Seed Production and Spring Seedling Establishment of Diffuse and Spotted Knapweed

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Abstract

Annual seed production of diffuse *(Centurea diffusa)* and spotted knapweed *(Centurea maculosa)* is reduced in dry years by a reduction in the number of viable seeds per seed head and increases when above-normal precipitation occurs by increase in the number of heads/flower stem. Seed production was approximately 1,000-fold that needed to maintain observed levels of infestation. Seedlings emerging in April had a high rate of survival with most plants flowering the following season, while those emerging after May 15 had a very low survival rate and almost no flower stem production the following season.

Diffuse and spotted knapweed are short-lived perennials of the *Centaurea* genus that have become major weed problems on semi-arid range and pasture lands of the Pacific Northwest. The problem of these weeds, which are continuing to spread into many prime grazing areas, was recently reviewed (Maddox 1979). Control of these species is possible by chemical means (Renney and Hughes 1969) but these measures are not always practical because of economics, terrain, or environmental considerations. Several biotic agents are under study [Maddox (1979); Watson and Renney (1974,] but at present have only a minor impact.

Watson and Renney (1974) summarized observations related to the reproduction of these species. In general, they reported that these species under range conditions were capable of producing 400–900 seeds/plant that would germinate under a range of temperatures of 7 to 34° C when optimum moisture was supplied. Some post harvest and light-induced dormancy was measured. We have also observed viability greater than 80% of the seeds still retained in the seed heads of diffuse in April. These normally are fully dispersed by mid June. Both fall and spring seedling emergence is common with these species.

The objective of this study was to assess the reproductive ability of these species under a wide range of sites prior to the introduction of bio-control agents and to measure the establishment of seedlings that would emerge following the date when herbicide treatments would normally be made in the spring.

Methods

Annual Seed Production

Natural field infestations in 11 diverse sites of northwestern Washington and northern Idaho were selected for evaluation (Table 1). Each site was sampled annually the first week of August in 1973 through 1976. The number of flower stems per unit area was estimated by random counts of m^2 hoop. Each area was subsampled to determine the number of seed heads/flower stem and the number of mature achenes/flower head. Only seed heads that were in the maturity range of well-developed seed, but had bracts still tightly closed, were counted for the latter measurement. Location and general features of each site are shown in Table 1.

Table 1. Location and description of knapweed sites sampled for estimate of seed production.

Site No.	Location (near)	Description
1	Spokane, Washington	Abandoned farm land
2	Addy, Washington	Abandoned farm land
3	Addy, Washington	Pasture
4	Addy, Washington	Rangeland
5	Barstow, Washington	Forested
6	Gifford, Washington	Rangeland
7	Fruitland, Washington	Rangeland
8	Garwood, Idaho	2nd growth timber
9	Chilco, Idaho	Pasture
10	Segal, Idaho	Timber (disturbed)
11	Athol, Idaho	Rangeland (ungrazed)

Spring Seedling Establishment

A site near Spokane, Washington, with Garrison Gravely loam soil that represented the habitat where knapweeds are commonly established was selected for this experiment. In 1971 only diffuse knapweed was seeded, while in 1972 and 1973 both diffused and spotted knapweed were sown at 3-week intervals, beginning the last week in March. Existing native vegetation was removed prior to the start of each season and the trial area maintained free of competition during the observation period. One hundred seeds in three replications were sown on each date in rows 1 meter long. Each seed row was separated from the adjacent rows by 33 cm. Approximately 5 mm of soil was placed over the seed to improve the seed-soil contact. In 1971 and 1972 seeds were sown within the plot at random, while in 1973 seeds were precision placed to allow exact identification of emerged seedlings. The seed for each year was collected the prior fall from a nearby field infestation. Laboratory germination tests showed greater than 95% viability of all seed lots. Plants were counted at weekly intervals for at least 6 weeks after seeding and observed at the onset of fall regrowth and at the time of flower stem bolting the following year.

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Table 2. Components of annual seed production of diffuse knapweed sampled at selected sites in N.E. Washington.

Site No.	1973	1974	1975	1976	1973	1974	1975	1976
	Number flower stems/m²				Avg. number seed head flower stem			
1	17.9	40.4	30.3	26.9	119.7	49.5	282.9	103.6
2	7.8	29.2	20.2	15.7	73.8	91.3	140.1	121.7
3	43.7	13.5	24.7	24.3	28.6	66.7	132.6	86.8
4	61.1	19.6	15.7	34.0	46.7	48.4	134.6	91.7
5	16.8	10.7	10.7	20.5	30.4	41.7	125.2	61.8
6	33.1	16.3	12.3	37.3	40.2	89.1	180.8	46.8
7	28.6	10.1	10.1	14.2	33.4	65.0	65.1	73.6
Avg	29.8	19.9	20.5	24.7	53.3	64.5	151.6	83.7
	Avg. number seed/flower head				Calculated, 000 seed/m²			
1	6.4	11.5	17.1	13.7	13.7	22.5	146.3	38.2
2	7.3	15.6	17.1	17.3	4.2	35.8	48.3	33.0
3	9.7	18.4	20.5	16.5	10.6	16.0	67.0	34.8
4	8.1	14.3	10.0	15.9	21.9	12.8	21.1	49.5
5	9.1	15.2	13.0	12.6	6.2	6.8	17.3	15.9
6	11.6	11.4	13.1	12.6	15.9	17.1	29.2	22.0
7	6.4	9.6	12.1	11.9	5.9	6.3	7.9	12.4
Avg	8.4	13.7	15.2	14.4	11.2	16.7	48.1	29.4

Results

Annual Seed Production

The diffuse knapweed sites that were sampled all occurred within a precipitation zone of 40 to 50 cm and were characterized by well-drained soils. The general productivity classification of the sites is reflected primarily in the number of flower stems/site and, to a lesser degree, in the number of seed heads/stem and achenes/flower. We attribute variations between years shown in Table 2 to be primarily due to seasonal differences in precipitation. The growing season of 1973 was hot and dry when compared with the long-term average and the resultant lowering of achenes/seed head is observed. In contrast, the 1975 season had above-normal precipitation and significant increases in the number of seed heads/flower stem and total seed production were measured.

Table 3. Components of annual seed production of spotted knapweed sampled at selected sites in Northern Idaho.

Site No.	1973	1974	1975	1976	1973	1974	1975	1976
	Number flower stems/m²				Avg. number seed head/flower stem			
8	36.4	49.3	48.8	41.3	21.7	7.4	8.6	12.6
9	11.2	39.8	25.2	31.4	12.0	8.0	9.3	9.3
10	—	94.2	65.0	51.6	—	25.8	37.3	17.9
11	—	—	50.5	59.4	—	—	6.0	4.9
Avg	23.8	61.1	47.4	45.9	16.8	13.7	15.3	11.2
	Avg. number seed/flower head				Calculated, 000 seed/m²			
8	24.2	32.1	25.6	30.3	19.3	10.4	10.7	15.7
9	24.4	29.4	36.7	35.0	3.3	7.2	8.6	10.2
10	—	27.5	37.2	33.7	—	70.3	90.2	31.1
11	—	—	29.1	32.9	—	—	8.8	9.6
Avg	24.3	29.7	32.2	33.0	11.3	29.3	29.6	16.7

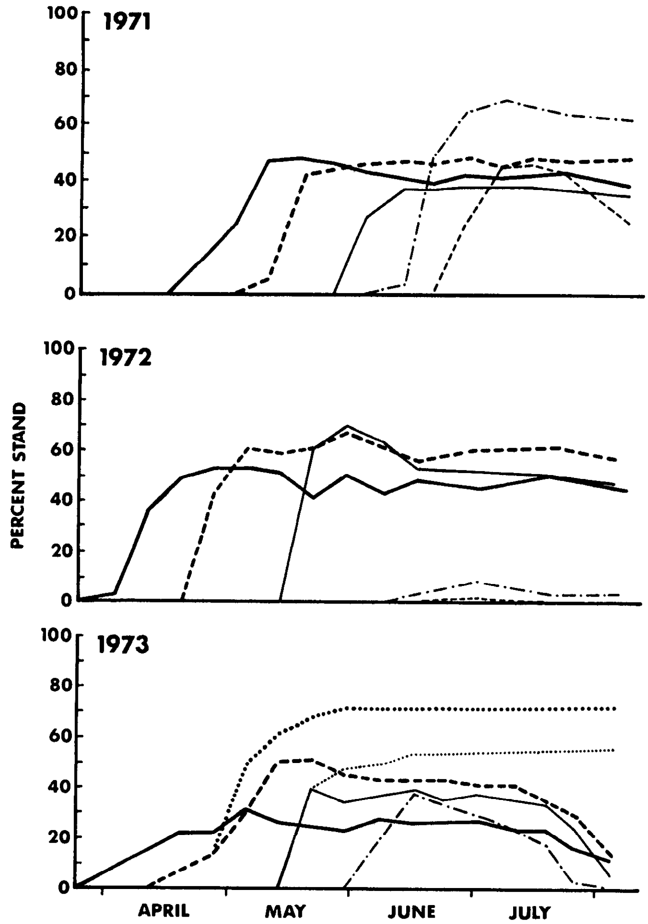

Fig. 1. *Observed stand of diffuse knapweed seeded on various dates in 1972, 1972 and 1973. Cumulative emergence is shown for the April 11 and May 2, 1973, seedings (-----).*

All the sites sampled for spotted knapweed occurred in the 64 to 76 cm precipitation zone. Less variability between years was measured with diffuse knapweed (Table 3). Although seed production per unit area is similar for these two species, the fact that spotted knapweed normally produces multiple flower stems would reflect higher levels of seed production per plant.

It is readily apparent that survival of only about 0.1 percent of the seed produced is required to maintain the stand at the level we observed. If biocontrol agents, such as *Urophora affinis,* that act primarily on the developing seed are to reduce the density of existing stands, it appears that very high levels of parasitism would be necessary. Such agents, nevertheless, might be ineffective in retarding the spread of these weeds to adjacent, noninfested areas.

Table 4. Stnad (no./m²) and percent of plants flowering 1 year after seeding diffuse and spotted knapweed.

	Diffuse						Spotted			
	Stand			% flowering			Stand		% flowering	
Seeding date	1972	1973	1974	1972	1973	1974	1972	1973	1972	1973
March 25	—	45	22	—	89	70	27	29	93	89
April 11	41	51	30	88	76	70	18	14	94	21
May 2	37	34	7	70	62	14	0	3	0	0
May 14	25	—	—	72	—	—	—	—	—	—
May 23	8	1	0	25	65	0	0	2	0	0
June 10	3	0	2	0	0	0	0	2	0	0
July 3	—	0	13	—	0	0	0	16	0	0

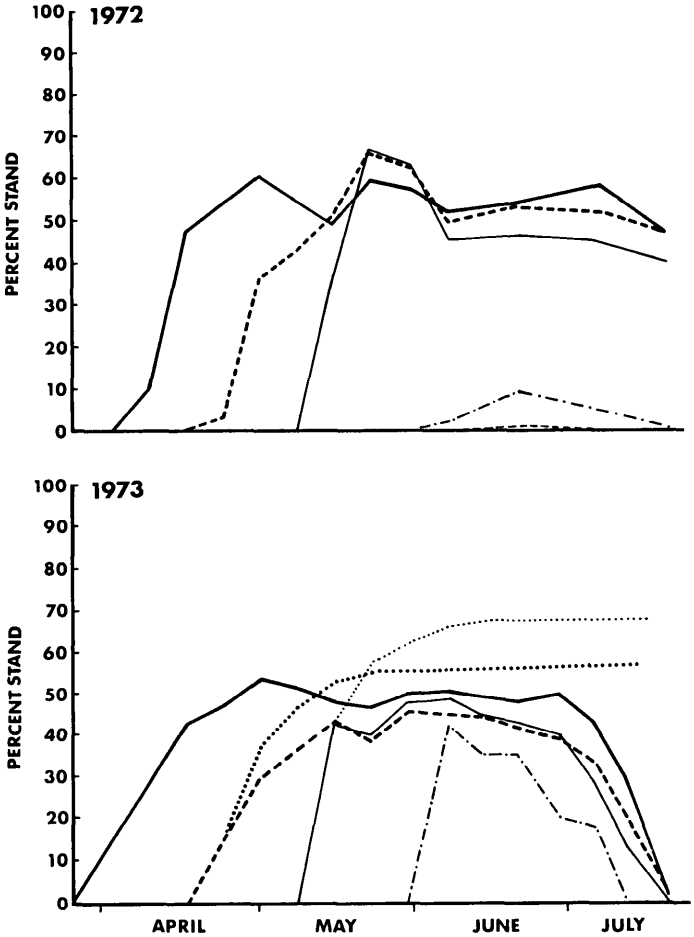

Fig. 2. *Observed stand of spotted knapweed seeded on various dates in 1972 and 1973. Cumulative emergence is shown for the April 11 and May 2, 1973, seeding.*

Spring Seedlings Establishment

Seedlings stands observed on various dates after seeding are shown in Figures 1 and 2. The maximum stand observed for seedings prior to June is basically the same. However, the survival of these plants decreases with delay in emergence as shown by the survival of these plants 1 year after seeding (Table 4).

Since maximum observed values in the field were considerably below the viability level shown in laboratory tests, we attempted in 1973 to measure mortality and delayed emergence. The total observed emergence from the April 11 and May 23 dates are also shown in Figures 1 and 2. It is possible that seedlings emerged and died between our weekly observations. Seedlings emerged in the fall only from seed planted in June or July and had given no emergence during the summer season. The factor of dormancy caused by light suggested by Watson and Renney (1974) should have been minimized in that the seeds were covered with soil, yet a significant number of seed failed to emerge.

In all years the leaves of the emerged seedlings totally dessicated during August. Fall regrowth occurred only on those plots where seedlings had emerged prior to June.

Flowering the year of seeding was observed only from the earliest seeding date and was less than 1% of the plants in any year. Flowering 1 year after seeding was also directly related to the time of emergence. March and April seeding produced flower stems from 70 to 95% of the plants while no flowering occurred from the June or July plants. Therefore, if emergence is effectively controlled with herbicides through June, only minimal flowering is likely to occur in the following growing season.

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