Canada Thistle Control and Competition in Sugarbeets

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ABSTRACT

Canada thistle *(Cirsium arvense* (L.) Scop.) is an aggressive perennial weed found in sugarbeet *(Beta vulgaris* L.) fields throughout the northern half of the United States. Field trials were conducted at Powell, WY from 1988 to 1991 to evaluate the effectiveness of clopyralid (3,6-dichloro-2-pyridine carboxylic acid) for Canada thistle control in sugarbeet and to evaluate the effect of several Canada thistle densities on sugarbeet yield and sucrose percentage. Clopyralid provided good (83 to 89%] control of Canada thistle at 210 g ae/ha whether applied as a single or split treatment, alone or in combination with desmedipham (ethyl[3-[[(phenylamino)carbonyl]oxy]phenyl] carbamate) plus phenmedipham (3-[(methoxy carbonyl)amino]phenyl-(3-methylphenyl)carbamate) when at least half the rate of clopyralid was applied after all Canada thistle rosettes had emerged. Sugarbeet yield, sucrose percentage and grower net returns decreased as Canada thistle density increased. Each one thousand Canada thistle shoots/ha reduced root yield by 0.4 Mg/ha, sucrose content by 0.01% and grower net returns by $19.02/ha.

Additional Key Words: Yield, sucrose, crop tolerance, stand, *Cirsium arvense, Beta vulgaris.*

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Canada thistle is a serious weed problem in the northern United States and southern Canada (Donald, 1990; Hodgson, 1968). Canada thistle's range is estimated to cover 9,770,000 km^2 in North America extending 2090 km north to south and 470 km east to west (Erickson, 1983). The northern extent of Canada thistle is 59°N in Canada and its southern limit 40°N in the United States (Erickson, 1983). It is well adapted to temperate regions, those with moderate summer temperatures and moderate rainfall (45 to 90 cm/yr) (Hodgson, 1968).

Canada thistle is an aggressive perennial with an extensive spreading root system (Amor and Harris, 1975; Hayden, 1934). Adventitious buds arise from its roots to form new shoots (Hamdoun, 1972; Hayden, 1934); this is the primary method of propagation for Canada thistle after seedling establishment (Hodgson, 1955). Canada thistle shoot densities seldom exceed 60 m^{-2} (Donald, 1990; Hodgson, 1968).

Clopyralid has excellent activity on Canada thistle and holds promise for postemergence Canada thistle management in a wide range of crops including sugarbeets (Alley, 1976; Curtis and Haagsma, 1986; Lake 1980). Canada thistle stands in cereals have reportedly been reduced 80 to 85% or more following clopyralid applications at 100 to 140 g ae/ha (Curtis and Haagsma, 1986). In contrast, control in vegetables or other crops that form a canopy slowly has been less than that in cereals (Lake,1980), possibly because of prolonged periods of shoot emergence. In such situations sequential or split treatments of clopyralid have been more effective (Lake, 1980).

Canada thistle competition has been evaluated in a number of crops including winter and spring wheat *(Triticum aestivum* L.) (Hodgson, 1955 and 1968; Peschken et al, 1980), barley *(Hordeum vulgare* L.) (Hodgson, 1955; O'Sullivan et al, 1982), oats *(Avena sativa* L.) (Hodgson, 1955), rapeseed *(Brassica napus* L.) (O'Sullivan, Weiss and Kossatz, 1985) and alfalfa *(Medicago sativa* L.) (Schreiber, 1967) but not sugarbeets. Yield loss in these crops appears to be best modeled as a linear function of Canada thistle shoot density (Donald, 1990). Total shoot density appears to be more closely correlated with barley yield than shoot dry weight or flowering shoot density (O'Sullivan et al, 1982).

The objectives of this research were to a) determine the effectiveness of clopyralid for Canada thistle control when applied as a single or split treatment alone or in combination with desmedipham plus phenmedipham, and b) determine the influence of several Canada thistle densities on sugarbeet yield and sucrose percentage.

MATERIALS AND METHODS

Field experiments were conducted in 1989, 1990, and 1991 at the Research and Extension Center, Powell, WY on a Garland clay loam soil (fine, mixed Mesic, Typic Haplargid) with pH 7.7 and 1.4% organic matter. All studies were conducted in areas naturally infested with Canada thistle (average shoot density 60,000/ha). Sugarbeet 'MonoHy R2' was seeded to stand (138,000 seed/ha) in 56 cm rows around the 20th of April all years. Ethofumesate [(±)-2-ethoxy-2,4-dihydro-3,3-dimethyl-5-benzofuranyl methanesulfonate] plus diethatyl [N-(chloroacetyl)-N-(2,6-diethylphenyl)glycine] (2.2 plus 2.2 kg/ha) was applied in an 18 cm band over the sugarbeet row with a tractor mounted sprayer delivering 360 L/ha at 175 kpa and incorporated to a depth of 2 to 3 cm with a rotary power incorporator during the planting operation. Weed escapes other than Canada thistle were removed by cultivation and hand hoeing.

Plots were four rows wide and 10 m long and all data were collected from the center two rows. Canada thistle populations were determined by counting two 15 cm by 3 m areas in each plot. Sugarbeet harvest population and yields were determined by hand harvesting two random 3 m lengths of row in each plot and counting the sugarbeets. Sucrose percentage and tare weight were determined by Western Sugar Company. All plots were essentially free of weeds other than Canada thistle at harvest.

The experimental design for all studies was a randomized complete block with four replications. The data were analyzed by standard analysis of variance procedures (Snedecor and Cochran, 1967). If significant differences ($P \leq 0.05$) were detected among treatments, then Fisher's protected Least Significant Difference (LSD) was calculated and used as a means separation technique. Regression analysis was employed to study the relationship of Canada thistle shoot density on sugarbeet yield, sucrose content and grower net return. Coefficient of variation (CV) values for yield and sucrose were less than 10% for all studies.

Canada thistle emerged after the sugarbeets in all studies. Sugarbeets were in the cotyledon to 2-leaf stage when Canada thistle rosettes began to emerge and emergence continued for two to eight weeks depending on year and study.

Canada thistle control. All herbicide treatments were applied postemergence with a CO_2 pressurized knapsack sprayer delivering 95 L/ha at 276 kpa. Treatments were applied to two-leaf sugarbeets and 0 to 5 cm Canada thistle rosettes approximately one month after planting, or to four-leaf sugarbeets and 5 to 10 cm Canada thistle

Table 1. Canada thistle control and sugarbeet response with clopyralid alone or in combination with desmedipham plus phemedipham at Powell, WY in 1989 to 1991.

Treatment[†]	Application stage	Rate	Sugarbeet Injury	Sugarbeet Stand	Sugarbeet Sucrose	Sugarbeet Yield	Canada thistle Control
	(sugbt lf no)	(g/ha)	(%)	(1000 pl/ha)	(%)	(Mg/ha)	(%)
desmedipham + phenmedipham(des-phe)	4	1120	4	57.1	14.6	32.1	7
des-phen + clopyralid	4	1120+105	4	67.9	15.4	45.7	76
des-phe + clopyralid	4	1120+210	5	67.4	15.4	48.7	88
clopyralid	4	105	0	66.9	15.3	46.4	76
clopyralid	4	210	0	68.9	15.3	47.4	89
clopyralid	4	280	2	66.4	15.4	48.9	92
des-phe/des-phe	2/4	560/560	0	56.8	14.7	32.6	0
des-phe/des-phe + clopyralid	2/4	560/560 + 210	0	66.7	15.5	48.2	87
des-phe + clopyralid/ des-phe	2/4	560+210/ 560	0	65.8	15.2	43.1	68
des-phe + clopyralid/ des-phe + clopyralid	2/4	560+105/ 560+105	0	66.9	15.5	48.5	85
clopyralid/clopyralid	2/4	105/105	0	66.4	15.4	49.6	83
weedy check	———	———	0	56.3	14.7	31.2	0
LSD (0.05)			3	8.6	0.5	6.8	9

[†] split treatment and data are averaged over 3 years.

rosettes 10 to 14 days after the initial application. All weeds but Canada thistle were removed by hand weeding two times during the growing season. Data were combined over years for analysis as error terms were homogeneous.

Canada thistle competition. Canada thistle densities of 0, 0.2, 0.7, 1.3 and 3.3 shoots per m of row were established in a 15 cm band over the sugarbeet row. The desired density of Canada thistle was marked with 10 cm long plastic stakes at the four-leaf stage of sugarbeets and all other weeds were removed. In order to maintain the desired Canada thistle shoot density in plots, the weeding process was repeated three times during the growing season.

RESULTS AND DISCUSSION

Canada thistle control. Canada thistle control was poor (0 to 7%) with desmedipham plus phenmedipham whether applied as a single or split treatment (Table 1). Canada thistle control with clopyralid ranged from 68 to 92% and was influenced by rate and application time. Canada thistle control increased from 76 to 92% as clopyralid rate increased from 105 to 280 g ae/ha. The only clopyralid treatment not providing >75% Canada thistle control at 210 g ae/ha was a single application at the two-leaf stage of sugarbeets. Reduced control with this treatment probably resulted because not all Canada thistle rosettes were emerged when the treatment was applied. Canada thistle control with 210 g ae/ha clopyralid was similar whether applied alone or in combination with desmedipham plus phemedipham as a single or split treatment, provided half of the clopyralid was applied at the four-leaf stage of sugarbeets to insure emergence of all Canada thistle rosettes. These data indicate that applying clopyralid at the two-leaf stage of sugarbeets is probably too early to maximize Canada thistle control.

Sugarbeet tolerance to clopyralid was good and was not influenced by desmedipham plus phenmedipham applications (Table 1). Sugarbeet yield and sucrose content were closely related to Canada thistle control in this trial. Highest root yields and sucrose were obtained with treatments containing clopyralid. Sugarbeet yield and sucrose were not different among clopyralid treatments even though there was a trend for higher yield and sucrose content with treatments providing greatest Canada thistle control.

Canada thistle competition. Environmental conditions for the total growing season were similar in 1989 and 1990 (Table 2). However, early season (April, May) conditions were warmer (2.6 C) and drier (1.6 cm) in 1989. Sugarbeet stands decreased as Canada thistle density increased (Table 3). The high density of Canada thistle reduced sugarbeet stands

Table 2. Monthly temperature and precipitation at the Powell Research and Extension Center 1989 and 1990.

Month	Temperature		Precipitation	
	1989	1990	1989	1990
	— Degrees C —		—— cm ——	
April	7.8	7.3	2.5	3.3
May	12.4	10.5	3.8	4.6
June	17.2	16.7	1.0	0.8
July	22.7	20.3	2.2	3.3
August	19.3	20.3	2.7	2.3
September	13.3	17.0	2.1	0.4
Total	92.7	92.1	13.9	14.7

Table 3. Influence of Canada thistle density on sugarbeets at Powell, Wyoming in 1989 and 1990.

Canada thistle density	Year		
	1989	1990	Mean
	—— Sugarbeet stand (1000 pl/ha) ——		
(pl/m)			
0	67.2	64.8	66.0
0.2	65.2	66.0	65.6
0.7	64.7	63.2	64.0
1.3	59.8	63.2	61.5
3.3	58.1	60.2	59.2
LSD (0.05)	7.2	5.5	6.1
	—— Sucrose (%) ——		
0	15.8	15.5	15.7
0.2	15.6	15.6	15.6
0.7	15.7	15.1	15.4
1.3	15.2	15.0	15.1
3.3	15.1	14.9	15.0
LSD (0.05)	0.4	0.2	0.3
	—— Yield (Mg/ha) ——		
0	45.4	48.6	47.0
0.2	43.0	47.0	45.0
0.7	39.6	42.8	41.2
1.3	31.6	37.2	34.4
3.3	21.1	24.2	22.6
LSD (0.05)	7.6	9.0	8.5

approximately 14 and 7% in 1989 and 1990, respectively, when compared to the weed-free check. This difference between years was possibly related to increased early season growth and thus greater competition from Canada thistle in 1989 because of the warmer and drier condition.

The density by year interaction was not significant for sucrose or yield (Table 3). Sucrose content was 4.5 and 4.0% lower and yield 54 and 49% lower with the high density of Canada thistle in 1989 and 1990, respectively, compared to the weed-free check. This suggests that early season environment, even though impacting sugarbeet stand, did not appear to influence the final reduction in sucrose or root yield with Canada thistle in sugarbeets.

Since sucrose and yield reduction from Canada thistle were similar both years, mean data were regressed against Canada thistle density (Figures 1 and 2). A linear regression equation best fit the data. Sugarbeet sucrose content decreased an average of 0.01% ($R^2=0.81$) and root yield 0.4 Mg/ha (R2=0.99) for each 1000 Canada thistle shoots/ha. Canada thistle is very competitive with sugarbeets even at low shoot densities.

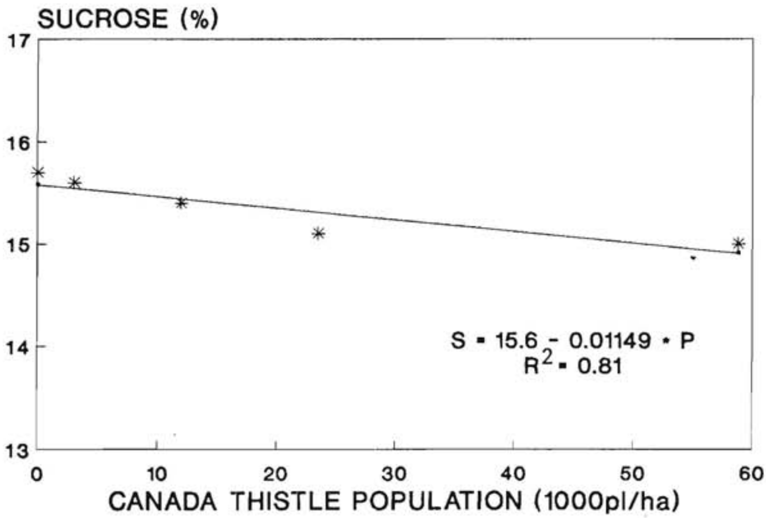

Figure 1. Regression of sucrose content of sugarbeet against Canada thistle shoot density.

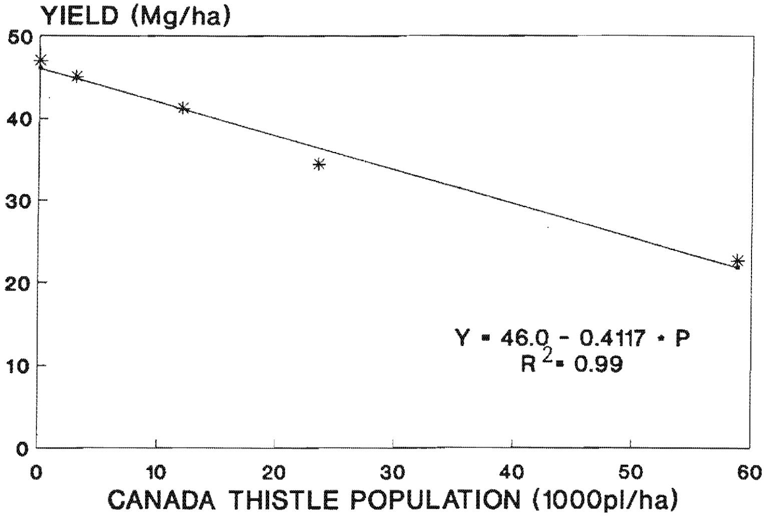

Figure 2. Regression of sugarbeet root yield against Canada thistle shoot density.

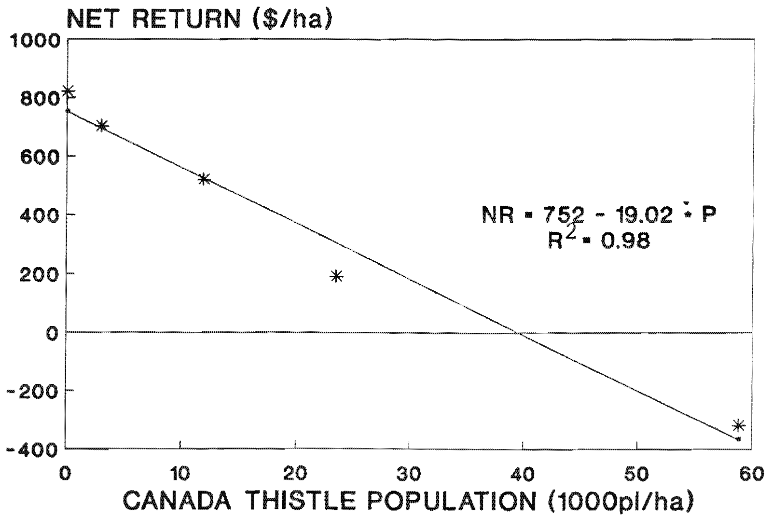

Figure 3. Regression of grower net return from sugarbeets against Canada thistle shoot density.

An enterprise budget was developed by incorporating data for approximate prices, yield, labor requirements, number and type of field operations, machinery complement and operating inputs (fertilizer, beet seed, diethatyl, ethofumesate, desmedipham plus phenmedipham, insecticide and fuel) for a 100 ha sugarbeet enterprise on a representative 240 ha farm (Miller et al, 1990). Gross income per ha was derived as the product of experimental yield and price adjusted for sugar content (1990 Western Sugar grower contract). Management and general overhead cost were estimated as a percentage of variable costs, 5 and 10%, respectively. Per acre fixed costs where charged against machinery and equipment so that the projected net return represented the return over total cost of production. For net return regressed against Canada thistle density (Figure 3), a linear regression equation best fit the data. Grower net return decreased as Canada thistle density increased and at the highest density was negative. Grower net return decreased an average of \$19/ha ($R^2 = 0.98$) for every 1000 Canada thistle shoots/ha.

One thousand Canada thistle shoots per hectare is equivalent to one every 6 m of sugarbeet row. Canada thistle does not grow in normally spaced densities in fields but rather as scattered patches throughout the field. However, it does not take many patches (average density 10 shoots per m^2, Donald, 1990) to impact sugarbeet yield, sucrose content, and grower net return.

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