EVALUATION OF CHLORSULFURON FOR WEED CONTROL IN WINTER WHEAT (*TRITICUM AESTIVUM* L.) AND ITS EFFECT ON SUBSEQUENT RECROPPING WITH SOYBEANS (*GLYCINE MAX* (L.) MERR.) OR GRAIN SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH).

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INTRODUCTION

Since chlorsulfuron was labeled and marketed as "Glean" in 1982, it has been used for mainly broadleaf weed control in wheat (*Triticum aestivum*). The only other crops this herbicide can be used on are barley (*Hordeum vulgare*) and oats (*Avena sativa*), since it inhibits growth of most other agronomic crop plants.

Chlorsulfuron has some unique characteristics. Cell division can be inhibited in susceptible plants at extremely low concentrations. For example, Du Pont research has shown that corn growth can be inhibited at $2.8 * 10^{-9}$ M (1 ppb). Consequently, the maximum recommended use rate is 1/2 oz of product per acre (26.25 g/ha ai). Another characteristic of chlorsulfuron is, even at the low rates, it can be persistent in the soil for up to 48 months. It is decomposed in the soil by microorganisms and by hydrolysis, but the latter is thought to be responsible for most of the decomposition in soils. Since hydrolysis is a chemical process, the soil pH, moisture content, organic matter, and temperature are the determining factors in the rate of decomposition.

Many farmers are now making an increased effort to eradicate weeds in wheat fields. The objectives of this research were: 1) evaluate chlorsulfuron for use as a herbicide in wheat, 2) compare its weed control efficacy with other common herbicides used in wheat, 3) determine any crop injury risk that might be associated with chlorsulfuron, and 4) determine if soybeans or grain sorghum can be grown in rotation with wheat treated with chlorsulfuron. Since soybeans and grain sorghum commonly are grown in rotation with wheat in Kansas, these crops could be injured by chlorsulfuron carry over.

REVIEW OF THE LITERATURE

Evaluation of Chlorsulfuron for Weed Control

Chlorsulfuron is a herbicide with promise for control of many broadleaf weeds and suppression of certain annual grasses in small grains. However, there are some problem weeds that are tolerant to this herbicide. Hageman and Behrens (1984) demonstrated that eastern black nightshade (Solanum nigrum) was not controlled by chlorsulfuron at rates up to 560 g/ha ai (active ingredient) , while at the same time velvetleaf (Abutilon theophrasti) was controlled by 22 g/ha. They reported a selectivity ratio between these two weed species of 29,298 to 1 when rates were applied to get equivalent dry weight reductions.

Broadleaf Control

When Ulrich and Miller (1983) applied 9, 18, and 35 g/ha in the spring, they found that chlorsulfuron provided 94 to 100 % control of wild mustard (Brassica kaber), redroot pigweed (Amaranthus retroflexus), Russian thistle (Salsola kali), and common lambsquarter (Chenopodium album). Kochia (Kochia scoparia) was controlled 81 to 100 %.

Foy and Mersie (1984) applied 10 g/ha to barley and wheat at the 2-3 leaf stage and reported excellent control of chickweed (Stellaria media), henbit (Lamium amplexicaule), mayweed (Anthemis cotula), wild geranium (Geranium maculatum), and cornflower (Centaurea cyanus). They also found that chlorsulfuron was superior to 2,4-D and bromoxynil in their effect on both chickweed and mayweed. Speedwell (Veronica officinalis) is moderately tolerant to the lower rates, and it required 40 g/ha to achieve adequate control.

Wild garlic (Allium vineale), derived from aerial bulblets, has been controlled by chlorsulfuron at rates as low as 10 g/ha, either fall or spring postemergent (Leys and

Slife, 1983, 1984). Wild garlic can be a serious problem in the humid winter wheat producing areas of the north central states (North Central Reg. Res. Pub. 281,1981). There is some question as to the best time of application for control. It appears that to control underground bulb production, at least 20 g/ha of chlorsulfuron must be applied fall postemergent. Aerial bulblets can be best reduced by a fall application of 10 g/ha or greater (Leys and Slife, 1983, 1984). A combination of warm spring temperatures and application at the stage of growth where there is depletion of old bulb reserves and early development of new bulbs, results in optimum herbicide activity (Leys and Slife, 1982). They reported close to 100% reduction in aerial bulblet, soft offset bulb, and hardshell bulb production by an application of chlorsulfuron at 20 g/ha. Retzinger and Kitchen (1984) reported 90-95% control of wild garlic by a preemergent application of 35 g/ha.

Chlorsulfuron has shown some promising effects on Canada thistle (*Cirsium arvense*). Donald (1983) studied the effect of 66 g/ha applied foliarly. He found that this treatment was more effective in inhibiting subsequent root growth when applied at the vegetative stage versus the flower or seed dispersal stages. The addition of a surfactant enhanced root bud injury, but had no effect on the inhibition of shoot growth. A soil-applied treatment had no effect on root fresh weight or root bud regrowth. Dyer and Fay (1983) found that chlorsulfuron applied at rates of 17, 35, and 70 g/ha to Canada thistle in the five leaf stage, reduced the number of stems/m^2 the following year by 23, 52, and 90 % respectively. Applications made in the bud stage were less effective. Henson and Zindahl (1983) applied 35, 70, and 140 g/ha to Canada thistle at four different growth stages. They found that to control 90% regrowth after 17 months on a soil with pH 7.7, an application after the spring rosette (pre-bud, flowering, or fall rosette), at the higher rates, was more successful for longer periods of time.

As mentioned earlier, Ulrich and Miller (1983) showed that Russian thistle can be quite susceptible to chlorsulfuron. Young and Gealy (1984) applied 17.5, 35, and 70 g/ha immediately after wheat harvest and found chlorsulfuron provided excellent control of this weed, even after one year. In a greenhouse study they found that the addition of a surfactant greatly enhanced control. Norwood (1982) reported excellent control of Russian thistle at 26 g/ha, and kochia with 8.7 g/ha, spring postemergent.

In tartary buckwheat (Fagopyrum tartarium) chlorsulfuron caused temporary growth inhibition , chlorosis, shrivelling of the stem below the cotyledonary node, and inhibition of stem elongation (Bestman and Vanden Born, 1983). They also found that the effect of chlorsulfuron on this weed was decreased as the leaf stage at time of application advanced from one to four.

Control of winter annuals appears to be more successful with a fall postemergent application than with a spring postemergent application (Khodayari et al., 1984). They reported excellent control of henbit, hairy vetch (Vicia villosa), and mustard species (Cruciferae spp.) with 17.5 and 35 g/ha fall postemergent. When the same species were evaluated at the same rates spring postemergent, poor control was reported.

Control of cow cockle (Vaccaria segetalis) was reported by Hunter (1982) to be very slow at rates of 20 to 80 g/ha. Considerable growth occurred as the plants slowly became chlorotic and were finally killed. Addition of a surfactant increased control and speed of kill. When applied to cow cockle at the 4 leaf stage, control with 5 g/ha with a surfactant was equivalent to 40 g/ha without a surfactant.

Excellent control of wild radish (Raphanus raphanistrum) was achieved by both 8.75 and 35 g/ha applied postemergent (Becke, 1984).

Grass Control

According to the "Glean" label, this herbicide has provided only suppression of grassy weed species. Suppression is defined in the label as "a visual reduction in weed competition (reduced population and/or vigor) as compared to an untreated area. Degree of suppression will vary with rate used, size of weeds, and environmental conditions following treatment." However there are exceptions. Miller and Nalewaja (1983) reported that chlorsulfuron at 30 g/ha provided good to excellent season long control of yellow and green foxtails (Setaria lutescens and S. viridis). Green foxtail was controlled 65 to 95 % by 9, 18, and 35 g/ha. When chlorsulfuron was applied preemergence at 35 g/ha, annual bluegrass (Poa annua) was controlled 90-95% (Haley et al., 1982). In a study on the response of some range grasses to chlorsulfuron, Davison et al. (1984) reported that 'Nordan' crested wheatgrass (Agropyron desertorum), Russian wildrye (Elymus junceus), and bermudagrass (Cynodon dactylon) were tolerant to preemergent or postemergent applications of chlorsulfuron, at rates ranging from 26.3 to 157.7 g/ha. The growth of 'Alta' tall fescue (Festuca arundinacae) and alkaligrass (Puccinellia distans) was reduced by the same rates, by both times of application. Response of alkali scanton (Sporoblus airoides) to the herbicide was variable and dependent on the rate and time of application.

Response of Wheat to Chlorsulfuron

Wheat has shown to be tolerant to chlorsulfuron at rates as high as 200 g/ha (Hunter, 1982; Peterson and McKelvey, 1984). Hunter (1982) reported that spring wheat seed weight, yield, and germination were unaffected by 200 g/ha. Brewster and Appleby (1983) reported that spring wheat was injured by rates of 35 to 560 g/ha. However, significant yield reductions were seen only at 280 g/ha. Leys and Slife (1982) and Young and Gealy (1984) reported this same general pattern with rates within the label recommendations. They saw visible injury to wheat, but no significant yield reductions. In fact, even though there was visible injury to the wheat, the latter reported an increased yield in spring wheat when compared to an untreated weedy area, because the herbicide treatment reduced the weed population. Dyer and Fay (1983) reported that 70 g/ha reduced plant height, number of tillers, seed per head, and crop yield in spring wheat. However, it has been reported that wheat is tolerant to chlorsulfuron when applied at label recommended rates (Miller and Nalewaja, 1983; Ulrich and Miller, 1983; Burkhart, Dyer, and Fay, 1984).

Response of Soybeans (*Glycine max* (L.) Merr.) and Grain Sorghum (*Sorghum bicolor* (L.) Moench) To Chlorsulfuron

Ulrich and Miller (1983) reported that soybean stand was reduced up to 41% when recropped 12 months after 9, 18, and 35 g/ha, on a soil with pH 7.6. Peterson and Arnold (1982) applied rates of 17, 34, and 68 g/ha and recropped one year later with five crops. They reported that soybean and grain sorghum dry weights per plant were reduced more than 50% at the lowest rate at one location. At a second location, there was no significant reduction in plant dry weight, even at the highest rate. They contributed the difference between locations to differences in soil pH and organic matter.

Chlorsulfuron has caused significant soybean injury and yield reduction when double-cropped after wheat (Kurtz and Jordan, 1983; Peters and McKelvey, 1984; Ritter and Harris, 1983; Leys and Slife, 1982). Kurtz and Jordan (1983) reported that chlorsulfuron at 35 and 70 g/ha applied preemergent, fall postemergent, and spring postemergent, caused significant reduction in vigor and yield of the subsequent soybean crop. Ritter and Harris (1983) reported 2 years of double-cropping research. In 1981, rates of 7 and 26 g/ha were applied to fully tillered wheat. Soybean injury was observed at both rates, but yield was reduced by only 26 g/ha. In 1982, rates of 7, 13, 26, and 39 g/ha were applied preemergent, at early tillering, and to fully tillered wheat. Soybeans were not injured, nor was yield significantly reduced by any rate, applied at any time. Leys and Slife (1982) applied 10, 20, 40, 60, and 120 g/ha fall and spring postemergent. In one study the soil had 6.2% organic matter and it took 40 g/ha to cause a yield reduction. Again on another soil with 3.9% organic matter, it took 20 g/ha to cause a yield reduction. On a soil with only 2.0% organic matter, it took only 10 g/ha to cause a yield reduction. They concluded that as the percent of organic matter goes up, so does the amount of chlorsulfuron it takes to cause a yield reduction.

There is a possibility that through genetic manipulation a plant could be made resistant to chlorsulfuron. 'Forrest' soybean variety, planted following wheat has shown good tolerance to chlorsulfuron when applied fall or spring postemergent to wheat at 17.5 or 35 g/ha (Khodayari, 1984).

It has been demonstrated that grain sorghum shows acceptable crop tolerance in the higher rainfall areas of the south central plains when planted the season following an application of chlorsulfuron (Johnson et al., 1983). Norwood (1982, 1983) applied rates of 12.5, 17.5, 26.25, 35, and 52.5 g/ha at jointing, and 17.5, and 35 g/ha after wheat harvest. Sorghum was planted 10 months later. On a soil with pH 6.8, all treatments caused injury, but injury was more severe from a combination of a jointing plus a post-harvest treatment. None of the treatments reduced the yield. On another soil, with pH 7.8, the same injury patterns were seen, but the combination treatments caused a yield reduction. This would indicate an increase in chlorsulfuron carryover as pH increases. Peterson and Arnold (1983) indicated a rapid increase in chlorsulfuron carryover as pH changes from 6 to 7.

MATERIALS AND METHODS

Field Plots for Weed Control Evaluation

The field studies were established at two locations in Kansas: at the Ashland Agronomy Farm on unit II near Manhattan and at the Harvey County Experiment Field south unit near Hesston. The herbicide treatments are shown in table 1. All rates in this text are expressed in terms of active ingredient, the amount of actual herbicide and not the amount of product. The soil at Ashland for both years of the study was a Reading silt loam (fine, mixed, mesic, Typic Argiudoll) with 2.0% organic matter and pH of 6.7. In 1982 the study at Hesston was on a Ladysmith silty clay loam (fine, montmorillonitic, mesic, Pachic Argiustoll) with 1.8% organic matter and pH of 5.6. In 1983 at Hesston the soil was a Geary silt loam (fine-silty, mixed, mesic, Udic Argiustoll) with 1.9% organic matter and pH of 5.3.

Ashland Agronomy Farm

Seed bed preparation at Ashland consisted of chisel plowing, followed by tilling with a power driven rotary tiller. The plot area was clean-tilled until planting. To prevent lodging, no fertilizer was applied. 'TAM 105' hard red winter wheat was planted both years, 2.5 cm deep, at a rate of 67 kg/ha. Vitavax treated seed was used to prevent fungal infections. A Tye drill with double disk openers was used. The plot area was 3 m wide and 9.2 m long, consisting of two drill swathes, six rows 20 cm apart, on 1.5 m centers.

In 1982 the wheat was planted and the preplant incorporated and preemergent treatments were applied on October 6. The fall postemergent treatments were applied on November 16, and the spring postemergent treatments were applied on April 18, 1983. On June 24 wheat heights were

Table 1. Herbicide Treatments

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied
1.	Chlorsulfuron	8.75	PPI
2.	Chlorsulfuron	8.75	PRE
3.	Chlorsulfuron	8.75	FP
4.	Chlorsulfuron	8.75	SP
5.	Chlorsulfuron	17.5	PPI
6.	Chlorsulfuron	17.5	PRE
7.	Chlorsulfuron	17.5	FP
8.	Chlorsulfuron	17.5	SP
9.	Chlorsulfuron	26.25	PPI
10.	Chlorsulfuron	26.25	PRE
11.	Chlorsulfuron	26.25	FP
12.	Chlorsulfuron	26.25	SP
13.	Chlorsulfuron	35.0	PPI
14.	Chlorsulfuron	35.0	PRE
15.	Chlorsulfuron	35.0	FP
16.	Chlorsulfuron	35.0	SP
17.	Chlorsulfuron	17.5-26.25	FP-SP
18.	Chlorsulfuron	26.25-17.5	FP-SP
19.	Metribuzin	420.0	FP
20.	2,4-D Amine	560.0	SP
21.	Bromoxynil	560.0	FP
22.	Dicamba	140.0	SP
23.	Metribuzin	560.0	SP
24.	No Treatment	--	--

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

recorded and on June 29 visual weed control ratings were made. The plots were harvested on July 6. In the experiment established in 1983, the wheat was planted and the preplant incorporated and preemergent treatments were applied on October 17. The fall postemergent treatments were applied on November 21, and the spring postemergent treatments were applied on May 9, 1984. On June 9 wheat heights were recorded, and on June 28 visual weed control ratings were made. The plots were harvested on July 2.

A compressed air, tractor mounted plot sprayer was used with flat fan nozzles spaced 51 cm apart and 46 cm high. The sprayer pressure was 1.2 kg/cm^2 calibrated for 188 L/ha output. A power driven rotary tiller was used to incorporate the preplant herbicide treatments. Wheat heights were taken by visually averaging the height of all plants in the plot. A Gleaner E combine modified for research plot work was used to harvest the grain. The wheat collected was weighed for yield. A grain sample was taken from each plot and a Dicky John grain analyzer measured the test weight and percent moisture. The yields were adjusted to 12.5% moisture for statistical analysis.

Harvey County Experiment Field

Seed bed preparation at Hesston consisted of cultivation with a tandem disc and a field cultivator as necessary to keep the plot area clean-tilled until planting. The study established in 1982 was top-dressed on March 10, 1983, with 45 kg/ha nitrogen as 34-0-0. Fertilizer was not necessary in the 1983 plot. 'Newton' hard red winter wheat was planted both years, 2.5 cm deep at rates of 67 and 81 kg/ha in 1982 and 1983, respectively. Vitavax treated seed was used to prevent fungal infection. The plot area was 3 m wide and 9.2 m long, consisting of two drill swathes, 7 rows 18 cm apart, on 1.5 m centers.

In 1982 the wheat was planted and the preplant incorporated and preemergent herbicide treatments were applied on October 5. The fall postemergent treatments were applied on December 7, and the spring postemergent treatments were applied on April 20, 1983. Visual weed control ratings were made on June 24, and the plots were harvested on July 5. In the experiment established in 1983, the wheat was planted and the preplant incorporated and the preemergent treatments were applied on October 20. The fall postemergent treatments were applied on November 21, and the spring postemergent treatments were applied on April 16, 1984. Visual weed control ratings were made on June 25, and the plots were harvested on July 3.

A compressed air, tractor mounted plot sprayer was used with flat fan nozzles spaced 51 cm appart and 46 cm high. The sprayer pressure was 1.2 kg/cm^2 calibrated at 188 L/ha output. A field cultivator was used to incorporate the preplant herbicide treatments. A Gleaner E combine modified for research plot work was used to harvest the grain. The wheat collected was weighed for yield determination. Percent moisture was measured from a grain sample taken from each plot, and yield was adjusted to 12.5% moisture for statistical analysis.

<u>Recropping After Wheat Treated with Chlorsulfuron</u>
<u>Ashland Agronomy Farm</u>

'Sparks' soybeans (semi-determinant, group 3 maturity) were planted on June 6, 1984, in the field plot that had been established in 1982. Seed bed preparation consisted of tilling twice with a power driven rotary tiller before planting. Soybeans were planted at a rate of 67 kg/ha, 2.5 cm deep with a John Deere Max-Emerge planter. Captan-Moly seed treatment was used to guard against fungal infection prior to emergence, to lubricate the seed as it was being planted, and to provide molybdenum for nodulation. Alachlor at 2.24 kg/ha and chloramben at 2.24 kg/ha were applied preemergent with a compressed air, tractor mounted plot sprayer, with flat fan nozzles calibrated for 188 L/ha. Soybean heights were taken by visually averaging the height of all plants in a plot on September 23, 1984. The plots were harvested on September 26 with a Gleaner E combine modified for research purposes. The grain collected was weighed for yield determination. A sample of the grain was used to determine the percent moisture and test weight using a Dicky John grain analyzer. The yield was adjusted to 13.0% moisture for statistical analysis.

Harvey County Experiment Field

'DK-46' grain sorghum was planted in the field plots established in 1982 on June 29, 1984. Due to severe chinch bug (*Bliss spp.*) damage, the experiment had to be replanted on July 11. Seed bed preparation consisted of tillage with a disc and field cultivator prior to planting. Nitrogen as ammonium nitrate was applied at 78 kg/ha on May 17. Grain sorghum was planted at a rate of 63 kg/ha, 2.5 cm deep with a White air planter. Carbofuran at 1.12 kg/ha was applied in the furrow at planting. Propachlor at 3.4 kg/ha and atrazine at 1.7 kg/ha were applied preemergent with a compressed air, tractor mounted plot sprayer with flat fan nozzles calibrated at 188 L/ha output. Grain sorghum heights and stand counts were taken on August 31. The experiment was harvested on November 5 with a Gleaner E combine modified for research purposes. The grain collected was weighed for yield, and the percent moisture was corrected to 12.5% moisture for statistical analysis.

Statistical Analysis of the Field Data

The statistical design of the field experiments was a randomized complete block with 3 blocks and 24 treatments.

The data were analyzed two ways with Statistical Analysis System. First, all 24 treatments were analyzed in a one-way factorial, the factor being the treatment. Second, the treatments that were one-time chlorsulfuron treatments were analyzed in a two-way factorial, with the factors being the rate and time of application. The Least Significant Difference multiple comparison method was used at the 5% significance level.

Greenhouse Recropping Experiments

Both years after wheat harvest soil samples were collected from each field-treated plot area from both locations. The samples were taken with a sod plug device, except in 1984 at Hesston where a small bucket auger was used due to hard soil conditions. The samples were taken to a depth of 15 cm and were 5 cm in diameter. Each plot area was sampled six times to make a total sample volume of ca 2 L. The samples were screened and stored below 2 C until they were used.

The samples from the plots at Ashland were collected on August 8, 1983, and July 2, 1984, from the study established the previous year respectively. The plots at Hesston were sampled on October 29, 1983, and July 11, 1984, from the study established the previous year respectively. The collection of the first set of samples at Hesston was delayed due to hard dry soil conditions.

Both 'Williams 82' soybeans and 'Funks GBR-623' grain sorghum were planted in the soil from both locations. Ten seeds were planted in each 2 L pot. Captan-Moly and Vitavax seed treatments were used on the soybeans and grain sorghum respectively. These were to protect against fungal infections. On January 9, 1984, grain sorghum was planted in the Hesston samples and cut February 7, and soybeans were planted in the Ashland samples on January 12 and cut February

10. After the plants were cut, the soils were screened again to remove previous plant roots. On February 10 soybeans were planted in the Hesston samples, and grain sorghum was planted February 13 in the Ashland samples; both were also cut 30 days after planting.

This procedure was repeated with the soil samples collected in 1984. Soybeans were planted in the Ashland samples, and grain sorghum was planted in the Hesston samples on August 27, 1984. However, excessive water applied to the soil surface inhibited germination of these two plantings. On September 27 soybeans were replanted in the Ashland samples, and grain sorghum was replanted in the Hesston soil samples on September 28. These were cut 30 days later on October 26 and 27, respectively. The soil samples were screened again to remove previous plant roots, and on October 30, soybeans were planted in the Hesston samples and grain sorghum was planted in the Ashland samples. These plants were cut 30 days later on November 29.

The greenhouse was maintained at 27 to 31 C, and no additional light was provided. The pots were subsurface irrigated to maintain adequate plant growth.

The plants were cut at the soil surface, one pot at a time. A paper bag was weighed just before the plants in a pot were cut then the plant sample was weighed in the bag. The fresh weight was determined by subtracting the weight of the bag from the weight of the bag with plant material. The plant samples were then oven dried for 48 h at 55 C. The dry weight was determined by subtracting the weight of the empty dry bag from the total dry weight with plant material.

Statistical Analysis of the Greenhouse Data

The statistical design of the greenhouse studies was completely random. Since the soil came from the plots treated in the field, there were three replications and 24 treatments. The sample origin location in the greenhouse was kept separate. Due to variation in germination between pots, an analysis of covariance was used, with the covariate being the number of plants in a pot. The data were analyzed two ways with Statistical Analysis System. First, all 24 treatments were analyzed in a one-way factorial, with the factor being the treatment. Second, the treatments that were one-time chlorsulfuron applications only were analyzed in a two-way factorial, with the factors being the rate and time of application. Least Significant Difference multiple comparison method was used at the 5% significance level.

RESULTS AND DISCUSSION

Field Plots for Weed Control Evaluation

Evaluations of chlorsulfuron for weed control were done at both locations in 1983 and 1984. The weed control ratings in all cases are expressed as the percent control, which is the percent of the weed that is not present in the plot that was removed by the herbicide treatment. This is achieved by comparing the herbicide treatment to the no treatment. Complete eradication is 100% control.

Ashland Agronomy Farm

The weed species evaluated in the first year were: common purslane (*Portulaca oleracea*), prickly lettuce (*Lactuca serriola*), common yellow woodsorrel (*Oxalis stricta*), common lambsquarter (*Chenopodium album*), smooth groundcherry (*Physalis subglabrata*), and smooth pigweed (*Amaranthus hybridus*). In the second year, the following weed species were evaluated: puncturevine (*Tribulus terrestris*), eastern black nightshade (*Solanum ptycanthum*), common yellow woodsorrel, and smooth pigweed. The weed populations were natural infestations and were light both years. It would appear that the winter annual wheat was competitive with the summer annual weeds. Wicks et al. (1983) evaluated many herbicides, including chlorsulfuron, for weed control in winter wheat. They reported that summer annual weeds cannot compete with a winter annual crop because they do not germinate soon enough to rise above the canopy.

Results obtained from both years of this study at Ashland showed that there were significant differences in the percent control of all weed species evaluated (Tables 2,3,4). However, there are no real trends in the data. In most cases the chlorsulfuron treatments gave better control than the standard wheat treatments. All herbicide treatments gave better control than the no treatment. When the chlorsulfuron treatments from the first year were partitioned into rate and time of application, it was found that the higher rates of 26.25 and 35 g/ha gave better control of common purslane and common yellow woodsorrel than the two lower rates. This same rate response was also observed in the second year by common yellow woodsorrel. Since this weed can be a annual or perennial, the higher rates should be used. Generally chlorsulfuron does not control perennial weeds, as exemplified by the lowered control of smooth groundcherry. Common purslane was controlled best in the first year by a spring application. There was no difference in the soil applied treatments, but the fall postemergent treatments gave the least control of this weed. These results would indicate that chlorsulfuron does control summer annual weeds.

The results obtained in the first year showed no crop injury, or reduction in grain yield or plant height, from any treatment (Table 5). Due to prolonged cool wet conditions after the wheat was planted in the second year, the wheat had less than 3 tillers when the fall postemergent treatments were applied. Because of these conditions, the metribuzin treatment caused slight injury by stunting and delaying wheat maturity (Table 6). The spring postemergent treatment of metribuzin also caused some stunting due to slow growing wheat. The injury was also evident by delayed maturity, with green kernels present at harvest. Heavy infestations of soil borne mosaic also caused yield reductions across all plots. However, there was no yield reduction caused by any treatment. Yield was not increased by lowered weed competition from any treatment.

Table 2. Percent control of common purslane, prickly lettuce, and common yellow woodsorrel at the Ashland Agronomy Farm - 1982/1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Copu	Prle	Yews
1.	Chlorsulfuron	8.75	PPI	90	97	95
2.	Chlorsulfuron	8.75	PRE	83	99	90
3.	Chlorsulfuron	8.75	FP	82	98	93
4.	Chlorsulfuron	8.75	SP	92	100	93
5.	Chlorsulfuron	17.5	PPI	87	98	87
6.	Chlorsulfuron	17.5	PRE	83	99	92
7.	Chlorsulfuron	17.5	FP	85	99	93
8.	Chlorsulfuron	17.5	SP	96	98	98
9.	Chlorsulfuron	26.25	PPI	91	100	95
10.	Chlorsulfuron	26.25	PRE	90	99	98
11.	Chlorsulfuron	26.25	FP	88	99	96
12.	Chlorsulfuron	26.25	SP	99	95	100
13.	Chlorsulfuron	35.0	PPI	97	100	99
14.	Chlorsulfuron	35.0	PRE	95	100	98
15.	Chlorsulfuron	35.0	FP	92	100	99
16.	Chlorsulfuron	35.0	SP	98	99	99
17.	Chlorsulfuron	17.5-26.25	FP-SP	85	99	95
18.	Chlorsulfuron	26.25-17.5	FP-SP	96	100	99
19.	Metribuzin	420.0	FP	97	88	86
20.	2,4-D Amine	560.0	SP	83	92	85
21.	Bromoxynil	560.0	FP	80	85	83
22.	Dicamba	140.0	SP	77	93	88
23.	Metribuzin	560.0	SP	98	99	100
24.	No Treatment	--	--	0	0	0
	LSD (.05)	--	--	8.5	5.2	9.4

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Sring Postemergent before the weeds are 3" tall

Table 3. Percent control of common lambsquarter, smooth groundcherry, and smooth pigweed at the Ashland Agronomy Farm - 1982/1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Colq	Smgc	Smpw
1.	Chlorsulfuron	8.75	PPI	100	92	86
2.	Chlorsulfuron	8.75	PRE	100	92	92
3.	Chlorsulfuron	8.75	FP	100	97	88
4.	Chlorsulfuron	8.75	SP	100	96	92
5.	Chlorsulfuron	17.5	PPI	100	92	93
6.	Chlorsulfuron	17.5	PRE	100	96	90
7.	Chlorsulfuron	17.5	FP	100	88	93
8.	Chlorsulfuron	17.5	SP	100	93	95
9.	Chlorsulfuron	26.25	PPI	100	98	95
10.	Chlorsulfuron	26.25	PRE	100	93	95
11.	Chlorsulfuron	26.25	FP	100	96	90
12.	Chlorsulfuron	26.25	SP	100	97	97
13.	Chlorsulfuron	35.0	PPI	100	92	77
14.	Chlorsulfuron	35.0	PRE	100	92	97
15.	Chlorsulfuron	35.0	FP	100	98	95
16.	Chlorsulfuron	35.0	SP	100	95	98
17.	Chlorsulfuron	17.5-26.25	FP-SP	100	96	91
18.	Chlorsulfuron	26.25-17.5	FP-SP	100	90	99
19.	Metribuzin	420.0	FP	100	90	98
20.	2,4-D Amine	560.0	SP	100	88	92
21.	Bromoxynil	560.0	FP	99	62	72
22.	Dicamba	140.0	SP	100	92	95
23.	Metribuzin	560.0	SP	100	93	98
24.	No Treatment	--	--	0	0	0
	LSD (.05)	--	--	.2	9.4	13.0

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 4. Percent control of common yellow woodsorrel, smooth pigweed, puncturevine, and eastern black nightshade at the Ashland Agronomy Farm - 1983/1984.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Yews	Smpw	Puvi	Ebns
1.	Chlorsulfuron	8.75	PPI	77	88	93	80
2.	Chlorsulfuron	8.75	PRE	53	89	93	80
3.	Chlorsulfuron	8.75	FP	70	72	97	63
4.	Chlorsulfuron	8.75	SP	80	83	98	78
5.	Chlorsulfuron	17.5	PPI	53	92	96	77
6.	Chlorsulfuron	17.5	PRE	75	75	83	65
7.	Chlorsulfuron	17.5	FP	53	90	60	75
8.	Chlorsulfuron	17.5	SP	98	75	86	40
9.	Chlorsulfuron	26.25	PPI	79	91	100	82
10.	Chlorsulfuron	26.25	PRE	92	73	95	58
11.	Chlorsulfuron	26.25	FP	85	83	98	72
12	Chlorsulfuron	26.25	SP	98	91	86	70
13.	Chlorsulfuron	35.0	PPI	93	93	77	70
14.	Chlorsulfuron	35.0	PRE	88	85	97	68
15.	Chlorsulfuron	35.0	FP	93	73	86	40
16.	Chlorsulfuron	35.0	SP	99	94	99	83
17.	Chlorsulfuron	17.5-26.25	FP-SP	66	98	99	85
18.	Chlorsulfuron	26.25-17.5	FP-SP	90	97	99	73
19.	Metribuzin	420.0	FP	98	72	70	62
20.	2,4-D Amine	560.0	SP	40	70	78	77
21.	Bromoxynil	560.0	FP	0	53	68	70
22.	Dicamba	140.0	SP	47	66	93	76
23.	Metribuzin	560.0	SP	98	88	82	68
24.	No Treatment	--	--	0	0	0	0
	LSD (.05)			39	27	29	27

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 5. Summary of the wheat response at the Ashland Agronomy Farm - 1982/1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Yield (kg/ha)	Height (cm)	Crop Injury (%)
1.	Chlorsulfuron	8.75	PPI	3440	95.9	0
2.	Chlorsulfuron	8.75	PRE	3470	92.3	0
3.	Chlorsulfuron	8.75	FP	2920	90.6	0
4.	Chlorsulfuron	8.75	SP	3090	94.1	0
5.	Chlorsulfuron	17.5	PPI	3420	94.1	0
6.	Chlorsulfuron	17.5	PRE	3100	91.6	0
7.	Chlorsulfuron	17.5	FP	3150	93.8	0
8.	Chlorsulfuron	17.5	SP	3140	90.8	0
9.	Chlorsulfuron	26.25	PPI	3180	93.8	0
10.	Chlorsulfuron	26.25	PRE	2860	93.8	0
11.	Chlorsulfuron	26.25	FP	3190	93.1	0
12.	Chlorsulfuron	26.25	SP	3400	93.8	0
13.	Chlorsulfuron	35.0	PPI	3290	93.1	0
14.	Chlorsulfuron	35.0	PRE	3290	94.8	0
15.	Chlorsulfuron	35.0	FP	3220	92.1	0
16.	Chlorsulfuron	35.0	SP	3160	92.3	0
17.	Chlorsulfuron	17.5-26.25	FP-SP	3030	92.1	0
18.	Chlorsulfuron	26.25-17.5	FP-SP	3080	91.6	0
19.	Metribuzin	420.0	FP	3000	92.3	0
20.	2,4-D Amine	560.0	SP	3100	92.3	0
21.	Bromoxynil	560.0	FP	3150	91.6	0
22.	Dicamba	140.0	SP	2950	91.0	0
23.	Metribuzin	560.0	SP	3130	95.0	0
24.	No Treatment	--	--	3090	91.4	0
	LSD (.05)	--	--	NS	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 6. Summary of the wheat response at the Ashland Agronomy Farm - 1983/1984

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Yield (kg/ha)	Height (cm)	Crop Injury (%)
1.	Chlorsulfuron	8.75	PPI	1350	71.3	0
2.	Chlorsulfuron	8.75	PRE	890	64.8	0
3.	Chlorsulfuron	8.75	FP	1640	74.9	0
4.	Chlorsulfuron	8.75	SP	1220	70.9	0
5.	Chlorsulfuron	17.5	PPI	1040	66.7	0
6.	Chlorsulfuron	17.5	PRE	1070	66.0	0
7.	Chlorsulfuron	17.5	FP	1170	70.3	0
8.	Chlorsulfuron	17.5	SP	990	71.3	0
9.	Chlorsulfuron	26.25	PPI	1160	69.2	0
10.	Chlorsulfuron	26.25	PRE	1250	71.8	0
11.	Chlorsulfuron	26.25	FP	1130	70.6	0
12.	Chlorsulfuron	26.25	SP	1340	70.6	0
13.	Chlorsulfuron	35.0	PPI	1080	69.3	0
14.	Chlorsulfuron	35.0	PRE	1030	67.9	0
15.	Chlorsulfuron	35.0	FP	1080	68.6	0
16.	Chlorsulfuron	35.0	SP	1320	72.9	0
17.	Chlorsulfuron	17.5-26.25	FP-SP	1330	74.2	0
18.	Chlorsulfuron	26.25-17.5	FP-SP	1260	69.9	0
19.	Metribuzin	420.0	FP	840	68.1	7.7
20.	2,4-D Amine	560.0	SP	1120	68.6	0
21.	Bromoxynil	560.0	FP	970	69.3	0
22.	Dicamba	140.0	SP	890	62.2	0
23.	Metribuzin	560.0	SP	820	66.8	10.2
24.	No Treatment	--	--	1060	70.5	0
	LSD (.05)	--	--	NS	NS	.85

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Harvey County Experiment Field

The evaluation of weed control at Hesston in the first year consisted of one rating for all broadleaf species present and one for all grass species present. The percent control of broadleaf weeds in the first year showed no differences by either method of analysis (Table 7). However, percent control of the grass species was significantly different. When the chlorsulfuron treatments were partitioned into rate and time of application, the fall postemergent applications controlled less grass then the spring postemergent or the soil applied treatments. There were no reductions in wheat yield from any treatment in the first year.

In the second year there were significant differences in the percent control of the following weeds: smooth pigweed, smooth groundcherry, Pennsylvania smartweed (Polygonum pensylvanicum), and puncturevine (Table 8). Chlorsulfuron generally controlled the summer annual weeds present better than the standard wheat treatments, and weed populations in all herbicide treatments were lower than in the no treatment.

There were no reductions in wheat yield from any of the treatments in the first year (Table 9). Because of the cool wet weather after planting in the second year, the fall postemergent treatments were applied to wheat with less than 3 tillers. Consequently the wheat was stunted and the stand was reduced by the metribuzin and bromoxynil treatments (Table 10). The spring postemergent treatment of metribuzin also caused slight injury because of slow growth in the wheat. The metribuzin and bromoxynil treatments significantly reduced wheat yield.

Loss of wheat plants in the metribuzin and bromoxynil treatments caused less competition for the weeds in these plots, and these treatments showed significantly less control of all the species evaluated. When the one-time chlorsulfuron treatments were partitioned into rate and time of application, the postemergent fall treatments gave less control of smooth pigweed when compared to the other times of application.

These observations would indicate that chlorsulfuron does control summer annual broadleaf weeds. In most cases this herbicide will provide better season-long control than bromoxynil, dicamba, 2,4-D, or metribuzin. The rate and time of application would be dictated by the weed species present and their populations. Our research has not indicated that one time of application is generally better than another for summer annual weed control. However, the time of application could be determined by the crop rotation sequences. A spring application would have less time to decompose and would give excellent summer annual weed control. If a susceptible crop is going to be recropped after wheat, a postemergent fall application would allow a longer recropping interval, thereby allowing more time for chlorsulfuron to decompose, and less risk of subsequent crop damage. If summer annual weeds are the problem, a postemergent spring application at the lower label recommended rates will provide ample weed control. If the weeds are winter annuals, then a postemergent fall application would provide better control, because the herbicide is applied before the weeds are very large, and before they have over-wintered (Khodayari et al., 1984). Perennial weeds, such as Canada thistle, smooth groundcherry, and sometimes common yellow woodsorrel, will generally require a higher rate (Donald, 1983; Dyer and Fay, 1983; Henson and Zindahl, 1983). Wild garlic appears to be an exception (Leys and Slife, 1983, 1984).

Chlorsulfuron did not reduce the yield of wheat at any rate or time of application in our research. We concluded that winter wheat is tolerant at the label recommended rates. Even the postemergent split treatments, which exceed the label recommendations, did not injure or reduce the yield of wheat. This is contrary to some findings (Peters and Mckelvey, 1984; Hunter, 1982), yet agrees with what others have found (Leys and Slife, 1983, 1984; Young and Gealy, 1984; Dyer and Fay, 1983).

As mentioned previously, none of the chlorsulfuron applications increased yield by reducing weed competition. This might lead some to ask whether a herbicide treatment is necessary for summer annual weed control in winter wheat. When weeds are not at least suppressed, they produce and disseminate seed thus multiplying. Herbicides are an integral part of any attempt to reduce the population of weed seeds in the soil (Anderson, 1977). If a herbicide is not used, even if the population of weed seed in the soil is minimal, harvesting can be hindered, grain contaminated, and the weed population is increased for subsequent recropping.

Table 7. Percent control of the broadleaf and grass weed species at the Harvey County Experiment Field - 1982/1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Bdlf	Grass
1.	Chlorsulfuron	8.75	PPI	99	100
2.	Chlorsulfuron	8.75	PRE	100	99
3.	Chlorsulfuron	8.75	FP	100	99
4.	Chlorsulfuron	8.75	SP	100	99
5.	Chlorsulfuron	17.5	PPI	100	99
6.	Chlorsulfuron	17.5	PRE	100	99
7.	Chlorsulfuron	17.5	FP	98	99
8.	Chlorsulfuron	17.5	SP	100	100
9.	Chlorsulfuron	26.25	PPI	100	99
10.	Chlorsulfuron	26.25	PRE	100	99
11.	Chlorsulfuron	26.25	FP	98	98
12.	Chlorsulfuron	26.25	SP	99	100
13.	Chlorsulfuron	35.0	PPI	100	100
14.	Chlorsulfuron	35.0	PRE	100	100
15.	Chlorsulfuron	35.0	FP	100	98
16.	Chlorsulfuron	35.0	SP	99	100
17.	Chlorsulfuron	17.5-26.25	FP-SP	100	99
18.	Chlorsulfuron	26.25-17.5	FP-SP	100	97
19.	Metribuzin	420.0	FP	100	100
20.	2,4-D Amine	560.0	SP	100	100
21.	Bromoxynil	560.0	FP	99	99
22.	Dicamba	140.0	SP	100	99
23.	Metribuzin	560.0	SP	100	100
24.	No Treatment	--	--	0	0
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 8. Percent control of smooth pigweed, puncturevine, smooth groundcherry, and Pennsylvania smartweed at the Harvey County Experiment Field - 1983/1984.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Smpw	Puvi	Smgc	Pesw
1.	Chlorsulfuron	8.75	PPI	100	99	99	100
2.	Chlorsulfuron	8.75	PRE	99	100	100	100
3.	Chlorsulfuron	8.75	FP	95	98	100	100
4.	Chlorsulfuron	8.75	SP	99	100	95	100
5.	Chlorsulfuron	17.5	PPI	99	100	100	100
6.	Chlorsulfuron	17.5	PRE	99	99	98	100
7.	Chlorsulfuron	17.5	FP	99	98	100	100
8.	Chlorsulfuron	17.5	SP	100	99	100	100
9.	Chlorsulfuron	26.25	PPI	99	100	100	100
10.	Chlorsulfuron	26.25	PRE	98	93	100	100
11.	Chlorsulfuron	26.25	FP	99	100	92	99
12.	Chlorsulfuron	26.25	SP	99	100	100	100
13.	Chlorsulfuron	35.0	PPI	100	99	99	99
14.	Chlorsulfuron	35.0	PRE	98	98	98	100
15.	Chlorsulfuron	35.0	FP	96	95	97	99
16.	Chlorsulfuron	35.0	SP	99	97	100	100
17.	Chlorsulfuron	17.5-26.25	FP-SP	100	100	100	100
18.	Chlorsulfuron	26.25-17.5	FP-SP	100	99	97	100
19.	Metribuzin	420.0	FP	27	43	65	100
20.	2,4-D Amine	560.0	SP	96	100	98	97
21.	Bromoxynil	560.0	FP	20	27	67	47
22.	Dicamba	140.0	SP	99	100	100	99
23.	Metribuzin	560.0	SP	100	99	99	100
24.	No Treatment	--	--	0	0	0	0
	LSD (.05)	--	--	14	22	20	15

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 9. Summary of the wheat response at the Harvey County Experiment Field - 1982/1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Yield (kg/ha)	Crop Injury (%)
1.	Chlorsulfuron	8.75	PPI	3210	0
2.	Chlorsulfuron	8.75	PRE	3280	0
3.	Chlorsulfuron	8.75	FP	3820	0
4.	Chlorsulfuron	8.75	SP	3720	0
5.	Chlorsulfuron	17.5	PPI	3300	0
6.	Chlorsulfuron	17.5	PRE	3630	0
7.	Chlorsulfuron	17.5	FP	3420	0
8.	Chlorsulfuron	17.5	SP	3580	0
9.	Chlorsulfuron	26.25	PPI	3730	0
10.	Chlorsulfuron	26.25	PRE	3690	0
11.	Chlorsulfuron	26.25	FP	3191	0
12.	Chlorsulfuron	26.25	SP	3380	0
13.	Chlorsulfuron	35.0	PPI	3360	0
14.	Chlorsulfuron	35.0	PRE	3160	0
15.	Chlorsulfuron	35.0	FP	3580	0
16.	Chlorsulfuron	35.0	SP	3890	0
17.	Chlorsulfuron	17.5-26.25	FP-SP	3160	0
18.	Chlorsulfuron	26.25-17.5	FP-SP	3420	0
19.	Metribuzin	420.0	FP	3000	0
20.	2,4-D Amine	560.0	SP	3390	0
21.	Bromoxynil	560.0	FP	3150	0
22.	Dicamba	140.0	SP	3700	0
23.	Metribuzin	560.0	SP	2990	0
24.	No Treatment	--	--	3836	0
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 10. Summary of the wheat response at the Harvey County Experiment Field - 1983/1984.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Yield (kg/ha)	Crop Injury (%)
1.	Chlorsulfuron	8.75	PPI	2820	0
2.	Chlorsulfuron	8.75	PRE	2950	0
3.	Chlorsulfuron	8.75	FP	2980	0
4.	Chlorsulfuron	8.75	SP	2530	0
5.	Chlorsulfuron	17.5	PPI	2780	0
6.	Chlorsulfuron	17.5	PRE	2590	0
7.	Chlorsulfuron	17.5	FP	2730	0
8.	Chlorsulfuron	17.5	SP	2820	0
9.	Chlorsulfuron	26.25	PPI	2530	0
10.	Chlorsulfuron	26.25	PRE	2560	0
11.	Chlorsulfuron	26.25	FP	2740	0
12.	Chlorsulfuron	26.25	SP	2710	0
13.	Chlorsulfuron	35.0	PPI	2090	0
14.	Chlorsulfuron	35.0	PRE	2650	0
15.	Chlorsulfuron	35.0	FP	2640	0
16.	Chlorsulfuron	35.0	SP	2730	0
17.	Chlorsulfuron	17.5-26.25	FP-SP	2770	0
18.	Chlorsulfuron	26.25-17.5	FP-SP	2720	0
19.	Metribuzin	420.0	FP	1610	55
20.	2,4-D Amine	560.0	SP	2940	0
21.	Bromoxynil	560.0	FP	1510	55
22.	Dicamba	140.0	SP	3140	0
23.	Metribuzin	560.0	SP	2490	0
24.	No Treatment	--	--	2940	0
	LSD (.05)	--	--	390	34

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Recropping After Wheat Treated With Chlorsulfuron

At both locations, recropping has been done after the chlorsulfuron studies established in 1982 to determine if there are any residual effects of the herbicide on the respective crops. The time interval from the last herbicide treatment to the date a succeeding crop is planted is the recropping interval. The recropping intervals were 14 months at Ashland with soybeans and 15 months at Harvey County with grain sorghum. That is the time interval from the spring postemergent applications to the dates of planting.

Ashland Agronomy Farm

The soybean yields in this study were reduced overall by dry, hot weather at flowering and pod set. The soybean yield, height, grain test weight, and moisture content in the grain were not reduced by any treatment (Table 11). From this research, it would appear that soybeans can be grown in rotation with winter wheat that has been treated with chlorsulfuron. Location with respect to soil and weather conditions plays an important role in the decomposition of chlorsulfuron, and hence recropping intervals. Peterson and Arnold (1982) applied rates of 17, 34, and 68 g/ha and recropped one year later with five crops. They reported soybean and grain sorghum dry weight per plant was reduced more than 50% at the lowest rate at one location. At a second location, there was no significant reduction in plant dry weight, even at the highest rate. They attributed the differences between locations to differences in soil pH and organic matter. In Kansas, not only would the soil pH and organic matter be an important consideration in determining the recropping interval, but also the rainfall. The amount of rainfall decreases dramatically from east to west in Kansas, and dryland soybeans could be seriously injured in western

Kansas. Fortunately the soybeans in western Kansas are grown under irrigation, so increased soil moisture might be the solution to shortening the recropping interval for soybeans. However, high soil pH in the range of 7-7.9 will still slow decomposition. Johnson et al. (1983) reported that soybeans are more sensitive to chlorsulfuron than grain sorghum; recropping with grain sorghum might be the most feasible option after wheat treated with chlorsulfuron in western Kansas.

Harvey County Experiment Field

Since the chinch bugs damaged the first planting, the second planting was delayed to the point that the grain sorghum had not matured before the first frost. This combined with hot and extremely dry growing conditions reduced the yields to almost nothing (Table 12). However, analysis on the number of plants per hectare and on the plant height showed no reduction from any treatment. From this information it would appear that yields probably would not have been reduced from these treatments. However, research results from others is variable due to location. As mentioned earlier, grain sorghum is less sensitive to chlorsulfuron than soybeans (Johnson et al. 1983). Norwood (1982, 1983) has reported grain sorghum injury without yield reduction on a soil with pH 6.8, but on a soil with pH 7.8, not only was there injury to the crop, but also yield reduction. The research by Norwood was done in western Kansas, where rainfall is half of what it is in eastern Kansas, and the soils tend to range 1-2 pH units higher. It would appear that in eastern Kansas, grain sorghum could be grown in rotation with winter wheat treated with chlorsulfuron.

Table 11. Effect of residual chlorsulfuron on soybean planted in the study established in 1982 at the Ashland Agronomy Farm - 1984.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Yield (kg/ha)	Height (cm)
1.	Chlorsulfuron	8.75	PPI	590	95.5
2.	Chlorsulfuron	8.75	PRE	910	95.5
3.	Chlorsulfuron	8.75	FP	840	95.5
4.	Chlorsulfuron	8.75	SP	920	93.2
5.	Chlorsulfuron	17.5	PPI	540	88.1
6.	Chlorsulfuron	17.5	PRE	730	93.2
7.	Chlorsulfuron	17.5	FP	810	91.4
8.	Chlorsulfuron	17.5	SP	650	95.0
9.	Chlorsulfuron	26.25	PPI	940	92.0
10.	Chlorsulfuron	26.25	PRE	620	95.0
11.	Chlorsulfuron	26.25	FP	620	92.7
12.	Chlorsulfuron	26.25	SP	790	92.5
13.	Chlorsulfuron	35.0	PPI	610	94.2
14.	Chlorsulfuron	35.0	PRE	540	94.5
15.	Chlorsulfuron	35.0	FP	1070	93.0
16.	Chlorsulfuron	35.0	SP	650	97.0
17.	Chlorsulfuron	17.5-26.25	FP-SP	330	90.1
18.	Chlorsulfuron	26.25-17.5	FP-SP	480	91.9
19.	Metribuzin	420.0	FP	690	94.0
20.	2,4-D Amine	560.0	SP	720	93.2
21.	Bromoxynil	560.0	FP	400	91.0
22.	Dicamba	140.0	SP	770	94.7
23.	Metribuzin	560.0	SP	620	93.5
24.	No Treatment	--	--	780	94.0
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 12. Effect of residual chlorsulfuron on grain sorghum planted in the study established in 1982 at the Harvey County Experiment Field - 1984.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Yield (kg/ha)	Plant Height (cm)	Plants per ha (1000's)
1.	Chlorsulfuron	8.75	PPI	40.3	50.8	17.47
2.	Chlorsulfuron	8.75	PRE	60.5	53.3	19.62
3.	Chlorsulfuron	8.75	FP	134.4	48.3	21.52
4.	Chlorsulfuron	8.75	SP	73.9	50.8	19.84
5.	Chlorsulfuron	17.5	PPI	73.9	53.3	20.09
6.	Chlorsulfuron	17.5	PRE	40.3	48.3	22.02
7.	Chlorsulfuron	17.5	FP	80.6	50.8	16.75
8.	Chlorsulfuron	17.5	SP	26.9	50.8	22.02
9.	Chlorsulfuron	26.25	PPI	73.9	53.3	21.52
10.	Chlorsulfuron	26.25	PRE	20.2	50.8	14.36
11.	Chlorsulfuron	26.25	FP	20.2	48.3	17.22
12.	Chlorsulfuron	26.25	SP	20.2	48.3	17.69
13.	Chlorsulfuron	35.0	PPI	94.1	50.8	21.05
14.	Chlorsulfuron	35.0	PRE	33.6	50.8	19.62
15.	Chlorsulfuron	35.0	FP	60.9	50.8	17.22
16.	Chlorsulfuron	35.0	SP	33.6	50.8	15.79
17.	Chlorsulfuron	17.5-26.25	FP-SP	26.9	48.3	23.45
18.	Chlorsulfuron	26.25-17.5	FP-SP	100.8	50.8	21.52
19.	Metribuzin	420.0	FP	73.9	50.8	24.17
20.	2,4-D Amine	560.0	SP	26.9	50.8	25.80
21.	Bromoxynil	560.0	FP	60.5	50.8	20.81
22.	Dicamba	140.0	SP	40.3	50.8	24.17
23.	Metribuzin	560.0	SP	47.1	48.3	20.81
24.	No Treatment	--	--	107.5	50.8	22.73
	LSD (.05)	--	--	NS	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Greenhouse Experiments

In the greenhouse experiments the recropping intervals ranged from 2 to 6 months because of different dates the soil samples were collected from the field plots. The recropping interval is the time from when the spring postemergent treatments were applied to the time a succeeding crop is planted. Because the soil samples were frozen until they were used in the greenhouse, the time from when the samples were collected from the field, to the time when they were used in the greenhouse, is not included in the recropping interval. Actually in this situation the soil samples collected in July and August were double-cropped, which implies recropping in the same growing season. Because of the variation in the number of plants that germinated in a given pot, an analysis of covariance was used. However, this did not eliminate the variation caused by the competition among plants in a pot. Therefore, an analysis of covariance was done on the mean dry weight per plant, and those means were the basis on which the conclusions were made.

From the soil samples collected in 1983, there was no growth reduction in either soybeans or grain sorghum, grown in soil from either location (Tables 13,14). Essentially the soybeans, which were first to be planted in the Ashland soil, were planted four months after the postemergent spring application. Essentially, in the Hesston soil, the grain sorghum was planted six months after the postemergent spring application.

The research on the second year soil samples show the same trends, with no reduction in growth from any treatment on either crop, in soil from either location (Tables 15,16). Essentially the soybeans, which were planted first in the Ashland soil, were planted less than two months after the postemergent spring applications. The grain sorghum, which was planted first in the Hesston soil, was planted essentially three months after the postemergent spring applications. We can conclude that the vegetative growth of soybeans or grain sorghum is not reduced when grown in soil removed after harvest from field treated plots. There has been no indication that soybeans or grain sorghum cannot be grown in rotation with winter wheat treated with chlorsulfuron.

Results from other studies are varied. Peterson and Arnold (1982, 1983) and Ritter and Harris (1983) planted soybeans after wheat treated with chlorsulfuron, and in two different years found opposite results. One year soybean yield was reduced and in another year, not even injury occurred. These results are dependant on the factors determining the rate of decomposition; soil pH, moisture content, organic matter, and temperature. Norwood (1982, 1983) saw yield reduction in grain sorghum planted 10 months after wheat on a soil with pH 7.8. When the same research was done on a soil with pH 6.8, there was no reduction in sorghum yield.

Due to wide variation in soil pH, moisture content, organic matter, and temperature, between years and locations, more research needs to be done on the decomposition of chlorsulfuron, and its effect on soybeans and grain sorghum.

Table 13. Mean dry weight per plant of soybean and grain sorghum, planted in soil collected from the Harvey County Experiment Field on October 29, 1983, from the field study established in 1982.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Soybean (g)	Grain Sorghum (g)
1.	Chlorsulfuron	8.75	PPI	.342	.194
2.	Chlorsulfuron	8.75	PRE	.365	.225
3.	Chlorsulfuron	8.75	FP	.397	.196
4.	Chlorsulfuron	8.75	SP	.427	.180
5.	Chlorsulfuron	17.5	PPI	.375	.168
6.	Chlorsulfuron	17.5	PRE	.393	.147
7.	Chlorsulfuron	17.5	FP	.392	.198
8.	Chlorsulfuron	17.5	SP	.417	.215
9.	Chlorsulfuron	26.25	PPI	.407	.181
10.	Chlorsulfuron	26.25	PRE	.341	.201
11.	Chlorsulfuron	26.25	FP	.374	.181
12.	Chlorsulfuron	26.25	SP	.374	.183
13.	Chlorsulfuron	35.0	PPI	.406	.216
14.	Chlorsulfuron	35.0	PRE	.384	.220
15.	Chlorsulfuron	35.0	FP	.487	.211
16.	Chlorsulfuron	35.0	SP	.371	.182
17.	Chlorsulfuron	17.5-26.25	FP-SP	.437	.167
18.	Chlorsulfuron	26.25-17.5	FP-SP	.341	.162
24.	No Treatment	--	--	.350	.184
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 14. Mean dry weight per plant of soybean and grain sorghum, planted in soil collected from the Ashland Agronomy Farm on August 8, 1983, from the field study established in 1982.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Soybean (g)	Grain Sorghum (g)
1.	Chlorsulfuron	8.75	PPI	.356	.094
2.	Chlorsulfuron	8.75	PRE	.329	.127
3.	Chlorsulfuron	8.75	FP	.397	.090
4.	Chlorsulfuron	8.75	SP	.310	.095
5.	Chlorsulfuron	17.5	PPI	.329	.099
6.	Chlorsulfuron	17.5	PRE	.319	.125
7.	Chlorsulfuron	17.5	FP	.342	.077
8.	Chlorsulfuron	17.5	SP	.335	.091
9.	Chlorsulfuron	26.25	PPI	.442	.096
10.	Chlorsulfuron	26.25	PRE	.303	.085
11.	Chlorsulfuron	26.25	FP	.362	.101
12.	Chlorsulfuron	26.25	SP	.264	.095
13.	Chlorsulfuron	35.0	PPI	.351	.086
14.	Chlorsulfuron	35.0	PRE	.334	.090
15.	Chlorsulfuron	35.0	FP	.328	.110
16.	Chlorsulfuron	35.0	SP	.347	.099
17.	Chlorsulfuron	17.5-26.25	FP-SP	.408	.106
18.	Chlorsulfuron	26.25-17.5	FP-SP	.346	.093
19.	Metribuzin	420.0	FP	.384	.189
20.	2,4-D Amine	560.0	SP	.353	.102
21.	Bromoxynil	560.0	FP	.321	.100
22.	Dicamba	140.0	SP	.397	.086
23.	Metribuzin	560.0	SP	.357	.106
24.	No Treatment	--	--	.276	.120
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 15. Mean dry weight per plant of soybean and grain sorghum, planted in soil collected from the Harvey County Experiment Field on July 11, 1984, from the field study established in 1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Soybean (g)	Grain Sorghum (g)
1.	Chlorsulfuron	8.75	PPI	.289	.444
2.	Chlorsulfuron	8.75	PRE	.371	.485
3.	Chlorsulfuron	8.75	FP	.343	.563
4.	Chlorsulfuron	8.75	SP	.284	.515
5.	Chlorsulfuron	17.5	PPI	.351	.463
6.	Chlorsulfuron	17.5	PRE	.347	.457
7.	Chlorsulfuron	17.5	FP	.363	.479
8.	Chlorsulfuron	17.5	SP	.377	.432
9.	Chlorsulfuron	26.25	PPI	.343	.530
10.	Chlorsulfuron	26.25	PRE	.365	.450
11.	Chlorsulfuron	26.25	FP	.367	.367
12.	Chlorsulfuron	26.25	SP	.340	.522
13.	Chlorsulfuron	35.0	PPI	.321	.601
14.	Chlorsulfuron	35.0	PRE	.360	.420
15.	Chlorsulfuron	35.0	FP	.340	.479
16.	Chlorsulfuron	35.0	SP	.379	.490
17.	Chlorsulfuron	17.5-26.25	FP-SP	.367	.549
18.	Chlorsulfuron	26.25-17.5	FP-SP	.318	.540
19.	Metribuzin	420.0	FP	.309	.445
20.	2,4-D Amine	560.0	SP	.397	.549
21.	Bromoxynil	560.0	FP	.342	.488
22.	Dicamba	140.0	SP	.324	.545
23.	Metribuzin	560.0	SP	.347	.720
24.	No Treatment	--	--	.342	.438
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 16. Mean dry weight per plant of soybean and grain sorghum, planted in soil collected from the Ashland Agronomy Farm on July 2, 1984, from the field study established in 1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Soybean (g)	Grain Sorghum (g)
1.	Chlorsulfuron	8.75	PPI	.887	.239
2.	Chlorsulfuron	8.75	PRE	.639	.171
3.	Chlorsulfuron	8.75	FP	.630	.237
4.	Chlorsulfuron	8.75	SP	.618	.215
5.	Chlorsulfuron	17.5	PPI	.668	.169
6.	Chlorsulfuron	17.5	PRE	.557	.183
7.	Chlorsulfuron	17.5	FP	.617	.235
8.	Chlorsulfuron	17.5	SP	.631	.132
9.	Chlorsulfuron	26.25	PPI	.759	.213
10.	Chlorsulfuron	26.25	PRE	.669	.168
11.	Chlorsulfuron	26.25	FP	.596	.247
12.	Chlorsulfuron	26.25	SP	.501	.193
13.	Chlorsulfuron	35.0	PPI	.584	.164
14.	Chlorsulfuron	35.0	PRE	.624	.359
15.	Chlorsulfuron	35.0	FP	.720	.207
16.	Chlorsulfuron	35.0	SP	.606	.231
17.	Chlorsulfuron	17.5-26.25	FP-SP	.673	.178
18.	Chlorsulfuron	26.25-17.5	FP-SP	.562	.168
19.	Metribuzin	420.0	FP	.556	.253
20.	2,4-D Amine	560.0	SP	.640	.261
21.	Bromoxynil	560.0	FP	.576	.249
22.	Dicamba	140.0	SP	.556	.174
23.	Metribuzin	560.0	SP	.612	.138
24.	No Treatment	--	--	.695	.193
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

SUMMARY

Applications of chlorsulfuron at 8.75, 17.5, 26.25, and 35 g/ha applied either preplant incorporated, preemergent, fall postemergent, spring postemergent, or postemergent split fall and spring provided good to excellent weed control. Also, chlorsulfuron almost always provided better weed control than the more commonly used herbicides it was compared to. Eastern black nightshade was not controlled by any of the treatments.

The yield of wheat was not reduced by any treatment in the first year. However, in the second year due to wet, cool weather conditions at the time of application, metribuzin at both locations, and bromoxynil at the Harvey County Experiment Field did reduce wheat yields. Consequently, chlorsulfuron appears to be a safe herbicide for use on wheat at the rates and times of application evaluated.

It would appear that at the two locations this research was conducted, chlorsulfuron carry-over may not be a problem. Neither soybeans at the Ashland Agronomy Farm nor grain sorghum at the Harvey County Experiment Field were injured, nor were yields reduced by residual chlorsulfuron. In this situation the recropping intervals were 14 and 15 months respectively. These observations were taken in one year only, but the second year should confirm these results.

There was no reduction in growth of soybeans or grain sorghum when planted in the greenhouse in soil removed after harvest from field treated plots. In this situation the recropping intervals ranged from 2-6 months. It would appear that chlorsulfuron decomposes rapidly under the optimum conditions of low soil pH, high soil moisture content, high soil temperature, and low soil organic matter content.

This research would indicate that chlorsulfuron is a safe, effective herbicide for broadleaf weed control in

wheat. The threat of injury to soybeans or grain sorghum as a result of residual chlorsulfuron can not be underestimated. Since there is a wide varation in soil types and their pH, and in the weather across the state of Kansas, more research needs to be done to study the effects of these conditions on the rate of decomposition of this herbicide. Possibly with more research, some of the recropping restrictions currently on the label can be removed.

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APPENDIX

Table 17. Mean fresh weight per plant of soybean and grain sorghum, planted in the soil collected from the Ashland Agronomy Farm on August 8, 1983, from the field study established in 1982.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Soybean (g)	Grain Sorghum (g)
1.	Chlorsulfuron	8.75	PPI	2.17	.627
2.	Chlorsulfuron	8.75	PRE	1.92	.809
3.	Chlorsulfuron	8.75	FP	2.33	.589
4.	Chlorsulfuron	8.75	SP	2.12	.607
5.	Chlorsulfuron	17.5	PPI	1.96	.675
6.	Chlorsulfuron	17.5	PRE	2.25	.789
7.	Chlorsulfuron	17.5	FP	2.05	.526
8.	Chlorsulfuron	17.5	SP	2.06	.621
9.	Chlorsulfuron	26.25	PPI	2.45	.709
10.	Chlorsulfuron	26.25	PRE	1.95	.599
11.	Chlorsulfuron	26.25	FP	2.19	.657
12.	Chlorsulfuron	26.25	SP	1.78	.664
13.	Chlorsulfuron	35.0	PPI	2.10	.587
14.	Chlorsulfuron	35.0	PRE	2.06	.623
15.	Chlorsulfuron	35.0	FP	2.02	.717
16.	Chlorsulfuron	35.0	SP	2.16	.668
17.	Chlorsulfuron	17.5-26.25	FP-SP	2.51	.700
18.	Chlorsulfuron	26.25-17.5	FP-SP	2.09	.615
19.	Metribuzin	420.0	FP	2.54	.651
20.	2,4-D Amine	560.0	SP	2.20	.619
21.	Bromoxynil	560.0	FP	2.05	.688
22.	Dicamba	140.0	SP	2.39	.641
23.	Metribuzin	560.0	SP	2.09	.725
24.	No Treatment	--	--	1.68	.781
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 18. Mean total fresh and dry weights of sorghum per pot, and the mean number of plants per pot, grown in soil collected from the Ashland Agronomy Farm on August 8, 1983, from the field study established in 1982.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Fresh Weight (g)	Dry Weight (g)	# of Plants
1.	Chlorsulfuron	8.75	PPI	6.08	.92	9.7
2.	Chlorsulfuron	8.75	PRE	7.28	1.15	9.0
3.	Chlorsulfuron	8.75	FP	5.50	.84	9.4
4.	Chlorsulfuron	8.75	SP	5.43	.84	9.0
5.	Chlorsulfuron	17.5	PPI	6.14	.91	9.0
6.	Chlorsulfuron	17.5	PRE	7.35	1.17	9.3
7.	Chlorsulfuron	17.5	FP	4.74	.69	9.0
8.	Chlorsulfuron	17.5	SP	6.01	.88	9.7
9.	Chlorsulfuron	26.25	PPI	6.38	.87	9.0
10.	Chlorsulfuron	26.25	PRE	5.58	.80	9.3
11.	Chlorsulfuron	26.25	FP	5.92	.92	9.0
12.	Chlorsulfuron	26.25	SP	5.26	.76	8.3
13.	Chlorsulfuron	35.0	PPI	5.47	.80	9.3
14.	Chlorsulfuron	35.0	PRE	5.61	.81	9.0
15.	Chlorsulfuron	35.0	FP	6.45	.97	9.0
16.	Chlorsulfuron	35.0	SP	6.43	.95	9.7
17.	Chlorsulfuron	17.5-26.25	FP-SP	5.81	.88	8.3
18.	Chlorsulfuron	26.25-17.5	FP-SP	5.76	.87	9.3
19.	Metribuzin	420.0	FP	5.61	.78	8.7
20.	2,4-D Amine	560.0	SP	5.57	.92	9.0
21.	Bromoxynil	560.0	FP	5.69	.82	8.3
22.	Dicamba	140.0	SP	5.96	.80	9.3
23.	Metribuzin	560.0	SP	5.97	.88	8.3
24.	No Treatment	--	--	7.25	1.12	9.3
	LSD (.05)	--	--	NS	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 19. Mean total fresh and dry weights of soybean per pot, and the mean number of plants per pot, grown in soil collected from the Ashland Agronomy Farm on August 8, 1983, from the field study established in 1982.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Fresh Weight (g)	Dry Weight (g)	# of Plants
1.	Chlorsulfuron	8.75	PPI	10.88	1.75	5.3
2.	Chlorsulfuron	8.75	PRE	10.03	1.72	5.3
3.	Chlorsulfuron	8.75	FP	12.63	2.07	5.7
4.	Chlorsulfuron	8.75	SP	7.70	1.12	3.7
5.	Chlorsulfuron	17.5	PPI	13.63	2.29	6.7
6.	Chlorsulfuron	17.5	PRE	8.65	1.11	4.0
7.	Chlorsulfuron	17.5	FP	9.81	1.67	4.7
8.	Chlorsulfuron	17.5	SP	10.69	1.74	4.7
9.	Chlorsulfuron	26.25	PPI	11.23	1.98	4.7
10.	Chlorsulfuron	26.25	PRE	12.38	1.93	6.3
11.	Chlorsulfuron	26.25	FP	6.67	1.13	3.0
12.	Chlorsulfuron	26.25	SP	8.23	1.19	4.7
13.	Chlorsulfuron	35.0	PPI	8.01	1.34	4.0
14.	Chlorsulfuron	35.0	PRE	10.63	1.76	5.3
15.	Chlorsulfuron	35.0	FP	8.51	1.32	3.7
16.	Chlorsulfuron	35.0	SP	10.71	1.71	5.3
17.	Chlorsulfuron	17.5-26.25	FP-SP	9.16	1.54	4.0
18.	Chlorsulfuron	26.25-17.5	FP-SP	10.59	1.75	5.0
19.	Metribuzin	420.0	FP	9.17	1.43	4.0
20.	2,4-D Amine	560.0	SP	10.99	1.77	5.0
21.	Bromoxynil	560.0	FP	7.69	1.22	4.0
22.	Dicamba	140.0	SP	9.66	1.62	4.3
23.	Metribuzin	560.0	SP	9.34	1.66	5.0
24.	No Treatment	--	--	8.50	1.42	5.3
	LSD (.05)	--	--	NS	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 20. Mean fresh weight per plant of soybean and grain sorghum, planted in the soil collected from the Ashland Agronomy Farm on July 2, 1984, from the field study established in 1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Soybean (g)	Grain Sorghum (g)
1.	Chlorsulfuron	8.75	PPI	5.51	1.59
2.	Chlorsulfuron	8.75	PRE	4.16	1.26
3.	Chlorsulfuron	8.75	FP	4.28	1.59
4.	Chlorsulfuron	8.75	SP	4.43	1.66
5.	Chlorsulfuron	17.5	PPI	4.06	1.07
6.	Chlorsulfuron	17.5	PRE	3.58	1.27
7.	Chlorsulfuron	17.5	FP	3.50	1.48
8.	Chlorsulfuron	17.5	SP	4.20	.91
9.	Chlorsulfuron	26.25	PPI	5.04	1.50
10.	Chlorsulfuron	26.25	PRE	4.03	1.21
11.	Chlorsulfuron	26.25	FP	4.02	1.66
12.	Chlorsulfuron	26.25	SP	2.91	1.42
13.	Chlorsulfuron	35.0	PPI	3.44	1.31
14.	Chlorsulfuron	35.0	PRE	3.40	1.84
15.	Chlorsulfuron	35.0	FP	4.64	1.40
16.	Chlorsulfuron	35.0	SP	3.11	1.64
17.	Chlorsulfuron	17.5-26.25	FP-SP	4.26	1.30
18.	Chlorsulfuron	26.25-17.5	FP-SP	3.46	1.05
19.	Metribuzin	420.0	FP	3.17	1.84
20.	2,4-D Amine	560.0	SP	3.78	1.94
21.	Bromoxynil	560.0	FP	5.11	1.95
22.	Dicamba	140.0	SP	3.37	1.21
23.	Metribuzin	560.0	SP	3.66	1.01
24.	No Treatment	--	--	4.17	1.29
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 21. Mean total fresh and dry weights of sorghum per pot, and the mean number of plants per pot, grown in soil collected from the Ashland Agronomy Farm on July 2, 1984, from the field study established in 1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Fresh Weight (g)	Dry Weight (g)	# of Plants
1.	Chlorsulfuron	8.75	PPI	12.90	1.97	8.3
2.	Chlorsulfuron	8.75	PRE	9.28	1.29	7.3
3.	Chlorsulfuron	8.75	FP	11.51	1.72	7.7
4.	Chlorsulfuron	8.75	SP	10.09	1.37	6.7
5.	Chlorsulfuron	17.5	PPI	9.68	1.51	9.0
6.	Chlorsulfuron	17.5	PRE	8.60	1.31	7.7
7.	Chlorsulfuron	17.5	FP	10.01	1.59	7.0
8.	Chlorsulfuron	17.5	SP	7.49	1.10	8.7
9.	Chlorsulfuron	26.25	PPI	8.19	1.17	6.0
10.	Chlorsulfuron	26.25	PRE	9.13	1.27	7.7
11.	Chlorsulfuron	26.25	FP	10.70	1.58	6.7
12.	Chlorsulfuron	26.25	SP	10.70	1.46	7.7
13.	Chlorsulfuron	35.0	PPI	10.03	1.45	9.0
14.	Chlorsulfuron	35.0	PRE	11.88	2.35	6.7
15.	Chlorsulfuron	35.0	F	10.70	1.86	9.0
16.	Chlorsulfuron	35.0	SP	10.70	1.46	7.7
17.	Chlorsulfuron	17.5-26.25	FP-SP	9.66	1.29	8.0
18.	Chlorsulfuron	26.25-17.5	FP-SP	7.94	1.28	7.7
19.	Metribuzin	420.0	FP	10.65	1.47	6.0
20.	2,4-D Amine	560.0	SP	11.02	1.51	6.3
21.	Bromoxynil	560.0	FP	12.87	1.60	7.0
22.	Dicamba	140.0	SP	9.51	1.37	8.0
23.	Metribuzin	560.0	SP	8.69	1.21	9.0
24.	No Treatment	--	--	9.05	1.35	7.0
	LSD (.05)	--	--	NS	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 22. Mean total fresh and dry weights of soybean per pot, and the mean number of plants per pot, grown in soil collected from the Ashland Agronomy Farm on July 2, 1984, from the field study established in 1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Fresh Weight (g)	Dry Weight (g)	# of Plants
1.	Chlorsulfuron	8.75	PPI	17.25	2.84	4.0
2.	Chlorsulfuron	8.75	PRE	21.15	3.33	5.3
3.	Chlorsulfuron	8.75	FP	25.36	3.74	6.0
4.	Chlorsulfuron	8.75	SP	26.30	3.82	6.3
5.	Chlorsulfuron	17.5	PPI	19.89	3.23	5.0
6.	Chlorsulfuron	17.5	PRE	19.71	3.04	5.7
7.	Chlorsulfuron	17.5	FP	19.43	3.38	5.7
8.	Chlorsulfuron	17.5	SP	19.46	2.98	5.0
9.	Chlorsulfuron	26.25	PPI	14.43	2.23	3.0
10.	Chlorsulfuron	26.25	PRE	18.77	3.03	5.0
11.	Chlorsulfuron	26.25	FP	22.82	3.39	5.7
12.	Chlorsulfuron	26.25	SP	21.22	3.65	7.3
13.	Chlorsulfuron	35.0	PPI	14.73	2.54	4.3
14.	Chlorsulfuron	35.0	PRE	16.73	3.13	5.7
15.	Chlorsulfuron	35.0	FP	21.51	3.33	4.7
16.	Chlorsulfuron	35.0	SP	19.14	3.59	6.3
17.	Chlorsulfuron	17.5-26.25	FP-SP	18.24	2.96	4.7
18.	Chlorsulfuron	26.25-17.5	FP-SP	12.77	2.07	3.7
19.	Metribuzin	420.0	FP	15.84	2.76	5.0
20.	2,4-D Amine	560.0	SP	19.36	3.19	5.3
21.	Bromoxynil	560.0	FP	23.12	3.81	6.7
22.	Dicamba	140.0	SP	17.97	2.99	5.3
23.	Metribuzin	560.0	SP	20.92	3.52	6.0
24.	No Treatment	--	--	21.33	3.59	5.3
	LSD (.05)	--	--	4.72	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 23. Mean fresh weight per plant of soybean and grain sorhgum, planted in soil collected from the Harvey County Experiment Field on October 29, 1983, from the field study established in 1982.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Soybean (g)	Grain Sorghum (g)
1.	Chlorsulfuron	8.75	PPI	1.72	1.50
2.	Chlorsulfuron	8.75	PRE	1.94	1.61
3.	Chlorsulfuron	8.75	FP	1.93	1.66
4.	Chlorsulfuron	8.75	SP	2.05	1.28
5.	Chlorsulfuron	17.5	PPI	1.92	1.40
6.	Chlorsulfuron	17.5	PRE	1.91	1.28
7.	Chlorsulfuron	17.5	FP	1.99	1.98
8.	Chlorsulfuron	17.5	SP	2.06	1.42
9.	Chlorsulfuron	26.25	PPI	2.02	1.41
10.	Chlorsulfuron	26.25	PRE	1.67	1.38
11.	Chlorsulfuron	26.25	FP	1.84	1.48
12.	Chlorsulfuron	26.25	SP	1.82	1.35
13.	Chlorsulfuron	35.0	PPI	1.91	1.73
14.	Chlorsulfuron	35.0	PRE	1.97	1.58
15.	Chlorsulfuron	35.0	FP	1.90	1.77
16.	Chlorsulfuron	35.0	SP	1.79	1.50
17.	Chlorsulfuron	17.5-26.25	FP-SP	2.23	1.59
18.	Chlorsulfuron	26.25-17.5	FP-SP	1.60	1.31
24.	No Treatment	--	--	1.69	1.39
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 24. Mean total fresh and dry weights of sorghum per pot, and the mean number of plants per pot, grown in soil collected from the Harvey County Experiment Field on October 29, 1983, from the field study established in 1982.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Fresh Weight (g)	Dry Weight (g)	# of Plants
1.	Chlorsulfuron	8.75	PPI	13.94	1.80	9.3
2.	Chlorsulfuron	8.75	PRE	13.99	1.87	9.0
3.	Chlorsulfuron	8.75	FP	15.38	1.82	9.3
4.	Chlorsulfuron	8.75	SP	11.78	1.49	9.3
5.	Chlorsulfuron	17.5	PPI	12.63	1.51	9.0
6.	Chlorsulfuron	17.5	PRE	12.50	1.28	8.7
7.	Chlorsulfuron	17.5	FP	15.57	1.84	9.3
8.	Chlorsulfuron	17.5	SP	13.27	1.78	9.3
9.	Chlorsulfuron	26.25	PPI	13.00	1.76	9.3
10.	Chlorsulfuron	26.25	PRE	13.19	1.81	9.7
11.	Chlorsulfuron	26.25	FP	13.26	1.63	9.0
12.	Chlorsulfuron	26.25	SP	12.92	1.70	9.7
13.	Chlorsulfuron	35.0	PPI	13.96	1.79	8.3
14.	Chlorsulfuron	35.0	PRE	15.34	1.98	9.7
15.	Chlorsulfuron	35.0	FP	14.80	1.96	8.3
16.	Chlorsulfuron	35.0	SP	12.92	1.64	8.7
17.	Chlorsulfuron	17.5-26.25	FP-SP	13.07	1.60	8.3
18.	Chlorsulfuron	26.25-17.5	FP-SP	11.80	1.46	9.0
24.	No Treatment	--	--	13.33	1.66	9.7
	LSD (.05)	--	--	NS	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 25. Mean total fresh and dry weights of soybean per pot, and the mean number of plants per pot, grown in soil collected from the Harvey County Experiment Field on October 29, 1983, from the field study established in 1982.

Trt #	Herbicide	Rate (g/ha ai)	When * Applied	Fresh Weight (g)	Dry Weight (g)	# of Plants
1.	Chlorsulfuron	8.75	PPI	11.52	2.29	6.7
2.	Chlorsulfuron	8.75	PRE	8.76	1.65	4.7
3.	Chlorsulfuron	8.75	FP	13.48	2.81	7.7
4.	Chlorsulfuron	8.75	SP	12.35	2.58	6.3
5.	Chlorsulfuron	17.5	PPI	10.83	2.13	5.6
6.	Chlorsulfuron	17.5	PRE	14.67	3.01	7.7
7.	Chlorsulfuron	17.5	FP	10.46	2.07	5.3
8.	Chlorsulfuron	17.5	SP	11.71	2.38	5.7
9.	Chlorsulfuron	26.25	PPI	10.44	2.13	5.7
10.	Chlorsulfuron	26.25	PRE	13.25	2.72	8.0
11.	Chlorsulfuron	26.25	FP	12.04	2.48	6.7
12.	Chlorsulfuron	26.25	SP	12.76	2.62	7.0
13.	Chlorsulfuron	35.0	PPI	11.40	2.43	6.0
14.	Chlorsulfuron	35.0	PRE	11.78	2.29	6.0
15.	Chlorsulfuron	35.0	FP	8.82	2.17	5.0
16.	Chlorsulfuron	35.0	SP	11.55	2.40	6.3
17.	Chlorsulfuron	17.5-26.25	FP-SP	11.56	2.19	5.0
18.	Chlorsulfuron	26.25-17.5	FP-SP	12.72	2.72	8.0
24.	No Treatment	--	--	10.17	2.11	6.0
	LSD (.05)	--	--	NS	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 26. Mean fresh weight per plant of soybean and grain sorhgum, planted in soil collected from the Harvey County Experiment Field on July 11, 1984, from the field study established in 1983.

Trt #	Herbicide	Rate (g/ha ai)	When * Applied	Soybeans (g)	Grain Sorghum (g)
1.	Chlorsulfuron	8.75	PPI	2.07	3.60
2.	Chlorsulfuron	8.75	PRE	2.50	3.51
3.	Chlorsulfuron	8.75	FP	2.11	4.29
4.	Chlorsulfuron	8.75	SP	1.94	4.46
5.	Chlorsulfuron	17.5	PPI	2.30	3.61
6.	Chlorsulfuron	17.5	PRE	2.34	3.61
7.	Chlorsulfuron	17.5	FP	2.64	3.47
8.	Chlorsulfuron	17.5	SP	2.67	3.38
9.	Chlorsulfuron	26.25	PPI	2.38	4.40
10.	Chlorsulfuron	26.25	PRE	2.36	3.52
11.	Chlorsulfuron	26.25	FP	2.57	2.89
12.	Chlorsulfuron	26.25	SP	2.40	4.26
13.	Chlorsulfuron	35.0	PPI	2.09	5.12
14.	Chlorsulfuron	35.0	PRE	2.35	3.30
15.	Chlorsulfuron	35.0	FP	2.31	3.46
16.	Chlorsulfuron	35.0	SP	2.37	3.87
17.	Chlorsulfuron	17.5-26.25	FP-SP	2.18	4.57
18.	Chlorsulfuron	26.25-17.5	FP-SP	2.03	3.91
19.	Metribuzin	420.0	FP	1.93	4.05
20.	2,4-D Amine	560.0	SP	2.26	3.98
21.	Bromoxynil	560.0	FP	2.19	3.79
22.	Dicamba	140.0	SP	2.22	4.28
23.	Metribuzin	560.0	SP	2.25	5.76
24.	No Treatment	--	--	2.20	3.34
	LSD (.05)	--	--	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 27. Mean total fresh and dry weights of sorghum per pot, and the mean number of plants per pot, grown in soil collected from the Harvey County Experiment Field on July 11, 1984, from the field study established in 1983.

Trt #	Herbicide	Rate (g/ha ai)	When * Applied	Fresh Weight (g)	Dry Weight (g)	# of Plants
1.	Chlorsulfuron	8.75	PPI	23.24	2.10	6.7
2.	Chlorsulfuron	8.75	PRE	26.45	3.64	8.7
3.	Chlorsulfuron	8.75	FP	28.66	3.74	6.6
4.	Chlorsulfuron	8.75	SP	29.26	3.47	7.0
5.	Chlorsulfuron	17.5	PPI	24.46	3.32	7.3
6.	Chlorsulfuron	17.5	PRE	32.59	5.18	9.0
7.	Chlorsulfuron	17.5	FP	28.86	4.00	8.3
8.	Chlorsulfuron	17.5	SP	25.19	3.25	7.7
9.	Chlorsulfuron	26.25	PPI	32.28	3.96	7.7
10.	Chlorsulfuron	26.25	PRE	26.41	3.43	7.7
11.	Chlorsulfuron	26.25	F	25.52	3.27	8.7
12.	Chlorsulfuron	26.25	SP	27.32	3.47	6.7
13.	Chlorsulfuron	35.0	PPI	26.64	3.16	5.3
14.	Chlorsulfuron	35.0	PRE	23.01	2.92	7.0
15.	Chlorsulfuron	35.0	FP	28.91	4.00	8.3
16.	Chlorsulfuron	35.0	SP	23.23	3.00	6.7
17.	Chlorsulfuron	17.5-26.25	FP-SP	26.48	3.19	6.0
18.	Chlorsulfuron	26.25-17.5	FP-SP	27.35	3.82	7.3
19.	Metribuzin	420.0	FP	29.35	3.23	7.3
20.	2,4-D Amine	560.0	SP	29.59	4.13	7.7
21.	Bromoxynil	560.0	FP	30.35	3.90	8.0
22.	Dicamba	140.0	SP	28.60	3.67	7.0
23.	Metribuzin	560.0	SP	26.94	3.40	5.0
24.	No Treatment	--	--	25.33	3.33	7.7
	LSD (.05)	--	--	NS	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

Table 28. Mean total fresh and dry weights of soybean per pot, and the mean number of plants per pot, grown in soil collected from the Harvey County Experiment Field on July 11, 1984, from the field study established in 1983.

Trt. #	Herbicide	Rate (g/ha ai)	When * Applied	Fresh Weight (g)	Dry Weight (g)	# of Plants
1.	Chlorsulfuron	8.75	PPI	7.60	1.09	3.7
2.	Chlorsulfuron	8.75	PRE	12.00	1.84	5.0
3.	Chlorsulfuron	8.75	FP	11.27	1.86	5.3
4.	Chlorsulfuron	8.75	SP	10.96	1.61	5.7
5.	Chlorsulfuron	17.5	PPI	10.69	1.62	4.7
6.	Chlorsulfuron	17.5	PRE	10.20	1.54	4.3
7.	Chlorsulfuron	17.5	FP	11.14	1.73	5.0
8.	Chlorsulfuron	17.5	SP	9.16	1.34	3.7
9.	Chlorsulfuron	26.25	PPI	5.58	.85	2.7
10.	Chlorsulfuron	26.25	PRE	13.41	2.07	5.7
11.	Chlorsulfuron	26.25	FP	8.52	1.26	3.3
12.	Chlorsulfuron	26.25	SP	12.75	1.80	5.3
13.	Chlorsulfuron	35.0	PPI	11.30	1.75	5.3
14.	Chlorsulfuron	35.0	PRE	12.45	1.91	5.3
15.	Chlorsulfuron	35.0	FP	9.49	1.41	4.3
16.	Chlorsulfuron	35.0	SP	10.21	1.63	4.4
17.	Chlorsulfuron	17.5-26.25	FP-SP	15.92	2.67	7.3
18.	Chlorsulfuron	26.25-17.5	FP-SP	12.53	2.00	6.3
19.	Metribuzin	420.0	FP	11.12	1.84	6.0
20.	2,4-D Amine	560.0	SP	12.85	2.26	5.7
21.	Bromoxynil	560.0	FP	11.81	1.85	5.3
22.	Dicamba	140.0	SP	12.06	1.83	5.7
23.	Metribuzin	560.0	SP	13.73	2.12	6.3
24.	No Treatment	--	--	10.87	1.70	5.0
	LSD (.05)	--	--	NS	NS	NS

* When Applied in respect to planting and plant development:

PPI-Preplant Incorporated

PRE-Preemergent to the wheat and weeds

FP-Fall Postemergent before the weeds are 2" tall

SP-Spring Postemergent before the weeds are 3" tall

EVALUATION OF CHLORSULFURON FOR WEED CONTROL IN WINTER WHEAT (TRITICUM AESTIVUM L.) AND ITS EFFECT ON SUBSEQUENT RECROPPING WITH SOYBEANS (GLYCINE MAX (L.) MERR.) OR GRAIN SORGHUM (SORGHUM BICOLOR (L.) MOENCH).

by

Michael Scott Leetch

B.S., Central Missouri State University, 1982

AN ABSTRACT OF A MASTER'S THESIS

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requirements for the degree

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Department of Agronomy

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Chlorsulfuron has some unique characteristics. This herbicide can inhibit cell division in susceptible plants at very low concentrations. Chlorsulfuron is persistent in the soil for up to 48 months, depending on soil pH, moisture content, organic matter, and temperature. The objectives of this research were: 1) to evaluate chlorsulfuron for weed control in winter wheat (*Triticum aestivum* L.), 2) to determine if soybeans (*Glycine max* (L.) Merr.) or grain sorghum (Sorghum bicolor (L.) Moench) can be grown in rotation with winter wheat treated with chlorsulfuron.

In 1982 and 1983, field experiments were established at the Ashland Agronomy Farm near Manhattan, Kansas, and at the Harvey County Experiment Field near Hesston, Kansas. Chlorsulfuron at rates of 8.75, 17.5, 26.25, 35 g/ha was applied preplant incorporated, preemergent, postemergent fall, and postemergent spring. Two postemergent split treatments were evaluated at 17.5-26.25 and 26.25-17.5 g/ha fall-spring. Also included were the following standard wheat treatments: metribuzin at 4.2 kg/ha postemergent fall and 5.6 kg/ha postemergent spring, 2,4-D at 5.6 kg/ha postemergent spring, bromoxynil at 5.6 kg/ha postemergent fall, and dicamba at 1.4 kg/ha postemergent spring. These treatments, as well as a no treatment, were used for comparisons.

The results showed better control of the annual broadleaved weeds evaluated from all the chlorsulfuron treatments than from any of the standard treatments. The rates of 26.25 and 35 kg/ha gave better control of common yellow woodsorrel (*Oxalis stricta* L.) than the lower rates. The data did not show any other significant trends. Chlorsulfuron did not reduce the yield of wheat; however, when metribuzin was applied before the wheat had 3 tillers in the second year, yield was reduced.

The same soil from these field plots was used for recropping research, both in the field and in the greenhouse.

The soil at Ashland had 2.0% organic matter and pH of 6.7, and at Hesston the soil had 1.8% organic matter and pH of 5.6. In the field, soybeans were planted in the Ashland plot established in 1982, 14 months after the spring postemergent treatments. Grain sorghum was planted in the Harvey county plot established in 1982, 15 months after the spring postemergent treatments. The statistical analysis showed no reduction in soybean or grain sorghum yield by any treatment. There was no injury to either crop.

Soil samples were collected from each plot in the field from both locations and recropped in the greenhouse. Soybeans and grain sorghum were planted in each sample, one at a time. The plants were grown for 30 days; then the fresh and dry weights of the plant material were measured. Because of variation in the dates the samples were collected, recropping intervals ranged from 2-6 months. Results showed no reduction in soybean or grain sorghum growth by any treatment.

Chlorsulfuron appears to control annual broadleaved weeds without injury or yield reduction to winter wheat. Soybeans or grain sorghum can be grown in rotation with winter wheat that has been treated with chlorsulfuron. However, more research needs to be done to study the effects of soil pH, rainfall, and organic matter on the rate of chlorsulfuron decomposition.