CHLORSULFURON (GLEAN) FOR CONTROL OF SHOOT GROWTH AND ROOT BUDS OF CANADA THISTLE

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Canada thistle [*Cirsium arvense* L. (Scop)] is a serious perennial weed because it spreads vegetatively by an extensive root system and forms new secondary shoots from root buds. It is a problem weed in the eastern half of North Dakota, although it also infests counties in the northwestern region of the state (5). In surveys conducted in 1978 and 1979, Canada thistle was estimated to infest 12 percent and 21 percent of farmland devoted to cereals in North Dakota, respectively.

Chlorsulfuron (tradename Glean)* is a herbicide that was recently introduced for selective control of broadleaf weeds and some grass weeds in cereals (8, 11). It belongs to a new structural class of herbicides that control many weeds at exceptionally low rates (0.14 -0.45 oz active ingredient per acre). Chlorsulfuron has both preemergence and postemergence activity, although slightly higher rates are needed for preemergence treatment. It is most effective as a postemergence treatment when applied to weeds between the two-leaf and tillering stages of cereals. Chlorsulfuron is unique in providing selective, season-long control of Canada thistle in cereals at rates of 0.49 to 0.95 active ingredient per acre (1, 2, 7, 9). Treatment of Canada thistle in the field at the rosette, prebud, and flowering stages provided greater than 90 percent control the following fall (7).

More information is needed on how chlorsulfuron affects Canada thistle shoot growth, root growth, and plant establishment from root buds in order to improve its efficacy in the field. It is especially critical to understand how foliar treatment with chlorsulfuron affects the growth and vigor of root buds because they help reestablish this perennial weed year after year. The goals of this greenhouse study were to answer several questions: (a) How quickly does foliarly applied chlorsulfuron stop parent shoot (aboveground) growth and secondary shoot development from root buds? (b) Can addition of surfactant to chlorsulfuron enhance its ability to reduce the outgrowth of root buds? (c) How much time must elapse after chlorsulfuron treatment before secondary shoot emergence is prevented or delayed? (d) Does the growth stage of Canada thistle at the time of spraying influence later control of secondary shoot emergence from root buds?

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General methods. Canada thistle plants were started in the greenhouse from 1.5 to 3.0 inch long root cuttings which were grown for 1.5 to 2 months in trays filled with fine vermiculite. The vermiculite was watered daily with ⅓ strength nutrient solution (3) or tap water. Uniform plants were selected and transplanted to potting soil to grow for an additional 1.5 to 2 months before herbicide treatment. Uniform, preselected plants were 24 to 28 inches tall when treated.

Foliar chlorsulfuron treatments were applied with a greenhouse hood sprayer. Commercially formulated chlorsulfuron (75 percent dry flowable) was applied at 0.95 oz active ingredient per acre plus 0.2 percent (v/v) nonionic oxysorbic surfactant (tradename Tween 80). The soil surface was covered with 1 inch of vermiculite to prevent herbicide from contacting the soil surface. The vermiculite was discarded after the spray had dried. In this way, plant response to shoot treatment could be studied alone without root uptake.

Roots were unearthed from pots one month after chlorsulfuron treatment, washed free of soil, weighed, and cut into 0.8 to 1.0 inch lengths. Roots were cut into segments to promote maximal secondary shoot sprouting. Root pieces were placed 0.5 inches deep in pots filled with fine vermiculite. Secondary shoots growing from root buds were counted five weeks after the roots were segmented. This new methodology provides a measure of the vigor of secondary shoot emergence, but may not adequately measure total root bud numbers, the proportion of viable, but dormant, buds, or bud death. Currently, there is no accepted procedure to measure bud death or dormancy.

Effects of surfactants. Treatments included an untreated control, chlorsulfuron alone, oxysorbic surfactant alone, and the combination of chlorsulfuron and surfactant. Roots of additional control plants were unearthed and segmented at the start of the experiment so that changes in root bud sprouting could be studied over time.

Time of exposure to chlorsulfuron. Plants were treated with chlorsulfuron plus surfactant or left unsprayed. Roots were harvested and segmented at the time of spraying and one, two and three weeks later. Emergence of secondary shoots was observed five weeks after each group of roots was segmented.

Effect of growth stage. Three growth stages of Canada thistle were either sprayed with foliar chlorsulfuron plus surfactant or left untreated for a total of six treatments. The three growth stages were small vegetative (22 to 30 leaves), large vegetative (35 to 45 leaves), and flowering (35 to 45 leaves). Large vegetative and flowering plants were comparable in height and leaf area at spraying.

Statistical analysis. All experiments were of a completely randomized design with nine to 11 plants per treatment. Data were subjected to analysis of variance and means were separated by Duncan's multiple range test. All experiments were repeated once or twice. The results are for one typical trial.

RESULTS AND DISCUSSION

Shoot injury symptoms. Foliar application of 0.95 oz active ingredient per acre chlorsulfuron plus surfactant to Canada thistle plants stopped main shoot growth immediately. However, visible damage to the topgrowth progressed slowly, taking up to two or three weeks to appear. Although young leaves remained turgid, they became yellow between one and two weeks after treatment, and leaf yellowing progressed up the stem. After the petioles became discolored and weakened, the lower leaves collapsed along the side of the stem. Death of the older leaves also progressed slowly up the stem. The topgrowth of larger, older plants was damaged more slowly than that of younger plants.

Effects of surfactant. For several reasons, it was advantageous to add surfactant to chlorsulfuron to control Canada thistle. Adding surfactant to chlorsulfuron hastened yellowing of Canada thistle shoots but did not reduce shoot growth any more than chlorsulfuron alone (Table 1). However, adding surfactant helped stop further root growth of Canada thistle. Plants treated with chlorsulfuron alone, without surfactant, formed more new roots and secondary shoots from root buds compared to the other treatments. The number of secondary shoots of these treated plants was reduced relatively more than was root fresh weight compared to the controls one month after spraying. The few secondary shoots that emerged following treatment grew normally, judging by their appearance and individual dry weight. Apparently, the herbicide did not interfere with the ability of root buds to tap stored food reserves in the root in order to grow.

Time of exposure to chlorsulfuron. It is important to know how quickly chlorsulfuron acts in order to properly time spraying in relation to field operations, such as fall tillage. Fresh weight of the control roots did not change, indicating the herbicide may have prevented new root growth soon after application.

Table 1. The effects of surfactant (0.2% v/v Tween 80) and chlorsulfuron (Glean) (0.95 oz ai/A) on shoot growth, root growth, and secondary shoot growth from root buds of segmented Canada thistle roots one month after shoot treatment. Means in a column followed by the same letter do not differ at $p = 0.05$ by Duncan's multiple range test.

Treatment	Shoot height increase after treatment		Root fresh weight per plant		Secondary shoots per plant 5 weeks after root segmentation	
	(in.)	(% of control plants)	(oz.)	(% of control plants)	(no.)	(% of control plants)
Control at time of spraying	—	—	1.35 cd	—	15 b	—
Control one month later	8.3 a	100	2.14 a	100	53 a	100
Surfactant	10.2 a	123	1.85 ab	85	42 a	80
Chlorsulfuron	3.8 b	46	1.65 bc	77	40 a	75
Chlorsulfuron + Surfactant	1.4 b	18	1.14 d	53	8 b	15

Secondary shoot formation also appeared to be stopped by chlorsulfuron soon after treatment (Figure 1). Control plants continued to form more secondary shoots over the course of three weeks before they were segmented. The results indicate that tillage operations should be delayed at least two weeks after treatment to allow the herbicide to act on root biomass and root buds.

Effect of growth stage. The response of Canada thistle to chlorsulfuron plus surfactant depended on growth stage. Chlorsulfuron stopped shoot growth and flowering of small vegetative plants shortly after treatment. However, shoots of large plants continued to grow to a limited extent following spraying.

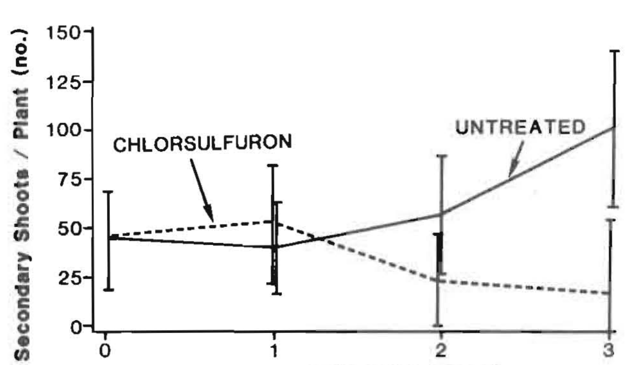

Figure 1. The effect of time after foliar treatment with chlorsulfuron (Glean) (0.95 oz ai/A) plus surfactant (0.2% v/v Tween 80) on the ability of secondary shoots to form from segmented roots of Canada thistle. Observations of secondary shoots were made five weeks after unearthing roots and cutting them into segments 0, 1, 2, and 3 weeks after foliar treatment. Means and standard deviations (vertical bars) are presented.

Large vegetative and flowering controls formed the same number of secondary shoots (Table 2). In contrast, fewer secondary shoots formed from small vegetative controls. Stage of growth at the time of treatment modified secondary shoot sprouting in response to chlorsulfuron (Table 2). Root fresh weight was reduced and secondary shoot numbers were only 10 and six percent of their respective controls for plants treated with chlorsulfuron at the small and large vegetative stages, respectively. Root biomass and root bud outgrowth of plants treated with chlorsulfuron at flowering were less affected than were those of large vegetative plants, despite similar leaf display. Pretreatment with chlorsulfuron delayed secondary shoot sprouting following segmentation irrespective of growth stage at spraying. Thus, chlorsulfuron controlled shoot growth, root growth, and secondary shoot emergence best when younger plants were sprayed compared to large vegetative or flowering Canada thistle plants.

Table 2. The effect of chlorsulfuron (Glean) (0.95 oz ai/A) plus surfactant (0.2% v/v Tween 80) and Canada thistle growth stage at the time of spraying on root fresh weight and secondary shoot emergence from buds of segmented Canada thistle roots one month after shoot treatment. Means followed in a column followed by the same letter do not differ at p = 0.05 by Duncan's multiple range test.

Treatment	Root fresh weight per plant		Secondary shoots per plant 5 weeks after root segmentation	
	(oz.)	(% of control plants)	(no.)	(% of control plants)
Control				
Small vegetative	2.1 c	—	42 b	—
Large vegetative	3.1 ab	—	78 a	—
Flowering	3.5 a	—	72 a	—
Chlorsulfuron + surfactant				
Small vegetative	0.6 d	30	4 c	10
Large vegetative	0.6 d	23	4 c	6
Flowering	2.7 bc	77	37 b	51

The results show that chlorsulfuron controls the topgrowth of Canada thistle. Smaller, younger plants were more easily and quickly suppressed than larger, older plants. Addition of nonionic surfactant improved suppression of root growth and secondary shoots by chlorsulfuron. Herbicide uptake into Canada thistle leaves may be limited without surfactant. Because the herbicide did not reduce root fresh weight or kill existing root buds, a single application will not eradicate this perennial weed. Higher application rates of chlorsulfuron cannot be used in the field to improve long term control of Canada thistle because of the herbicide's persistence in the soil and the potential for carryover injury to susceptible rotational crops (4, 10, 12). Although recommended registered rates (0.14 to 0.45 oz active ingredient per acre) provided selective weed control in cereals, herbicide residues may persist in the soil from one growing season to the next and damage susceptible rotational crops (10, 11). Sunflower (*Helianthus annuus* L.), sugarbeets (*Beta vulgaris* L.), and dry beans (*Phaselous vulgaris* L.) are only a few examples of rotational crops that can be injured by carryover of rates as low as 0.45 oz active ingredient per acre applied to cereals in the previous growing season (3, 10, 12). Its' persistence may limit the use of this herbicide.

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