ACTIVITY OF SULFONYLUREA HERBICIDES ON THREE CULTIVARS OF OLD WORLD BLUESTEM SEEDLINGS (BOTHRIOCHLOA SPP.)

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INTRODUCTION

This thesis is a manuscript to be submitted for publication in Weed Science, the Journal of the Weed Science Society of America.

Activity of Sulfonylurea Herbicides on Three Cultivars of Old World Bluestem Seedlings (*Bothriochloa* Spp.)

Abstract. The effects of four sulfonylurea herbicides at five rates on Old World bluestem seedlings were compared in greenhouse experiments. Rates required to reduce seedling growth by 50% (GR_{50}) were calculated and the minimum rate for weed control of each herbicide were compared on three Old World bluestem cultivars. Herbicides evaluated included chlorsulfuron, metsulfuron, CGA-131036, and CGA-136872 and cultivars treated included Caucasian, Plains, and WW Spar. Postemergence and preemergence applications of the herbicide use rate of chlorsulfuron caused more reduction in all growth parameters measured than the herbicide use rate of metsulfuron. Caucasian was more tolerant to both herbicides than Plains and WW Spar. Preemergence GR_{50} values were closer to use rates for both metsulfuron and chlorsulfuron than postemergence GR_{50} values. The herbicide use rate of CGA-136872 caused more growth reduction than the herbicide use rate of CGA-131036. All cultivars responded similarly to CGA-136872 while Caucasian and Plains were more tolerant of CGA-131036. Metsulfuron and CGA-131036 caused less

growth reduction than either chlorsulfuron or CGA-136872.

Nomenclature: Bothriochloa ischaemum var. ischaemum (L.) Keng. 'Plains' # DIHIS[1]; Bothriochloa ischaemum var. ischaemum (L.) Keng. 'WW Spar'; Bothriochloa caucasica (Trin.) C.E. Hubbard 'Caucasian'; chlorsulfuron, 2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl] benzenesulfonamide; metsulfuron, 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl] amino]sulfonyl]benzoic acid; CGA-131036, N-(6-methoxy-4-methyl-1,3,5-triazin-2-yl-aminocarbonyl)-2-(2-chlorethoxy)-benzenesulfonamide; CGA-136872, 2-[[[[[4,6-bis(difluoromethoxy)-2-pyrimidinyl] amino]carbonyl]amino]sulfonyl] benzoic acid methyl ester.

Additional index words. Herbicide injury, growth reduction, forage grass seedlings, chlorsulfuron, metsulfuron, CGA- 131036, CGA-136872. Andropogon spp., DIHIS

INTRODUCTION

The Old World bluestems are an introduced forage grass species from Europe and Asia. Old World bluestems are regarded as desirable forage grasses for the Southern Great Plains due to their ability to withstand heavy grazing, their relative ease of establishment, responsiveness to high fertility levels, and the high forage and beef

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[1]Letters following this symbol are a WSSA-approved computer code from the Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark St., Champaign, IL 61820.

production potential of these grasses (6). In addition, the forage production of the Old World bluestems also fit well into an overall forage program in the Southern High Plains when used in combination with native range and wheat, Triticum aestivum L., pasture. It is estimated that 20 to 40 million acres in the Southern Great Plains could eventually be established to Old World bluestems (2).

The Old World bluestems are primarily being established on marginal cropland, cropland going into the Conservation Reserve Program (CRP), and for upgrading of ranges depleted of desirable grasses. In Oklahoma there are three cultivars which have been primarily used for these purposes. Caucasian came into use in the 1930's and was the first Old World bluestem to be widely planted. Plains was released in 1972 and is a blend of seed from 30 accessions from the mid-elevations of six different Asian countries (28). The third cultivar of importance in Oklahoma, WW Spar, is one of the accessions found in Plains that was released in 1982 (25).

Poor stands or complete stand failures are possible when grass seedlings have to compete with weeds (5, 7, 16, 17, 20). In western Oregon it is estimated that 15 to 20 percent of new grass plantings are plowed up due to poor stands resulting from weed competition (16). In those instances where the stands are not lost, stands are often weakened and forage yields are frequently reduced. When several warm-season grasses grew in competition with large crabgrass, Digitaria sanguinalis (L.) Scop., second year forage production was reduced 28 to 70 percent when compared to those grown in weed free conditions (5). No reduction in Plains bluestem stand counts due to competition from large crabgrass was found but this competition did significantly reduce sod reserves, tiller number, and tiller weight. Competition from green foxtail, Seteria viridis (L.)Beauv., and redroot pigweed, Amaranthus retroflexus L., reduced the stands and forage yields of several native warm-season forage grass species (20). Where weeds were controlled during the establishment phase of new grass plantings, increased forage yields and improved stands have been obtained (5, 7, 16, 17, 20, 21).

One of the barriers to increased plantings of the Old World bluestems and other forage grasses in the Southern Great Plains is that stand establishment of forage grasses is difficult and stand failures frequently occur. A survey of forage grass stand establishment from 1960-1962 found that 25 percent of the forage grass plantings in Oklahoma were failures (8). Environmental conditions were cited as playing the major role in determining the success of stand establishment. In the Southern Great Plains, one of the most limiting environmental conditions for establishment of forage grass plantings is adequate soil moisture.

Researchers have shown that when growth of weedy grass seedlings were compared to growth of forage grass seedlings,the weedy grass seedlings were more vigorous in seedling development than the forage grass seedlings (12, 23). Warm season forage grasses such as the Old World bluestems are panicoid type seedlings having an elongated subcoleoptile internode and a short coleoptile (10). This means that the permanent roots are formed near the soil surface. The permanent roots of blue grama, Bouteloua gracilis (H.B.K.) Laq. ex Steud., a warm-season forage grass, develop only when soil moisture is adequate close to the soil surface (13, 30). Therefore, it is critical that weeds be controlled so that sufficient soil moisture near the soil surface is available for development of a permanent root system. In addition to the competition for soil moisture, competition for light can occur between the desirable grass and the weedy grasses. Giant foxtail, Setaria faberi Herrm., had the highest leaf elongation rate, the shortest time interval between collaring of successive leaves, and obtained more total leaf area and weight than forage grasses such as Caucasian bluestem, switchgrass, Panicum virgatum L., indiangrass, Sorghastrum nutans (L.) Nash, and big bluestem, Andropogon geradii Vitman (23). Caucasian bluestem was found to have more tillers and develop faster morphologically than the other warm-season forage grass seedlings but had a slower leaf elongation rate and obtained a significantly lower total biomass than giant foxtail and the other forage grasses tested. Large crabgrass seedlings developed more leaves, had greater leaf area, and accumulated more dry matter than did Caucasian bluestem, big bluestem, indiangrass, and switchgrass seedlings (12). Caucasian bluestem developed more tillers and leaves when compared to the other forage grasses although indiangrass and switchgrass developed more leaf area and accumulated more dry matter. The more rapid vegetative growth of weed seedlings means that shading of forage grasses by weeds will result if weeds are present. When levels of total nonstructural carbohydrates were reduced by low light conditions the leaf and crown mass along with the length and mass of the adventitious roots were reduced in blue grama seedlings (29).

While some components of seedling vigor of the Old World bluestems may be greater than some of the native warm-season grasses, stand failures due to weed competition can still occur and be very costly to the producer. This means that some method of effective weed control which could increase the success of a planting of an Old World bluestem would be helpful. Herbicides have been used to successfully aid in the establishment of forage grass stands (3, 7, 16, 17, 20, 21). One obstacle in the use of herbicides for establishment of the Old World bluestems is that many herbicides which can safely be used on established stands of forage grasses may cause unacceptable damage when applied at the seedling stage of growth. Differing degrees of tolerance to various herbicides have been found in many different species of forage grass seedlings (3, 4, 7, 11, 20, 21, 26). Sideoats grama, Bouteloua curtipendula (Michx.) Torr., was injured by all preemergence applications of norea, N,N-dimethyl-N'-(octahydro-4,7-methano-1H-inden-5-yl)urea 3aα, 4α, 5α, 7α, 7aα-isomer, propazine, 6-chloro-N,-N'-bis(1-methylethyl)-1,3,5-triazine-2,4-diamine, and siduron, N-(2-methylcyclohexyl)-N'-phenylurea] (21). In addition, norea retarded seedling establishment of all species at the 2.2 kg/ha rate and siduron significantly reduced stand establishment of several Old World bluestems. Propazine did not reduce the seedling establishment of any species tested and siduron did not reduce stand establishment of switchgrass, big bluestem, and indiangrass. Kleingrass, Panicum coloratum L. tolerated preemergence applications of propazine and 2,4-D, (2,4-dichlorophenoxy)acetic acid, but was injured by preemergence applications of dicamba, 3,6-dichloro-2-methoxybenzoic acid; picloram, 4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid; tebuthiuron, N-[5-(1,1-Dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimethylurea; and hexazinone, 3-cyclohexyl-6-(dimethyl amino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione (4). However kleingrass seedlings did tolerate early postemergence applications of propazine, low rates of dicamba, picloram, and 2,4-D. Mature kleingrass was generally more tolerant to applications of herbicides than the seedlings(4). Switchgrass, prairie sandreed, Calamovilfa longifolia (Hook) Scribn., Caucasian bluestem, and Plains bluestem were found to be most tolerant to atrazine, 6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4 diamine, while indiangrass and little bluestem were intermediate in tolerance, and blue and sideoats grama were least tolerant (3). Reduction of radicle elongation occurred in buffalograss, Buchloe dactyloides (Nutt.) Engelm., sideoats grama, and switchgrass when seeds were germinated in petri dishes containing picloram but shoot elongation was not affected (26). Also, root production of some forage grass seedlings were reduced when seedlings were grown in soil containing picloram (27). Germination and plumule growth were reduced in sideoats grama and buffalograss by picloram, 2,4,5-T, (2,4,5-trichlorophenoxy) acetic acid, and triclopyr, [(3,5,6-trichloro-2-pyridinyl)oxy] acetic acid. Germination and plumule growth of blue grama was less affected by these herbicides. Chlopyralid, 3,6-dichloro-2-pyridinecarboxylic acid, did not significantly affect either germination or plumule growth of any of the forage grasses tested (11).

It is possible that some of the newer herbicides like the sulfonylurea herbicides could be used to aid in establishing the Old World bluestems, but very little is known about the response of the Old World bluestem seedlings to these herbicides. Both chlorsulfuron and metsulfuron are currently used in the Southern Great Plains to control annual broadleaf weeds as well as some annual grasses in small grains (15). The weed control use rate of chlorsulfuron in small grains varies from 13.2 to 30 g ai/ha while metsulfuron is usually applied at 4.2 g ai/ha. Two new sulfonylurea herbicides, CGA-131036 and CGA-136872, are currently under development and are showing good herbicidal activity. Activity of CGA-131036 on weeds is comparable to that of chlorsulfuron (15), with use rates ranging from 5 to 30 g ai/ha[2]. CGA-136872 has activity on certain perennial and annual grasses as well as some broadleaf weeds with use rates ranging from 20 to 60 g ai/ha[2]. The sulfonylurea herbicides are growth inhibitors that inhibit the enzyme acetolactate synthase which prevents the synthesis of the amino acids valine, leucine, and isoleucine (24). Chlorsulfuron has been found to control weeds such as Russian thistle, Salsola iberica Sennen and Pau, which could be present in plantings of Old World Bluestems (1, 31).

Some forage grasses have been damaged by the sulfonylurea herbicides (9, 14, 18, 19, 22). Tall fescue, Festuca arundinacea Schreb., and perennial ryegrass, Lolium perenne L., were found to be susceptible to applications of chlorsulfuron while other species such as Kentucky bluegrass,

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[2]Technical bulletin, Ciba-Geigy Corp., Greensboro, NC 27419.

Poa pratensis L., creeping bentgrass, *Agrostis stolonifera* L., quackgrass, *Agropyron repens* (L.)Beauv., and smooth bromegrass, *Bromus inermis* Leyss., were tolerant (9, 18, 19, 22). Applications of chlorsulfuron retarded growth of Kentucky bluegrass and prevented seedhead formation in tall fescue (19, 22). Metsulfuron and sulfometuron, 2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]benzoic acid, both sulfonylurea herbicides, were found to cause shortened internodes and leaf blades, and lower dry matter production of bermudagrass turf when used alone and in combination (12).

The objectives of this study were to evaluate the effects of the herbicidal rates of chlorsulfuron, metsulfuron, CGA-131036, and CGA-136872 on seedlings of three Old World bluestems cultivars and to determine what herbicide rate would reduce growth by 50%.

MATERIALS AND METHODS

Greenhouse experiments were conducted to measure the effects of the sulfonylurea herbicides, metsulfuron, chlorsulfuron, CGA-131036, and CGA-136872, on seedlings of three Old World bluestem cultivars. The cultivars used in all experiments included Plains, WW Spar, and Caucasian. Several preliminary experiments were conducted to establish reliable methods to grow the grass seedlings under greenhouse conditions, and to determine what rates of herbicides would be needed to cause approximately 50% reduction of growth. Greenhouse temperature was maintained at 24 ± 10 C,and natural illumination was supplemented with high-pressure sodium lights to provide a day length of 18 h. All Old World bluestem grass seedlings were grown in 990 ml extruded plastic cups 14 cm tall by 10.5 cm wide, which had nine holes per cup drilled into the bottom of each to facilitate watering from the bottom. The cups were filled with approximately 930 grams of air-dry Norge loam (Fine-silty, mixed, thermic, Udic Paleustolls). The physical and chemical characteristics of this soil are listed in Table 1. Seeds used in all experiments were treated with 2.6 g/kg of seed with captan, N-trichloromethylthio-4-cyclohexene-1,2-dicarboximide, for control of seedling diseases. Approximately 100 seeds were covered with 40 g of soil to a depth of 0.5 cm. A thin layer of vermiculite was then added on top of this to prevent excessive surface drying. The vermiculite was removed with compressed air after the seedlings had emerged from the soil. Each experiment was fertilized twice with 50 ml of a water soluble fertilizer containing 130 mg of N, 260 mg of P, and 130 mg of K. All herbicide treatments were applied to the grass seedlings by moving the cups to a spray platform and broadcast spraying over the cups with a compressed gas plot sprayer in a carrier volume of 187 L/ha at 276 kPa.

Experimental design utilized for all experiments was a split plot, with the main plots being Old World bluestem cultivars and subplots being herbicide treatments. Four replications of herbicide treatments were arranged in randomized complete blocks within cultivars. Chlorsulfuron and metsulfuron were evaluated in experiments separate from CGA-131036 and CGA-136872. Both preemergence and postemergence experiments were conducted with chlorsulfuron and metsulfuron but only postemergence experiments were conducted with CGA-131036 and CGA-136872. Each experiment was repeated.

The herbicide rates used included rates that would give at least a growth reduction of 50% (GR_{50}) based on preliminary studies. The term herbicide use rate in this paper refers to the lowest rate required to adequately control weeds for each herbicide. The GR_{50} values are estimates of the amount of herbicide in g ai/ha to reduce a specified growth parameter by 50%. The rates of each herbicide used are listed in Table 2.

Plant heights were taken once from the preemergence experiments and three times from the postemergence experiments. Dry weight of tops and roots of 10 plants were taken at termination of each experiment. Plant heights were taken at random from 10 seedlings/cup for each experiment. Heights were measured to the nearest mm by holding the leaves upright and measuring from the soil surface to the leaf tip. Plant weights were determined by washing all of the soil out of a cup with water. Ten seedlings were then randomly selected and cut at the soil surface and separated into tops and roots. The dry weight of the tops and roots of 10 seedlings were determined for each experiment after being oven dried at 40 C for 48 hours.

Postemergence Experiments. Approximately 100 seed were planted/cup to insure that an adequate number of seedlings would be present. The seedlings were thinned to 30 seedlings/cup 2 weeks after planting. Before the herbicide treatments were applied, cups were watered as needed from both the top and bottom. All herbicide treatments were applied to the grass seedlings when they were in the 3- to 4-leaf stage. A 0.25% v/v of nonionic surfactant[3] was added to the herbicide solution. Once the treatments were applied to the seedlings, they were only watered from the bottom for the next 4 days to prevent washing of herbicide from the leaves. After this 4 day period, the plants were again watered as needed, alternating between watering from the top and watering from the bottom.

Height measurements were taken prior to treatment, 14 days after treatment, and 2 days prior to harvesting tops and roots. Growth in height after treatment was then calculated by subtracting the heights prior to treatment

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[3]The surfactant was X-77, containing a mixture of alkylarylpolypolyoxyethylene glycols, free fatty acids, and isopropanol, produced by Chevron Chem. Co., Ortho Div., San Francisco, CA 94110.

from each height measurement. Weights of tops and roots from 10 plants in each pot were harvested 3 to 4 weeks after herbicide treatments.

Preemergence Experiments. Preemergence activity of metsulfuron and chlorsulfuron was also evaluated on all three cultivars. One hundred seeds/cup were planted and then the cups were watered immediately before herbicide treatments were applied. After the herbicide treatments were applied, 50 ml of water was sprinkled over each cup to move the herbicides into the soil. The cups were watered as needed by alternating watering from the top and from the bottom. Plant height measurements were taken once 40 days after the herbicide treatments were applied. Roots and tops were harvested 43 days after treatment.

The data from the herbicide use rate of each herbicide were pooled over the two experiments for each set of herbicides and subjected to an analysis of variance. GR_{50} values were calculated by using both the linear and quadratic terms from each regression equation.

RESULTS AND DISCUSSION

There were significant treatment by experiment interactions in chlorsulfuron and metsulfuron preemergence experiments for all growth parameters except root weights; therefore, the data are presented by experiment except for the root weights where they are pooled over experiments. The cultivar by herbicide interactions for heights and top weights in Experiment 1 were significant at the 5% level and are listed in Table 3. In both cases the interaction was attributed to the magnitude of the differences in response of the three cultivars to the two herbicides. Chlorsulfuron was more active on all three cultivars. The effect of the herbicide use rate of chlorsulfuron and metsulfuron on heights and top weight in Experiment 2 were similar (Table 4). However, chlorsulfuron did significantly reduce root weight more than metsulfuron (Table 4). Chlorsulfuron treated plants root weights were 10 mg/10 plants while metsulfuron treated plants root weights were 24 mg/10 plants. While chlorsulfuron reduced root weights less than metsulfuron the herbicide use rate of metsulfuron significantly reduced root weights when compared to untreated check plants. Untreated check plants had roots which weighed 32 mg/10 plants while plants treated with the herbicide use rate of metsulfuron had roots which weighed 23 mg/10 plants. This reduction in root growth by metsulfuron could affect the Old World bluestem seedlings ability to withstand drought or overwintering ability. Caucasian appears to more resistant to both herbicides. There was less growth inhibition of all parameters evaluated with Caucasian and these differences were significant for height in both experiments and for top weight in Experiment 1 (Tables 3, 4). For example, Caucasian treated with chlorsulfuron was 68 mm in height 40 days after treatment while WW Spar was 24 mm. Metsulfuron treated Caucasian was 169 mm tall 40 days after treatment while WW Spar was 58 mm. Top weight of Caucasian treated with chlorsulfuron was 43 mg/10 plants while WW Spar weighed 10 mg/10 plants. Caucasian generally had the highest GR_{50} values for both height and top weight in Experiment 1 (Tables 7, 8, 9). Little difference existed between GR_{50} values for herbicides and cultivars for both height and top weight for Experiment 2. (Tables 7, 8, 9).

There were significant treatment by experiment interactions for all growth parameters except for root weights in the chlorsulfuron and metsulfuron postemergence experiments; therefore, all data are presented by experiment except the root weights were pooled over experiments. Cultivar by herbicide interactions were only significant at the 5% level for growth in height 21 days after treatment in Experiment 2 (Table 3). This was again due to the magnitude of the differences among cultivar response to the two herbicides. The herbicide use rate of chlorsulfuron applied postemergence was definitely more phytotoxic than the herbicide use rate of metsulfuron. Chlorsulfuron significantly reduced growth of all growth parameters more than metsulfuron (Table 5). In Experiments 1 and 2 respectively, chlorsulfuron treated plants grew only 9 and 15 mm in height 21 days after treatment compared to 37 and 165 mm for metsulfuron. Top weights of chlorsulfuron treated plants were 24 mg/10 plants while metsulfuron treated plants were 73 mg/10 plants. Root weights for chlorsulfuron treated plants were 10 mg/10 plants compared to 42 mg/10 plants for metsulfuron. While metsulfuron reduced root growth less than chlorsulfuron, the herbicide use rate of metsulfuron did significantly reduce root weights when compared to the untreated check plants. Untreated check plants had roots which weighed 70 mg/10 plants while plants treated with the herbicide use rate of metsulfuron had roots which weighed 42 mg/10 plants. This reduction in root growth by metsulfuron could affect the Old World bluestems ability to withstand drought or overwintering ability. Caucasian was definitely the most tolerant of the three cultivars to postemergence applications of both herbicides. Height growth of Caucasian 21 days after treatment was 1.5 to 1.9 times that of Plains and 3.2 to 3.9 times that of WW Spar. Reduction in growth in height was observed to be primarily due to shortening of internode length with both herbicides. This was also noted by King and Rogers (14) in bermudagrass treated with sulfometuron and metsulfuon. There was also reddening of the leaves with chlorsulfuron treatments. Generally, GR_{50} values for both metsulfuron and chlorsulfuron were under the herbicide use rate for each herbicide (Tables 10, 11, 12, 13). While GR_{50} values are fairly similar for the two herbicides, it is important to remember that the herbicide use rate of chlorsulfuron is about three times greater than the herbicide use rate of metsulfuron.

Goatley et al. (9) noted that differences in foliar absorption and translocation, foliar metabolism, and root translocation between Kentucky bluegrass and tall fescue appeared to account for differences in activity of chlorsulfuron on tall fescue and Kentucky bluegrass. Caucasian was more tolerant to chlorsulfuron but it is doubtful that the mechanisms of foliar absorption, foliar translocation and foliar metabolism are having a significant effect since chlorsulfuron significantly reduced growth with both preemergence and postemergence applications.

Significant treatment by experiment interactions were found for only the two growth in height measurements for CGA-131036 and CGA-136872 postemergence experiments, so that information is presented by experiment while the top weights and root weights were pooled over experiments. No cultivar by herbicide interactions were found to be significant at the 5% level. The herbicide use rate of CGA-136872 was more phytotoxic than the herbicide use rate of CGA-131036. The main effect of herbicide was found to be significant for every growth parameter except for growth in height 14 days after treatment in Experiment 2. CGA-136872 treated plants grew from 8 to 10 mm in height 21 days after treatment while CGA-131036 treated plants grew 24 to 53 mm. Top weights for CGA-136872 treated plants were 36 mg/10 plants compared to CGA-131036 treated plants which weighed 76 mg/10 plants.

Root weights were 23 mg/10 plants for CGA-136872 treated plants while roots from CGA-131036 treated plants weighed 70 mg/10 plants. While the herbicide use rate of CGA-131036 reduced root weights less than CGA-136872, the herbicide use rate of CGA-131036 did significantly reduce root weights when compared to untreated check plants. Untreated check plants had roots which weighed 105 mg/10 plants while plants treated with the herbicide use rate of CGA-131036 had roots which weighed 69 mg/10 plants. There did not appear to be any real differences among cultivars in their response to the two sulfonylurea herbicides (Table 6). There were no differences among cultivars in root weight and height parameters at 14 days after treatment in Experiment 1 and at 21 days after treatment in Experiment 2. Where cultivar differences existed, Caucasian was the most tolerant cultivar for growth in height while Plains was the most tolerant for top weight. There was an extreme purpling of leaves associated with plants treated with CGA-136872. GR_{50} values were often very close or over the herbicide use rate for CGA-131036 (Tables 14, 15, 16, 17). GR_{50} values for CGA-136872 were usually lower than the herbicide use rate.

There appears to be differences in the selectivity of some of the sulfonylurea herbicides on Old World bluestem seedlings. Differences in cultivar response were seen with all herbicides except CGA-136872. In experiments involving chlorsulfuron and metsulfuron, Caucasian was generally the most tolerant and usually no significant differences existed between Plains and WW Spar. This was expected since WW Spar is an accession selected from Plains. Applications of sulfonylurea herbicides to Caucasian might result in less injury than if the sulfonylurea herbicides are applied to either Plains or WW Spar. All seedling growth measurements taken showed differences between the herbicides compared.

Growth in height measurements appeared to be a good response variable to measure in predicting activity of sulfonylurea herbicides on the Old World bluestems. There was less variation associated with height measurements than either top weights or root weights.

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Table 1. Physical and chemical characteristics of soil

Soil Property	Value
Soil Source	Stillwater
Textural Class	Loam
Percent Sand	39.2
Percent Silt	41.3
Percent Clay	19.5
Percent Organic Matter	3.3
pH	6.2

Table 2. Herbicide rates used in all experiments.

Herbicide	Rate				
	(g ai/ha)				
Chlorsulfuron	0	5.3	6.6	8.8	13.1[a]
Metsulfuron	0	4.2[a]	5.3	7.0	10.5
CGA-131036	0	10[a]	20	30	40
CGA-136872	0	20[a]	40	60	80

[a]Herbicide use rate-minimum rate for weed control.

Table 3. Cultivar by herbicide means for effects of herbicide use rate of chlorsulfuron and metsulfuron on seedling growth when applied preemergence and postemergence to three Old World bluestem cultivars[a].

Treatments	Preemergence Experiment 1: Height (40 days)	Preemergence Experiment 1: Top weight	Postemergence Experiment 2: Growth in height after treatment 21 days
	(mm)	(mg/10 plants)	(mm)
Cultivar by herbicide means			
Caucasian by Chlorsulfuron	68	43	42
Caucasian by Metsulfuron	169	83	230
Plains by Chlorsulfuron	28	13	3
Plains by Metsulfuron	78	39	179
WW Spar by Chlorsulfuron	24	10	2
WW Spar by Metsulfuron	58	27	86
LSD (0.05)[c]	15	9	21
LSD (0.05)[d]	19	12	26

[a]Herbicide use rate for chlorsulfuron was 13.1 g ai/ha and 4.2 g ai/ha for metsulfuron.

[b]Cultivar by herbicide interaction significant at 5% level.

[c]LSD to compare herbicides within a cultivar.

[d]LSD to compare herbicides between cultivars.

Table 4. Main effects[a] of herbicide use rate of chlorsulfuron and metsulfuron on seedling growth when applied preemergence to three Old World bluestem cultivars[b].

Treatments	Height (40 days)		Top weight		Root weight
	Experiment		Experiment		Pooled
	1[a]	2	1[a]	2	
	----(mm)----		----------(mg/10 plants)-------		
Main effects-cultivar[c]					
Caucasian	119a	70a	63a	29a	19a
Plains	53b	42b	26b	23a	15a
WW Spar	41b	35b	19b	23a	14a
Main effects-herbicide[c]					
Chlorsulfuron	40a	43a	22a	22a	10a
Metsulfuron	101b	54a	49b	28a	24b

[a]The cultivar by herbicide interactions for heights and top weights in Experiment 1 were significant at 5% level, so look at cultivar by herbicide interactions in Table 4.

[b]Herbicide use rate for chlorsulfuron was 13.1 g ai/ha and 4.2 g ai/ha for metsulfuron.

[c]Within each main effect, values followed by the same letter are not significantly different at the 5% level according to protected LSD test.

Table 5. Main effects[a] of herbicide use rate of chlorsulfuron and metsulfuron on seedling growth when applied postemergence to three Old World bluestem cultivars[b].

Treatments	Growth in height after treatment (14 days) Experiment 1	(14 days) Experiment 2	(21 Days) Experiment 1	(21 Days) Experiment 2[a]	Top weight Pooled	Root weight Pooled
	(mm)				(mg/10 plants)	
Main effects-cultivar[c]						
Caucasian	9a	60a	39a	136a	63a	28a
Plains	5a	24b	21b	91b	44b	26a
WW Spar	5a	16b	10b	43c	38b	23a
Main effects-herbicide[c]						
Chlorsulfuron	3a	11a	9a	15a	24a	10a
Metsulfuron	9b	59b	37b	165b	73b	42b

[a]The cultivar by herbicide interaction for heights in Experiment 2 was significant at 5% level, so look at cultivar by herbicide interactions in Table 4.

[b]Herbicide use rate for chlorsulfuron was 13.1 g ai/ha and 4.2 g ai/ha for metsulfuron.

[c]Within each main effect, values followed by the same letter are not significantly different at the 5% level according to protected LSD test.

Table 6. Main effects of herbicide use rate of CGA-131036 and CGA-136872 on seedling growth when applied postemergence to three Old World bluestem cultivars[a].

Treatments	Growth in height after treatment (14 days) Experiment 1	(14 days) Experiment 2	(21 days) Experiment 1	(21 days) Experiment 2	Top weight Pooled	Root weight Pooled
	(mm)				(mg/10 plants)	
Main effects-cultivar[b]						
Caucasian	27a	20a	38a	25a	35a	14a
Plains	17a	11b	28b	14a	83b	67a
WW Spar	23a	7b	30ab	10a	51a	53a
Main effects-herbicide[b]						
CGA-131036	36a	15a	53a	24a	76a	70a
CGA-136872	8b	9a	10b	8b	36b	23b

[a]Herbicide use rate for CGA-131036 was 10 g ai/ha and 20 g ai/ha for CGA-136872.

[b]Within each main effect, values followed by the same letter are not significantly different at the 5% level according to protected LSD test.

Table 7. GR_{50} values for response in height 40 days after treatment of three Old World bluestem cultivars to chlorsulfuron and metsulfuron applied preemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
Chlorsulfuron	Caucasian	7.5	.98	3.6	.92
	Plains	4.9	.96	3.2	.94
	WW Spar	2.0	.99	2.5	.92
Metsulfuron	Caucasian	10.8	.92	3.3	.90
	Plains	12.7	.94	4.2	.88
	WW Spar	4.3	.85	3.9	.79

[a]Estimate of herbicide rate in g ai/ha required to reduce plant growth in height 40 days after treatment by 50% compared to untreated check plants.

Table 8. GR_{50} values for response in top weight of three Old World bluestem cultivars to chlorsulfuron and metsulfuron applied preemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
Chlorsulfuron	Caucasian	5.3	.89	7.2	.81
	Plains	2.5	.97	6.4	.62
	WW Spar	2.0	.97	2.6	.74
Metsulfuron	Caucasian	6.5	.98	6.0	.84
	Plains	2.5	.95	6.2	.71
	WW Spar	4.9	.54	7.0	.68

[a]Estimate of herbicide rate in g ai/ha required to reduce plant top weights by 50% compared to untreated check plants.

Table 9. GR_{50} values for response in root weight of three Old World bluestem cultivars to chlorsulfuron and metsulfuron applied preemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
Chlorsulfuron	Caucasian	1.6	.97	7.0	.79
	Plains	2.4	.94	8.3	.43
	WW Spar	1.7	.99	3.9	.64
Metsulfuron	Caucasian	2.7	.85	2.4	.88
	Plains	6.1	.87	5.0	.93
	WW Spar	10.1	.32	10.5	.54

[a]Estimate of herbicide rate in g ai/ha required to reduce plant root weights by 50% compared to untreated check plants.

Table 10. GR_{50} values for growth in height 14 days after treatment of three Old World bluestem cultivars to chlorsulfuron and metsulfuron applied postemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
Chlorsulfuron	Caucasian	2.1	.95	2.8	.98
	Plains	2.1	.92	1.4	.99
	WW Spar	1.5	.97	1.5	.98
Metsulfuron	Caucasian	2.0	.69	4.3	.89
	Plains	2.0	.91	2.3	.93
	WW Spar	1.4	.99	1.3	.99

[a]Estimate of herbicide rate in g ai/ha required to reduce plant growth in height 14 days after treatment by 50% compared to untreated check plants.

Table 11. Growth in height after treatment GR_{50} values at termination of experiment for chlorsulfuron and metsulfuron applied postemergence on three Old World bluestem cultivars.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1[b]	R^2	Exp. 2[c]	R^2
		(g ai/ha)		(g ai/ha)	
Chlorsulfuron	Caucasian	2.3	.88	2.3	.98
	Plains	1.3	.98	1.3	.99
	WW Spar	1.3	.98	1.2	.98
Metsulfuron	Caucasian	2.3	.90	1.7	.90
	Plains	2.8	.97	3.3	.84
	WW Spar	1.3	.99	1.3	.98

[a]Estimate of herbicide rate in g ai/ha required to reduce plant growth in height after treatment at termination of experiment by 50% compared to untreated check plants.

[b]Growth calculated 21 days after treatment.

[c]Growth calculated 26 days after treatment.

Table 12. GR_{50} values for response in top weight of three Old World bluestem cultivars to chlorsulfuron and metsulfuron applied postemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
Chlorsulfuron	Caucasian	3.3	.96	2.7	.89
	Plains	2.6	.99	1.8	.97
	WW Spar	2.8	.99	1.6	.97
Metsulfuron	Caucasian	2.4	.81	3.3	.99
	Plains	9.4	.67	3.0	.86
	WW Spar	4.1	.96	2.4	.99

[a]Estimate of herbicide rate in g ai/ha required to reduce plant top weights by 50% compared to untreated check plants.

Table 13. GR_{50} values for response in root weight of three Old World bluestem cultivars to chlorsulfuron and metsulfuron applied postemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
Chlorsulfuron	Caucasian	1.6	.95	1.8	.90
	Plains	2.3	.97	1.6	.98
	WW Spar	2.0	.97	1.4	.97
Metsulfuron	Caucasian	2.4	.81	1.5	.90
	Plains	9.4	.67	2.0	.85
	WW Spar	4.1	.96	1.6	.96

[a]Estimate of herbicide rate in g ai/ha required to reduce plant root weights by 50% compared to untreated check plants.

Table 14. GR_{50} values for growth in height 14 days after treatment of three Old World bluestem cultivars to CGA-131036 and CGA-136872 applied postemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
CGA-131036	Caucasian	4.7	.93	6.2	.66
	Plains	18.5	.96	5.6	.98
	WW Spar	6.3	.96	4.4	.83
CGA-136872	Caucasian	6.6	.87	7.2	.91
	Plains	6.8	.89	8.3	.89
	WW Spar	7.8	.83	7.2	.92

[a]Estimate of herbicide rate in g ai/ha required to reduce plant growth in height 14 days after treatment by 50% compared to untreated check plants.

Table 15. GR_{50} values for growth in height 21 days after treatment of three Old World bluestem cultivars to CGA-131036 and CGA-136872 applied postemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
CGA-131036	Caucasian	3.1	.86	8.1	.67
	Plains	15.1	.97	4.8	.99
	WW Spar	3.8	.83	5.0	.91
CGA-136872	Caucasian	6.6	.87	6.9	.87
	Plains	6.3	.85	7.3	.92
	WW Spar	6.8	.84	7.7	.84

[a]Estimate of herbicide rate in g ai/ha required to reduce plant growth in height 21 days after treatment by 50% compared to untreated check plants.

Table 16. GR_{50} values for response in top weight of three Old World bluestem cultivars to CGA-131036 and CGA-136872 applied postemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
CGA-131036	Caucasian	7.2	.74	10.5	.44
	Plains	22.4	.85	42.1	.75
	WW Spar	10.0	.81	9.6	.71
CGA-136872	Caucasian	8.9	.89	10.1	.87
	Plains	80.8	.41	9.7	.90
	WW Spar	23.1	.81	14.7	.87

[a]Estimate of herbicide rate in g ai/ha required to reduce plant top weights by 50% compared to untreated check plants.

Table 17. GR_{50} values for response in root weight of three Old World bluestem cultivars to CGA-131036 and CGA-136872 applied postemergence.

		GR_{50}[a]			
Herbicide	Cultivar	Exp. 1	R^2	Exp. 2	R^2
		(g ai/ha)		(g ai/ha)	
CGA-131036	Caucasian	3.6	.85	4.0	.75
	Plains	18.3	.87	40.5	.47
	WW Spar	18.9	.87	9.7	.51
CGA-136872	Caucasian	6.9	.87	6.6	.86
	Plains	31.7	.99	7.4	.90
	WW Spar	13.6	.90	22.2	.39

[a]Estimate of herbicide rate in g ai/ha required to reduce plant root weights by 50% compared to untreated check plants.

VITA

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Candidate for the Degree of

Master of Science

Thesis: ACTIVITY OF SULFONYLUREA HERBICIDES ON THREE CULTIVARS OF OLD WORLD BLUESTEM SEEDLINGS (BOTHRIOCHLOA SPP.)

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