g a.i. $ha^{-1}$), imazethapyr (30 g a.i. $ha^{-1}$), metosulam (5 g a.i. $ha^{-1}$) and flumetsulam (20 g a.i. $ha^{-1}$). Seedling dry weight four weeks after sowing and yield were measured. There was no significant biomass reduction (sorghum, maize, navybean, soybean and peanuts) to any of the herbicides when planted 3.5 months after application in a soil of pH 5.5. However in soils of pH 7.8 and 8.6, sulfonylurea residues caused a 3–83% reduction in biomass in sorghum, 23–67% in cotton and 5–81% in mungbeans, 4.5 months after application. Imazethapyr caused a 15–93% biomass reduction in sorghum and 23–79% in cotton in alkaline soils after 4.5 months. Metosulam and flumetsulam did not cause any significant biomass reduction at these sites except flumetsulam which caused a 12–75% reduction in the biomass of cotton. An increase in rainfall from 162 mm to 302 mm during the 4.5 month fallow caused an average increase in plant biomass of 61% in sorghum growing in sulfonylurea and imazethapyr residues (soil pH 7.8). The data we are generating will increase the flexibility of re-cropping after using residual herbicides and will assist in crop selection to reduce the impact of herbicide residues.

## INTRODUCTION

Cropping rotations in the summer dominant rainfall region of southern Queensland include both winter and summer crops. Principal summer crops are sorghum, cotton, mungbeans, sunflower, maize, peanuts, soybeans and navybean. Major winter crops are wheat, barley and chickpea. When rainfall allows, there is an opportunity to double crop from a winter crop directly into a summer crop or vice versa. This is more prevalent in the eastern areas of the region. Otherwise, fallows of up to 18 months are quite common. Soils range from kraznozems in the eastern part of southern Queensland (pH 5.5–6) to the heavy black cracking clays of the eastern Darling Downs (pH 7.5–9) and the grey clays of the western Downs (pH 7–8.5).

Residual herbicides are an important weed management option in winter crops. However persistent residues can restrict the choice and time of sowing following crops. The current recommended re-cropping intervals for chlorsulfuron are 15 to 22 months on neutral soils, and can be greater than 24 months on alkaline soils (pH 7.6–8.5). Re-cropping intervals for metsulfuron range from 9 to 14 months on soils of pH 5.6 to 8.5. However, farmer experience suggests that these re-cropping intervals may be too conservative under certain conditions. A series of experiments was conducted to ascertain the validity of these re-cropping intervals under different environmental conditions of southern Queensland.

## MATERIALS AND METHODS

Five field experiments were undertaken on three sites over two years. The sites were selected to cover a range of soils and pH (Table 1): Sites 1 and 2 are on a kraznozem with a pH of 5.5; sites 3 and 4 are black earths with pH of 7.8; and site 5 a black earth with pH of 8.6.

Chlorsulfuron (15 and 30 g a.i. $ha^{-1}$), triasulfuron (26 and 52 g a.i. $ha^{-1}$), metsulfuron methyl (4 and 8 g a.i. $ha^{-1}$), metosulam (5 and 10 g a.i. $ha^{-1}$), flumetsulam (20 and 40 g a.i. $ha^{-1}$) and imazethapyr (30 and 60 g a.i. $ha^{-1}$) were applied to fallow during the winter and re-cropped the following summer. The two rates were the recommended and double rates. Sorghum, maize, peanut, navy bean and soybean were planted at the Kingaroy sites, and sorghum, mungbean and cotton were planted at the Dalby and Pittsworth sites. Re-cropping intervals ranged from 99 to 182 days (Table 1).

Crop responses were measured at 4 to 5 weeks after sowing (seedling dry weight) and yield. However, drought prevented harvest at sites 1 and 3. Soil samples (0–5 cm and 5–15 cm) were collected at planting from chlorsulfuron and triasulfuron treated plots. Chlorsulfuron residue was measured using a bioassay based on the suppression of root growth of maize (*Zea mays* cv. Hycorn 74) (Walker *et al.* 1996). Triasulfuron residue was measured using an ELISA analysis method developed in Ciba laboratories (Swain personal communication).

## RESULTS

Sorghum seedling growth was reduced substantially (>50%) in chlorsulfuron, triasulfuron, and imazethapyr treated plots at sites 3 and 5, and in metsulfuron methyl plots at site 3 (Table 2). Metsulfuron methyl at the double rate, however, resulted in significant reduction in sorghum seedling growth at site 5 (data not presented). These affects on crop growth persisted resulting in significant yield reductions. Sorghum midge also affected yields in these plots at site 5 due to the delay in flowering. Sorghum was not affected by these herbicides at sites 1, 2 and 4. Also, sorghum growth (seedling and yield) was unaffected in metosulam and flumetsulam treated plots at any site.

Maize, peanut, navybean and soybean growth were also not affected by herbicide residues at sites 1 and 2 (Table 3, other data not presented).

Cotton seedling responses were similar to sorghum in the chlorsulfuron, triasulfuron, metsulfuron methyl and imazethapyr treated plots at sites 3, 4 and 5 (Table 3, other data not presented). However, cotton growth was reduced by flumetsulam (48–64%) at sites 3 and 5 (data not presented). In general, mungbeans were less affected by the sulfonylurea residues than sorghum and cotton.

Chlorsulfuron residues at planting were not detectable at site 1 and greatest at site 5 (Table 1). Triasulfuron residues were also greatest at site 5.

## DISCUSSION

Sorghum seedling response to the sulfonylurea herbicides (chlorsulfuron, triasulfuron and metsulfuron methyl) tended to increase with increasing soil pH. These differences in crop response are likely due to the influence of pH on the degradation of these herbicides. Beyer *et al*. (1988) stated that chemical hydrolysis and microbial breakdown are the most important pathways of sulfonylurea degradation/dissipation in soil. Walker *et al*. (1993) found that half-lives of chlorsulfuron in soils of southern Queensland varied from 10–109 days, and differences in soil pH accounted for 96% of this variation. Rapid degradation of the sulfonylureas was evident at the acidic field sites, resulting in no crop damage after three months. However, degradation was much slower at the alkaline sites with a substantial proportion of the

**Table 1.** Details of sites, herbicide application and re-cropping intervals.

| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---|---|---|---|---|---|
| Location | Kingaroy | Kingaroy | Dalby | Dalby | Pittsworth |
| Soil type | kraznozem | kraznozem | black earth | black earth | black earth |
| Soil pH | 5.5 | 5.5 | 7.8 | 7.8 | 8.6 |
| Clay (%) | 56 | 56 | 63 | 63 | 61 |
| Application date | 27.7.94 | 1.8.95 | 22.6.94 | 25.7.95 | 3.7.95 |
| Re-cropping interval (days) | 182 | 99 | 138 | 131<br>108 (cotton) | 129 |
| Fallow rainfall (mm) | 116 | 126 | 162 | 302<br>214 (cotton) | 133 |
| Chlorsulfuron (ng $g^{-1}$) at sowing | NDR[A] | – | 3.8 | 4.3 | 4.4 |
| Triasulfuron (ng $g^{-1}$) at sowing | | | | 2.4 | 8.7 |

[A] NDR = no detectable residue.

**Table 2.** Sorghum response, as measured by shoot dry matter (SDM g $m^{-1}$) and grain yield (t $ha^{-1}$), when sown after winter applications of residual herbicides.

| Herbicide | Rate | Site 1 | Site 2 | | Site 3 | Site 4 | | Site 5 | |
|---|---|---|---|---|---|---|---|---|---|
| | (g $ha^{-1}$) | SDM | SDM | Yield | SDM | SDM | Yield | SDM | Yield |
| Chlorsulfuron | 15 | 35 | 31 | 5.45 | 2[A] | 48 | 1.92 | 9[A] | 0.30[A] |
| Triasulfuron | 26 | 51 | 22 | 5.83 | 4[A] | 73 | 1.97 | 6[A] | 0.83[A] |
| Metsulfuron | 4 | 15 | 25 | 5.85 | 2[A] | 88 | 1.82 | 26 | 3.86[A] |
| Metosulam | 5 | 46 | 49 | 4.69 | 16 | 119 | 1.90 | 47 | 5.03 |
| Flumetsulam | 20 | – | – | – | 24 | 130 | 1.78 | 31 | 4.91 |
| Imazethapyr | 30 | – | – | – | 1[A] | 78 | 2.06 | 15[A] | 0.73[A] |
| Untreated | | 30 | 32 | 5.01 | 13 | 92 | 1.43 | 35 | 4.88 |
| SE | | 7 | 8 | 0.51 | 1 | 30 | 0.22 | 8 | 0.43 |

[A] Significantly less than untreated (P=0.05).

**Table 3.** Seedling response, as measured by shoot dry matter (g $m^{-1}$), of different crops when sown after winter applications of chlorsulfuron and metosulam.

| Site | Crop | Chlorsulfuron | Metosulam | Untreated | SE |
|---|---|---|---|---|---|
| 2 | Sorghum | 31 | 49 | 32 | 8 |
| | Maize | 48 | 34 | 47 | 9 |
| | Peanut | 33 | 32 | 23 | 5 |
| | Navy bean | 68 | 63 | 67 | 7 |
| | Soybean | 32 | 24 | 29 | 4 |
| 5 | Sorghum | 9[A] | 47 | 35 | 8 |
| | Mungbean | 28[A] | 61 | 67 | 6 |
| | Cotton | 5[A] | 14 | 14 | 2 |

[A] Significantly less than untreated (P=0.05).

residues remaining after 4.5 months which resulted in considerable crop damage.

Crop response to the sulfonylurea herbicides and imazethapyr tended to be less in the wetter season with the greatest influence being on imazethapyr. The increase in fallow rainfall from 162 to 302 mm at sites 3 and 4 resulted in an average increase in sorghum seedling biomass from 17% of the untreated to 78% of the untreated. Beyer *et al*. (1988) stated that the rates of chemical and microbial degradation of the sulfonylureas increase with soil water content. However this was not evident in the measured chlorsulfuron residues at sites 3 and 4. Imazethapyr is principally degraded by soil microbes, and persistence is greater in dry seasons (Anon.). Sorghum seedling biomass increased from 8% of untreated to 85% of the untreated with the increase in fallow rainfall of 140 mm (sites 3 and 4).

Metosulam and flumetsulam are principally degraded by microbial action (Anon. 1994). Metosulam has a relatively short half life of 6 to 47 days under field conditions (Anon. 1994). This resulted in no adverse affect on any crop irrespective of pH and rainfall. However cotton was much more susceptible to flumetsulam residues than the other crops grown at these sites.

Differences in crop response in the field were similar to responses of the same crops in a soil free system. In the field sorghum and cotton were more sensitive to chlorsulfuron residues than mungbeans. In the soil free system Churchett *et al*. (1996) measured that the doses for a 10% reduction in seedling biomass were 0.25 g $L^{-1}$ for sorghum, 0.23 g $L^{-1}$ for cotton, and 0.66 g $L^{-1}$ for mungbeans.

Preliminary data indicate re-cropping intervals may be modified based on local soil and climatic factors. It is safe to re-crop a range of summer crops on acidic soils 3–6 months after sulfonylurea herbicide application. It is safe to plant summer crops 3–6 months after metosulam and flumetsulam except for cotton after flumetsulam. However in alkaline soils and dry seasons it is not safe to plant following sulfonylurea herbicides or imazethapyr after a winter crop failure. However following a normal to wet season it may be possible to re-crop at 6 months. This is being investigated further.

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