Establishment of Diffuse and Spotted Knapweed from Seed on Disturbed Ground in British Columbia, Canada

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Abstract

The rangeland weeds diffuse and spotted knapweed (*Centaurea diffusa* L. and *C. maculosa* L.) were sown at densities of 208 to 1,504 seeds/m² on disturbed rangeland in Westwold, British Columbia, in 25 × 25-cm plots. Both species established well to the rosettes stage at the lowest sowing densities, but only 5% of the diffuse knapweed rosettes bolted in the second year compared to 45% of the spotted knapweed rosettes. Intraspecific competition appeared to decrease the number of spotted knapweed rosettes bolting at the higher sowing densities.

Diffuse and spotted knapweed (*Centaurea diffusa* Lam. and *C. maculosa* Lam.) threaten 10.7 million ha in western Canada (Harris and Cranston 1979). In British Columbia, spotted knapweed prefers the more mesic areas of the Interior, growing at elevations to 1,200 m. Diffuse knapweed, occupying 7 times the area of spotted knapweed, grows only up to an elevation of 900 m and is more successful in the hotter, drier habitats (Watson and Renney 1974). Diffuse knapweed is a biennial, producing a rosette in its first season and bolting in the second, when it bears many spiny seed heads. Spotted knapweed also produces a rosette in the first year, but it is a shortlived perennial, producing new rosettes at the bases of bolted stalks each fall for up to 3 years. Diffuse and spotted knapweed seed yield has been recorded as high as 28,000 and 6,000 seeds/m², respectively on rangeland (Roze 1981).

Seed-reducing gall flies, *Urophora affinis* Frauenfeld and *U. quadrifasciata* Meigen (Diptera:Tephritidae) are two biological control agents released against knapweed. Gall flies oviposit in immature seed heads, and the larvae feed on ovariole tissue. These flies have reduced diffuse and spotted knapweed seed yields by 80% at Pritchard and Chase, B.C.; but in spite of this, 2,000 seeds/m² were produced on both sites (Roze 1981). Can this amount of seed reduction decrease the rate of spread of knapweed, or decrease knapweed density in existing populations? In this study we determine if the density of seeds sown affects the chance of knapweed establishment on disturbed ground.

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Materials and Methods

This study took place on rangeland near Westwold, B.C. at an elevation of 646 m where spotted knapweed predominates. The site was a Douglas fir *(Pseudotsuga menziesii)* and pinegrass *(Calamagrostis rubescens)* community that was logged 40 years earlier and now consists of trees interspersed with large clearings. A 15 × 15-m area, free of knapweed, was cultivated and raked smooth. Plots were marked by delineating their borders with baler twine. Knapweed seed was collected in August, 1976—diffuse, from Pritchard, and spotted, from Westwold. The seeds were stored for 2 months at room temperature and then handsown in late October, 1976. Seeds were sprinkled evenly on the soil and pressed down firmly, a method found by Watson (1972) to give optimal seed germination. The sowing density for each plot was chosen by drawing random numbers.

Diffuse knapweed was sown at densities of 368, 944, and 1,504 seeds/m² and spotted knapweed at 208, 528, and 832 seeds/m². The actual numbers sown were 23, 59, and 94 for diffuse, and 13, 33, and 52 for spotted knapweed seeds because the plots were 25 × 25 cm. Plots were 75 cm apart. Fewer spotted knapweed seeds were sown because they are heavier (1.7 ± .1 mg) than diffuse knapweed seeds (1.05 ± .03 mg; Roze 1981) and could have a better chance of establishment. Each density was replicated 15 times. No seeds were added to 15 plots. The site was checked in September, 1977, to see if any rosettes had bolted. In June and September, 1978, numbers of rosettes were counted, and in September, 1978, the bolted plants and numbers of seed heads on each bolted plant were counted.

Results

No plants were found on control plots in September, 1977, and one of the rosettes had bolted. In June, 1978 average numbers of diffuse knapweed rosettes did not vary significantly between sowing densities of 368 and 944 seeds/m² but did increase significantly between sowing densities of 944 and 1,504 seeds/m² (Table 1).

Table 1. Average number of rosettes in June, 1978.

Knapweed species	Sowing density seeds/m²	Number of rosettes[1] per plot
Diffuse	368	3 ± 1 a
	944	6 ± 1 a
	1504	13 ± 2 b
Spotted	208	2 ± 1 a
	528	6 ± 1 b
	832	8 ± 1 c

[1]Means followed by the same letter do not differ significantly ($p = .05$) according to Duncan's New Multiple Range Test (LeClerge et al. 1962). Plot size is 25 cm × 25 cm.

Spotted knapweed rosettes increased significantly with the sowing density. Only 5% (0.3 ± 0.1 per plot) of the diffuse knapweed rosettes present in the spring of 1978 bolted that season and there were no significant differences in numbers of bolted plants between sowing densities. In contrast, 45% of the spotted knapweed rosettes bolted in 1978 and the number per plot increased significantly in plots with 208 to 528 seeds/m² (Table 2). However, the number of bolted plants per plot decreased significantly from the sowing density of 528 to 832 seeds/m².

Table 2. Average number of bolted spotted knapweed plants per plot in September, 1978.

Sowing density (seeds/m²)	Mean[1]
208	1.2 ± 3 a
528	5.5 ± .7 b
832	2.4 ± .5 c

[1]Means followed by the same letter do not differ significantly ($p = .05$) according to Duncan's New Multiple Range Test (LeClerge et al. 1962). Plot size is 25 cm × 25 cm.

The average numbers of seed heads per plant for diffuse (72 ± 10) and spotted (16 ± 1) knapweed were not affected by the sowing density. There was a trend, however for spotted knapweed: the number of seed heads per plant decreased with increasing sowing density (20 ± 3, 16 ± 2, and 13 ± 2 seed heads per plant for the sowing densities of 208, 528, and 832 seeds/m², respectively). Dissection of undehisced seed heads revealed that *Urophora affinis* and *U. quadrifasciata* had attacked both diffuse and spotted knapweed, but most seed heads contained some seeds.

Discussion

The density of seeds sown affects the chance of knapweed establishment on new ground, with fewer diffuse and spotted knapweed rosettes produced by fewer seeds. Therefore seed-reducing biological control agents could theoretically lower the chance of knapweed establishment in new locations. But, existing knapweed populations would have to be greatly reduced. Schirman (1981) predicted that even if the seed yield of diffuse and spotted knapweed were reduced to below 0.1% of their potential yield, and plant density declined, knapweed would spread to adjoining, non-infested land. In this study some rosettes and bolted plants appeared on plots with the lowest sowing densities, indicating that knapweed will establish on disturbed rangeland from very sparsely scattered seed. Once establishment occurs, seeds from the mature plants form a seed bank in the soil, and seedlings emerge for years to come. The gall flies were in the vicinity of this study site, and although they did find the new plant population, seed production was not prevented entirely.

There was a decrease in the number of spotted knapweed rosettes per plot with a decrease in numbers of seeds sown, but there appeared to be a plastic effect, where individual plant size, i.e., the average number of seed heads per plant, increased with decreasing rosette density. Thus, even if rosettes were thinned by biological control agents, seed yield per unit area may remain the same. Intraspecific competition among spotted knapweed rosettes accounted for the decrease in the number of bolted plants from the sowing density of 528 to 832 seeds/m² because rosette numbers were significantly greater at 832 than 528 seeds/m². A reduction in rosette density by biological control agents may result in a higher percentage of plants bolting in the second year.

So few diffuse knapweed rosettes bolted that the effect of rosette density on mature plant size could not be measured. A study similar to this was made in Kamloops, where diffuse knapweed is the predominate species, but the probability of bolting in the second year was not greater than in Westwold (Roze, unpublished data). Therefore, diffuse knapweed appears to remain vegetative for at least two years on rangeland before it bolts. This species can become very well established in the rosette stage before biological control agents that feed on the mature plants can attack it.

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