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Impact of Grass Seedings on Establishment and Density of Diffuse Knapweed and Yellow Starthistle

Abstract

Knapweeds (*Centaurea* spp.) are major weed pests of northwestern rangelands, reducing productivity and accelerating erosion. Heavily infested rangelands need to be revegetated with forage species that can compete with knapweed, if they are to be returned to former levels of productivity. We conducted a two-year study to evaluate the survival of diffuse knapweed (*C. diffusa* Lam.) and yellow starthistle (*C. solstitialis* L.) during the establishment period of four rangeland grass species. 'Covar' sheep fescue (*Festuca ovina* L.) was the slowest grass to become established in the study. The biomass and early growth of 'Covar' controlled knapweed establishment during the second growing season. 'Ephraim' crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) provided an effective control of knapweed during the first growing season, but did not compete well with knapweed during the second growing season. 'Paiute' orchardgrass (*Dactylis glomerata* L.) and 'Critana' thickspike wheatgrass (*A. dasystachyum* (Hook.) Scribn.) controlled knapweed during both years of the study. The proximity of knapweed seeds to grass plants increased knapweed survival. These results indicate that the rate of reestablishment of knapweed on newly seeded range can be reduced by selecting grass species with competitive biomass and early growth characteristics.

Introduction

Diffuse knapweed (*Centaurea diffusa* Lam.) and yellow starthistle (*C. solstitialis* L.) are Eurasian plants that were introduced into the western United States and Canada at the turn of the century (Watson and Renney 1974, Roché and Talbott 1986). These weeds currently infest millions of acres of rangeland in the United States and Canada (Maddox 1979, Strang *et al.* 1979, Talbott 1987).

Domination of rangelands by knapweed result in substantial decreases in forage production (Watson and Renney 1974, Harris and Cranston 1979, Maddox 1979, Kelsey and Mihalovich 1987). The future productivity of these lands depends upon control of knapweed infestations and establishment of competitive forage plants. This study was designed to test the hypothesis that above- and below-ground phytomass of seeded grass species and knapweed seed placement would influence knapweed survival on newly seeded ranges.

Methods

A two-year study was conducted in northeastern Oregon (Union County). The area selected for the study produced 1350 kg/ha of diffuse knapweed in 1985. Precipitation amounts were 37.3 cm in 1986 and 26.0 cm in 1987 (Table 1). The site, a fine sandy loam, was mechanically treated by disking and planting 'Paiute' orchardgrass (*Dactylis glomerata* L.), 'Ephraim' crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.), 'Critana' thickspike wheatgrass (*Agropyron dasystachyum* (Hook.) Scribn.), and 'Covar' sheep fescue (*Festuca ovina* L.) in separate plots. The trial area (0.5 ha) was seeded (3-m drill box, 18-cm drill row spacing, 1 Pure Live Seed/linear cm) in March 1986 as a completely random design. Each species was replicated four times within the trial.

Grass phytomass was measured during June 1986 and 1987. Above- and below-ground phytomass was collected for each species using a 0.1-m^2 frame. The 20 cm x 50 cm frame, when centered on the drill row, extended to the center of the interspace. Above-ground phytomass was measured by clipping the plant material contained in the frame at ground level. Below-ground phytomass (crowns + roots) was measured by excavating the area contained in the frame to a depth of 25 cm, hand separating the root crown and roots over a screen, and handwashing the plant materials until it was free of foreign debris. Samples were oven dried (50°C) to a constant weight.

Reestablishment of diffuse knapweed from the soil seed bank in the grass stands was determined by counting knapweed density in 16 temporary transects in July 1986 and 1987. Each transect consisted of five 0.5-m^2 frames placed at random along a 10-m tape in the center of each drill strip (3-m x 25-m). Sampling avoided areas impacted by destructive sampling.

TABLE 1. Monthly precipitation amounts (cm) that occurred near the study area in 1986 and 1987.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	7.6	4.8	2.5	3.3	1.5	3.0	0.3	0.6	6.6	2.8	2.1	2.2
1987	3.8	3.0	2.3	2.1	4.0	4.5	1.0	0.0	0.0	0.0	2.8	2.5

Two *Centaurea* species were planted to ensure a known seed source on the site. Diffuse knapweed and yellow starthistle plots, containing 30 seeds in a 50-cm line, were planted separately in each drill strip. Placement of the plots was designed to establish two treatments per grass species (placement of the seeds within 3 cm of the root crown of the grass, and placement of the seeds in the center of the interspace between drill rows). Controls were established by planting seeds in tilled areas devoid of grass competition. All treatments were replicated four times. Planting occurred in October 1986, and *Centaurea* densities readings were recorded on May 15, June 15, and July 15 during the 1987 field season.

All data were evaluated using analysis of variance. Mean separations using least significant difference (LSD) tests are reported at a 0.05 level of significance, unless otherwise stated.

Results

Grass Response

Total phytomass (top, crown, root) in 1986 indicate 'Covar' was the slowest of the four species to establish during the seedling year (Table 2). 'Paiute' and 'Critana' were the dominant grasses, exceeding the phytomass of 'Covar' by 184 and 175 percent respectively. 'Ephraim' was the first species to emerge in 1986. However, 'Ephraim' yields were not significantly different from 'Covar' or the dominant grasses. Comparison of the above- and below-ground phytomass (crown + root) yielded similar results.

In 1987 'Paiute' and 'Covar' were the dominant grasses (Table 2). The above-ground phytomass of 'Covar' was greater than 'Paiute,' 'Critana,' and 'Ephraim.' Most of this difference can be attributed to the production of a large seed crop by 'Covar' in 1987. The below-ground phytomasses of 'Paiute' and 'Covar' were not significantly different from each other but were significantly greater than 'Ephraim' and 'Critana.'

TABLE 2. Phytomass (g/0.1·m²) of 'Critana' thickspike wheatgrass, 'Paiute' orchardgrass, 'Ephraim' crested wheatgrass, and 'Covar' sheep fescue in 1986 and 1987. Species means separated by letters are different (P = .05, n = 16).

	1986 Above-Ground Phytomass	1986 Below-Ground Phytomass	1986 Total Phytomass
'Critana'	13.0 a	12.2 a	25.2 a
'Paiute'	11.8 a	14.7 a	26.5 a
'Ephraim'	9.8 ab	11.1 ab	20.8 ab
'Covar'	7.2 b	7.2 b	14.4 b
LSD	3.2	4.85	7.28

	1987 Above-Ground Phytomass	1987 Below-Ground Phytomass	1987 Total Phytomass
'Critana'	21.5 b	32.1 b	53.1 b
'Paiute'	21.6 b	60.1 a	81.7 a
'Ephraim'	13.2 b	28.5 b	42.3 b
'Covar'	35.4 a	53.7 a	89.1 a
LSD	8.4	7.2	15.1

Diffuse Knapweed from the Soil Seed Bank

There was a significant difference between the number of knapweed seedlings associated with the different grasses in 1986 (Table 3). The 'Covar' seeding had more knapweed plants than 'Ephraim' or 'Paiute.' 'Critana' was not significantly different from 'Paiute,' 'Ephraim'

TABLE 3. Density (plants/m²) of diffuse knapweed in 'Critana' thickspike wheatgrass, 'Paiute' orchardgrass, 'Ephraim' crested wheatgrass, and 'Covar' sheep fescue seedings. Species means separated by letters are different (P = .05, n = 80).

Grass species	Diffuse knapweed density 1986	Diffuse knapweed density 1987
'Critana'	1.3 ab	0.4 a
'Paiute'	0.7 b	0.2 a
'Ephraim'	0.5 b	3.0 b
'Covar'	2.0 a	0.1 a
LSD	0.8	0.8

or 'Covar.' The 'Ephraim' and 'Paiute' seedings emerged first and established vigorous stands during 1986, which is suggested here a primary reason for low knapweed establishment. During the second year (1987) 'Covar,' 'Paiute' and 'Critana' had significantly fewer knapweed seedlings than the 'Ephraim' seedings (Table 3).

Centaurea Seed Plantings

Diffuse Knapweed. Diffuse knapweed seeds germinated in every plot (Table 4). The seedlings went through a natural thinning process as the growing season progressed. Seeds placed next to the crowns of the grasses had a slower rate of thinning than those planted in the center of the interspace between drill rows.

Grass species influenced diffuse knapweed survival when the seeds were planted next to the crown of the grass plant. By mid-July the control and 'Ephraim' treatments were the only plots containing knapweed seedlings (Table 4).

Yellow Starthistle. Survival of yellow starthistle seedlings mirrored that of diffuse knapweed except that a significant number of yellow starthistle seedlings survived in the 'Ephraim' stands in the center of the drill row as well as next to the grass plants (Table 5). Yellow starthistle plants that survived in grass stands beyond July 15 were dwarfed (10-12 cm tall) with a single flower contrasted with control plants that were 25-38 cm tall with multiple flowers.

These results support the reestablishment data for diffuse knapweed. 'Ephraim' is the most susceptible grass to establishment of diffuse knapweed and yellow starthistle seedlings during the second growing season. In addition, survivorship of diffuse knapweed and yellow starthistle seedlings in a grass stand was increased by placing seeds next to the grass crown.

Discussion

The survival of diffuse knapweed and yellow starthistle in a grass stand depends upon the ability of the grasses to occupy the site and use available resources. Knapweed survival responses in this study indicate that the rate and degree of

TABLE 4. Survival (percent of seeds planted) of diffuse knapweed in stands of 'Critana' thickspike wheatgrass, 'Paiute' orchardgrass, 'Ephraim' crested wheatgrass, and 'Covar' sheep fescue. Knapweed seeds were planted near the crown of the grass plants or in the interspace between drill rows. Means (percent survival and knapweed seedlings/50 cm) separated by letters are different (P = .05, n = 20).

	Crown Planting					
	May 15		June 15		July 15	
	Survival	Seedling Numbers	Survival	Seedling Numbers	Survival	Seedling Numbers
'Critana'	25.6%	7.7 a	12.3%	3.7 ab	0.0%	0.0 b
'Paiute'	9.0%	2.7 b	6.6%	2.0 b	0.0%	0.0 b
'Ephraim'	25.0%	7.5 a	19.0%	5.7 a	13.0%	4.0 a
'Covar'	20.0%	6.0 ab	11.6%	3.5 ab	0.0%	0.0 b
Control	16.6%	5.0 ab	18.0%	5.5 a	17.0%	5.2 a
LSD		4.4		2.6		1.2

	Interspace Planting					
	May 15		June 15		July 15	
	Survival	Seedling Numbers	Survival	Seedling Numbers	Survival	Seedling Numbers
'Critana'	11.6%	3.5 ab	<1.0%	0.2 b	0.0%	0.2 b
'Paiute'	0.0%	0.0 c	1.6%	0.5 b	0.0%	0.0 b
'Ephraim'	7.0%	2.2 abc	1.6%	0.5 b	2.3%	0.7 b
'Covar'	3.0%	1.0 bc	2.3%	0.7 b	1.6%	0.5 b
Control	16.6%	5.0 a	18.0%	5.5 a	17.0%	5.2 a
LSD		3.2		1.3		1.2

TABLE 5. Survival (percent of seeds planted) of yellow starthistle in stands of 'Critana' thickspike wheatgrass, 'Paiute' orchardgrass, 'Ephraim' crested wheatgrass, and 'Covar' sheep fescue. Starthistle seeds were planted near the crown of the grass plant or in the interspace between drill rows. Means (percent survival and starthistle seedling numbers/50 cm) separated by letters are different (P = .05, n = 20).

	Crown Planting					
	May 15		June 15		July 15	
	Survival	Seedling Numbers	Survival	Seedling Numbers	Survival	Seedling Numbers
'Critana'	9.0%	2.7 bc	6.0%	1.8 b	0.0%	0.0 c
'Paiute'	22.3%	6.7 abc	8.3%	2.5 ab	0.0%	0.0 c
'Ephraim'	26.6%	8.0 ab	15.6%	4.7 a	13.0%	4.0 a
'Covar'	12.3%	3.7 bc	8.3%	2.5 ab	5.6%	1.7 b
Control	33.0%	10.0 a	16.6%	5.0 a	13.0%	4.0 a
LSD		4.6		2.5		1.1
	Interspace Planting					
	May 15		June 15		July 15	
	Survival	Seedling Numbers	Survival	Seedling Numbers	Survival	Seedling Numbers
'Critana'	11.6%	3.5 b	<1.0%	0.2 b	0.0%	0.0 c
'Paiute'	0.0%	0.0 b	1.6%	0.5 b	<1.0%	0.1 c
'Ephraim'	11.6%	3.5 b	5.0%	1.5 b	5.0%	1.5 b
'Covar'	<1.0%	0.2 b	5.0%	1.5 b	2.3%	0.7 bc
Control	33.0%	10.0 a	16.6%	5.0 a	13.0%	4.0 a
LSD		3.6		1.3		1.1

site occupation is different for each of the grass species.

'Covar' sheep fescue was the slowest of the four grass species to establish. The performance of 'Covar' was similar to that described by Hafenrichter *et al.* (1968) and Tiedemann and Klock (1974) for 'Durar' hard fescue (*F. ovina* L.). 'Covar' seedings had a significant number of diffuse knapweed seedlings (2 knapweed/m^2; Table 3) during the first year of grass establishment. However, 'Covar' demonstrated a strong second year growth response which allowed it to dominate the site. Consequently, the establishment of new knapweed plants during the second growing season was minimal.

'Ephraim' crested wheatgrass demonstrated a high seedling and first year vigor which resulted in a low knapweed density. The second year growth rate of 'Ephraim' was the lowest observed for any of the grasses studied. Knapweed establishment during the second growing season was significantly higher (3 knapweed/ m^2) than any of the other grass species.

'Paiute' orchardgrass was one of the most productive grasses in both years of the study. As a result, 'Paiute' orchardgrass was relatively free of knapweed seedlings during both growing seasons.

'Critana' thickspike wheatgrass was a dominant grass during the first year of establishment but had a second year growth rate that leveled out at a lower total phytomass than either 'Paiute' or 'Covar.' 'Critana' was relatively knapweed-free during the first year of establishment and although it had more knapweed seedlings in the second year of growth the number of seedlings was not significantly different from those found in 'Covar' or 'Paiute' seedings.

Centaurea seedling survival was influenced by seed placement. Seedling survival was longest in the microclimate next to the grass crowns. Survival of both knapweed species next to a grass plant appears to be directly influenced by the amount of grass phytomass. 'Ephraim' crested wheatgrass which had the lowest total phytomass during the second growing season was most susceptible to knapweed establishment. This relationship is also influenced by the amount of overlap between the active growth periods of the grass and the species of knapweed. For example, knapweed seeds planted next to 'Covar' root crowns had a higher rate of establishment than those planted next to 'Critana' or 'Paiute.' This difference may be because 'Covar' completed its annual life cycle prior to periods of moisture stress. Consequently, the stress placed on knapweed seedlings by 'Covar' was not as great as the stress placed on the knapweed seedlings next to 'Paiute' and 'Critana' plants which were actively growing during periods of moisture stress.

Data from this study do not imply that a grass species will totally prevent knapweed establishment in an area where there is a seed source. Similar results were reported by Huston *et al.* (1984) where a treatment of picloram and intermediate wheatgrass (*A. intermedium* (Host) Beauv.) reduced, but did not eliminate starthistle from study plots. A critical element in both studies appears to be the establishment of a grass species that will remove a significant proportion of the moisture and nutrients from the rooting zone of knapweed seedlings and overlap the active growth period of the knapweed species. In addition both studies used techniques that reduced initial knapweed competition. In the Huston study picloram was used to inhibit knapweed competition, whereas this study used tillage of the seedbed to bury a portion of the knapweed seed bank. We believe an initial control of knapweed competition is essential for quick establishment of new grass seedings.

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