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Fertilization augments Canada thistle (*Cirsium arvense* L. Scop) control in temperate pastures with herbicides

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Abstract

Integrated weed management combines treatments for improved weed control. Few studies have compared integrated approaches for longer-term control of *Cirsium arvense* in pasture. We evaluated the response of this weed in perennial pasture to one-time mowing or herbicide application (2,4-D ester, 2,4-D + mecoprop + dicamba, clopyralid, or picloram + 2,4-D) at the early bud stage of growth, both with and without annual spring fertilization over a 3-year period in central Alberta, Canada. Regardless of fertilization, all herbicide treatments suppressed *Cirsium arvense* in the year of treatment. Fertilization without control measures decreased *Cirsium arvense* density but increased biomass, while a one-time mowing treatment increased shoot densities. Although all herbicide treatments tended to reduce *Cirsium arvense* into the second and third year, picloram + 2,4-D at 0.24 + 0.89 kg ai/ha and clopyralid at 0.22 kg ai/ha provided the greatest weed suppression, particularly when fertilized annually. Overall, longer-term control of *Cirsium arvense* by herbicides was enhanced with annual spring fertilization, underscoring the importance of an integrated approach to controlling *Cirsium arvense* in temperate pastures.

Keywords: Biomass; Broadcast spraying; Competition; Fertilization; Forage; Weed density

1. Introduction

Cirsium arvense L. Scop., also known as Canada thistle, is a widespread, aggressive, perennial weed of agricultural areas (Donald, 1990; Skinner et al., 2000). In Canada it is found in all provinces as far north as 59°, and in Alberta, was reported in 40% of cereal and oilseed fields surveyed during 2001 (Moore, 1975; Leeson et al., 2001). Surveys of weeds in forage crops across western Canada indicate this weed is prevalent in alfalfa (*Medicago sativa* L.) seed fields as well as pasture and hay land (Thomas and Wise, 1983; Goodwin et al., 1986), where it reduces alfalfa seed yields (Moyer et al., 1991) and pasture forage production (Grekul and Bork, 2004). Forage decreases have been attributed to plant competition and allelopathy (Wilson, 1981). *Cirsium arvense* also reduces pasture utilization by grazing animals (Schreiber, 1967, Hartley and James, 1979), likely due to low palatability associated with its spiny morphology.

Mowing has potential to control *Cirsium arvense* by limiting carbohydrate assimilation and storage, thereby weakening plants and preventing seed formation (Moore, 1975; Donald, 1990). While repeated mowing reduced *Cirsium arvense* infestations in alfalfa hay fields in the northern US (Schreiber, 1967), infrequent mowing (e.g., once a year) did not provide longer-term control of this weed in Australian pastures (Amor and Harris, 1977).

Herbicides used for *Cirsium arvense* control have demonstrated variable effectiveness, and include, among others, 2,4-dichlorophenoxy acetic acid (2,4-D), 3,6-dichloro-2-methoxybenzoic acid (dicamba), 4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid (picloram), and 3,6-dichloro-2-pyridinecarboxylic acid (clopyralid) (Donald, 1990). Repeated applications of 2,4-D were required for longer-term suppression of *Cirsium arvense* in pastures of eastern Canada (Hay and Ouellette, 1959) and the US (Schreiber, 1967). Picloram, clopyralid, dicamba, and

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2,4-D all reduced *Cirsium arvense* density and biomass in the US (Reece and Wilson, 1983), while in grass seed crops of creeping red fescue (*Festuca rubra* L.) and timothy (*Phleum pratense* L.) in western Canada, picloram application resulted in lower *Cirsium arvense* shoot densities than either 2,4-D ester or dicamba (Gallagher and Vanden Born, 1976). In white clover (*Trifolium repens* L.)—perennial ryegrass (*Lolium perenne* L.) pastures of Australia, broadcast spraying with 2,4-D amine or ester did not reduce *Cirsium arvense* shoot densities, while picloram + 2,4-D provided control for 2 years (Amor and Harris, 1977).

Combining two or more treatments within an integrated management strategy may provide more effective control of *Cirsium arvense* in pastures than each treatment applied alone (Beck and Sebastian, 2000; Masters and Sheley, 2001). Management tools readily available to producers that could be integrated in pasture systems include mowing, herbicides, and the use of fertilizers to enhance crop competition.

Suppression of *Cirsium arvense* via plant competition may also be achieved through the seeding of alfalfa (Ominski, 1999) and grasses (Wilson and Kachman, 1999), or combining mowing with the seeding of competitive forages (Thrasher et al., 1963). Alternatively, fertilization may enhance competition between desirable forage species and weeds (Cole, 1998), although added nutrients may favor weed over crop growth, especially when initial weed density is high (DiTomaso, 1995). Nitrogen fertilization decreased *Cirsium arvense* densities in irrigated pastures of the US (Thrasher et al., 1963) and acid grassland of the UK (Edwards et al., 2000), increased *Cirsium arvense* density and biomass in pastures of the midwestern US (Reece and Wilson, 1983), and had no effect in pastures of eastern Canada (Hay and Ouellette, 1959). Reasons for these inconsistencies are unclear, but may be related to climate, vegetation and soil type, initial nitrogen concentration and distribution in the soil, or the form of nitrogen applied.

Robust information on the utility of integrating fertilization with herbicides for controlling *Cirsium arvense* in temperate pastures is currently lacking. The objectives of this study were to compare the effects of one-time mowing or herbicide application, with and without annual spring fertilization, on *Cirsium arvense* abundance over a 3-year period. Effects on forage yield and quality, as well as pasture vegetation composition were also assessed, but are not presented here (Grekul, 2003). We hypothesized that fertilization would enhance the control of herbicide-treated *Cirsium arvense*, while fertilization alone would increase weed abundance (density and biomass).

2. Materials and methods

2.1. Study sites

This research was conducted from 1999 to 2001 in 4 pastures located across the Aspen Parkland ecoregion of central Alberta (Table 1). All pastures met the following criteria: (1) internal uniformity in both physical conditions (e.g., soils and disturbance history) and forage sward composition, (2) abundant *Cirsium arvense*, and (3) not been sprayed for at least 3 years prior to 1999. All sites were dominated by combinations of grasses such as meadow brome (*Bromus biebersteinii* Roem. & Schult.), smooth brome (*Bromus inermis* Leyss.), Kentucky bluegrass (*Poa pratensis* L.), and quackgrass (*Agropyron repens* (L.) Beauv.). Pasture herbage production was greatest at Site 1 (Table 2), as it was situated on a river floodplain and contained nutrient-rich soils (Table 3). Among the four sites, *Cirsium arvense* shoot densities ranged from 22 to 51 shoots/m^2, and biomass from 381 to 3045 kg/ha within the unfertilized check plots sampled in August 1999 (Table 2). At Site 4, an additional noxious weed, *Sonchus arvensis* L. (perennial sow-thistle), was present, at an average of 31 shoots/m^2 and 134 kg/ha.

At each site, an area approximately 100 × 60 m was fenced to exclude livestock, and soil samples collected in May 1999 to provide base-line information on soil characteristics (Table 3) and establish recommendations for fertilization. Soils were sub-sampled (0–30 cm) at four random locations throughout each of the four, unfertilized

Table 1
Locations, landscape characteristics and growing season precipitation for the four study sites

Site	Latitude/longitude	Slope/aspect	Landform	May–August precipitation (mm)			
				1999	2000	2001	30-yr mean
1	54° 00′ 57″N 114° 22′ 44″W	Level/NA	Floodplain	281	301	292	319
2	53° 42′ 24″N 112° 33′ 10″W	Level/NA	Level moraine	235	272	279	263
3	52° 18′ 55″N 114° 31′ 48″W	2%/South	Rolling moraine	365	406	256	372
4	53° 47′ 5″N 111° 27′ 24″W	4%/West	Hummocky moraine	194	248	219	251