GERMINATION AND EMERGENCE OF NODDING THISTLE, *CARDUUS NUTANS* L.

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Summary. Innate dormancy of fresh seed of nodding thistle, *Carduus nutans*, was lost during four month's dry storage. Best germination was at 20-25°C in light. In seed burial experiments, seed at the soil surface disappeared in 2-3 years, but seed at 5 or 20 cm survived for 10 years. In a field experiment without flowering thistles seedlings were counted monthly for four and a half years in pasture, bare ground or lightly cultivated plots. Most emergence occurred in autumn. In vegetation-free plots significant emergence also occurred in spring. Emergence declined more rapidly in vegetation-free plots. Extrapolation suggested that seedlings would emerge for 7 years in vegetation-free plots and for over 13 years in pasture.

INTRODUCTION

Nodding thistle is a prolific producer of long-lived seed. In parts of New Zealand and Australia it is a noxious plant, which means that there are legal requirements to limit its spread and, where possible, to eradicate it. Size and longevity of seed banks in the soil are important in determining methods of control.

In pastures with a history of nodding thistle infestations, the soil contains 300 to 5000 seeds m^{-2} (6). One study of longevity (1) suggested that seed germination could fall to 1% after 15 years' burial at a depth of 23 cm.

This paper described work on seed longevity, periodicity of germination and germination characteristics of nodding thistle.

METHODS

1. Laboratory germination. Seed on nodding thistle was collected in Hawkes Bay in February 1983. Germination was tested on the day of collection and at 2-monthly intervals, after drying and storage at 20°C. Seeds were placed on germination trays in incubators at a range of constant temperatures or, in some cases, at alternating temperatures. Where germination was tested in the dark, seeds on germination trays covered with black polythene were counted under UV light in a dark-room. Germinated seeds were counted and removed for 35 days.

2. Seed burial experiments. Artificially buried seeds were exhumed annually for 10 years. Details of techniques are shown in (5).

3. Seedling emergence in the field. The site was a grazed paddock with a long history of nodding thistle infestation on Argyll Road near Otane in central Hawkes Bay. The experimental area, and the surrounding 20 m, were treated with MCPB (butyl ester) + clopyralid (amine salt) at 1+0.028 kg a.i. ha^{-1} in April 1981 to kill all thistle rosettes and seedlings. Plot size was 3.3x1.5 m, and the four treatments were in five randomised blocks. Treatments were: 1. Pasture caged from stock, mown occasionally; 2. Pasture grazed; 3. Paraquat (2 g a.i.L^{-1}) first applied 13 May 1981; re-applied when necessary to maintain bare soil. Glyphosate (4 g a.i.L^{-1}) was used when paraquat failed to kill the weeds present. Plots caged from stock; 4. Paraquat applied

13 May 1981; soil lightly cultivated to a depth of 5 cm on 18 June 1981 with a hand-held cultivator. Treatments repeated when necessary (every 3-4 months). Plots caged from stock.

At monthly intervals nodding thistle seedlings in each plot were counted and removed. The area within 20 m of the plots was kept free of flowering nodding thistles by boom spraying, spot spraying and grubbing.

In March 1984, the plots of Treatment 1 were treated with paraquat and half of each plot, selected at random, was then lightly cultivated. Both treatments were repeated at intervals. The experiment continued until February 1986.

RESULTS AND DISCUSSION

1. Laboratory germination. Freshly collected seed showed some innate dormancy at constant temperatures (Fig. 1). This dormancy gradually decreased over four months' dry storage. Germination was greatest at 20 and 25°C. Innate dormancy was less evident at alternating temperatures, with 71% of freshly collected seed germinating at 20-25°C for 16/8 h in light. After two months' storage, seed tested under these conditions gave 82% germination, whilst seed tested at the same temperatures but in total darkness gave only 19% germination.

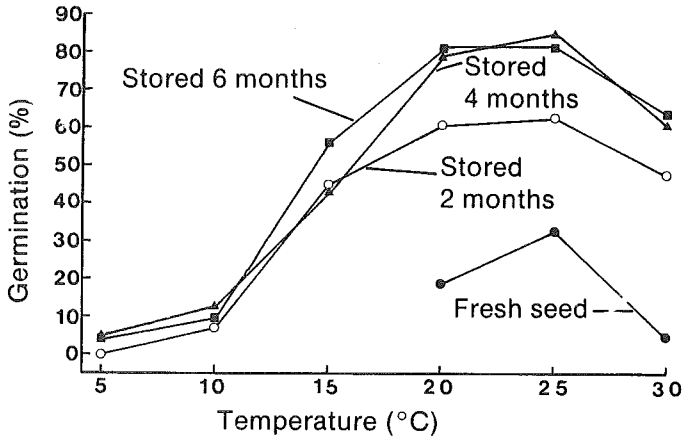

Figure 1. Germination of nodding thistle seed at different constant temperatures in the light.

The dormancy of freshly shed seeds, and requirement for warm temperatures and light for germination of seed shown here are in general agreement with reports in the literature (2, 3).

2. Seed burial experiments. As shown in (5), seed buried in the top 2 cm of the soil survived for only 2-3 years, partly because of germination. However, viability of seeds buried more deeply gradually declined over 10 years; at 4-6 cm depth viability loss was 3% per year, and at 19-21 cm 1.6% per year. At these rates, using 5% confidence limits, seed at 4-6 cm would take 18 to 28 years to be eliminated, and at 19-21 cm, 34 to 77 years.

3. Seedling emergence in the field. Most seedlings emerged in the lightly cultivated treatments and least in the grazed pasture (Table 1). After the caged, mown plots of Treatment 1 were treated with paraquat in March 1984, many new seedlings emerged and cultivation increased that number.

Table 1. Seedling emergence (plants/m^2) of nodding thistle in the field.

Treatment	Emergence up to 29.3.84[a]	Treatment applied on 29.3.84	Emergence 29.3.84 to 18.2.86
1. Caged, mown pasture	109	cultivated	212
		bare ground	131
2. Grazed pasture	64	unchanged	3
3. Bare ground	248	unchanged	4
4. Lightly cultivated	340	unchanged	5

[a] l.s.d. for difference between treatments 177.7 (P = 0.05)

In Figure 2, data from Treatments 1 and 2 have been combined where appropriate. In all treatments in most years, most emergence occurred between February and April, with a second peak between August and October (Fig. 2). The difference between these peaks was most pronounced in the pasture plots.

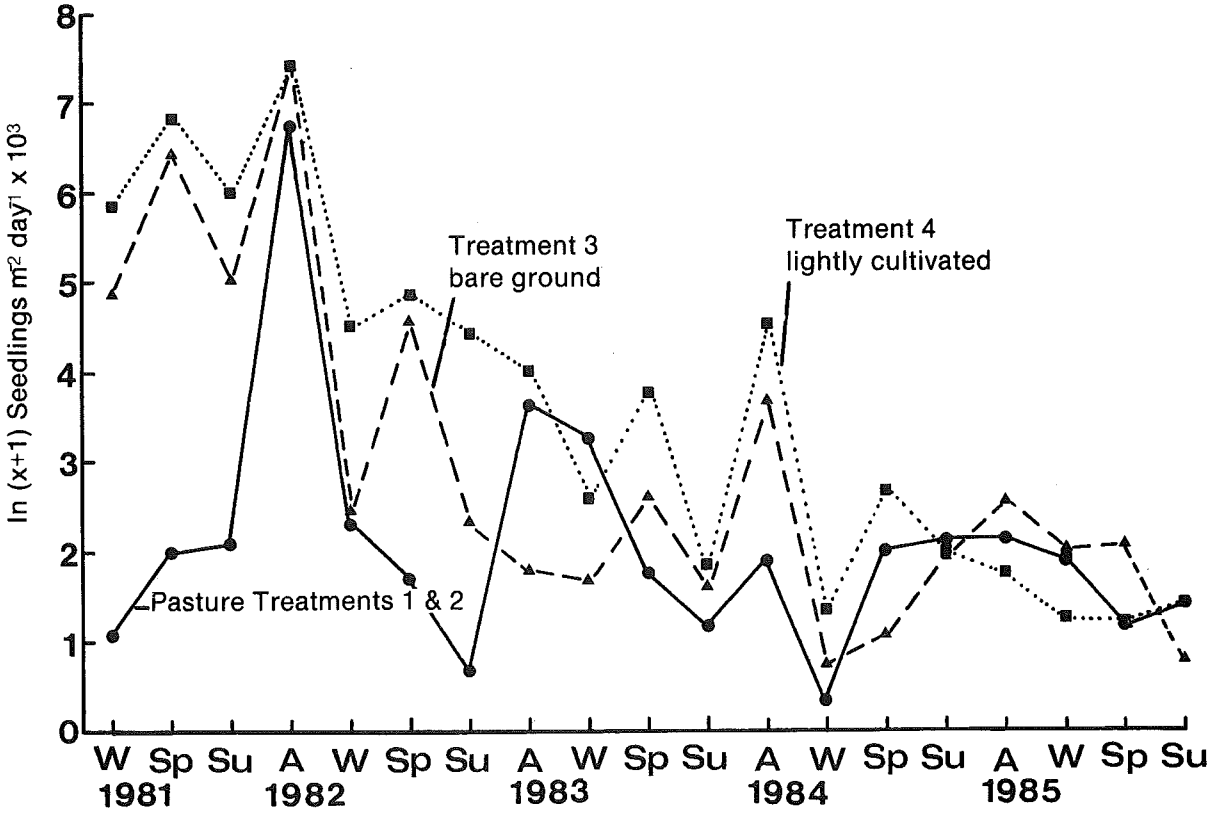

Figure 2. Average daily emergence, over three-month periods, of nodding thistle seedlings from natural seed populations, W = May, June, July: Sp = August, September, October: Su = November, December, January: A = February, March, April.

The slope of the regression line of emergence on time for pasture plots (Treatments 1 and 2: $Y = -0.069 x + 2.75$: $r^2 = 0.08$: $n = 19$) was significantly less than that for Treatment 3 ($y = -0.24 x + 5.36$: $r^2 = 0.53$: $n = 19$) or Treatment 4 ($y = -0.32 x + 6.78$: $r^2 = .81$: $n = 19$). This implies that a chemical or a cultivated fallow would eliminate nodding thistle seeds from the soil more quickly than leaving pasture there. Extrapolation of the regression lines suggests that seedlings would continue to emerge for about seven years in the bare ground or cultivated plots, and for about 13 years in pasture.

The innate dormancy of freshly-shed seed helps to ensure that some seed becomes buried before the first effective rains of autumn, or can remain dormant until covered by pasture species recovering from drought. Once seeds are buried or covered by pasture, other dormancy systems are activated (3, 4).

Seedling emergence is inhibited by pasture cover (4). In the absence of pasture, more seedlings emerge and there is also appreciable spring germination, as can happen in Britain (7).

Seeds continue to germinate over several years. Possibly, buried seeds are brought to the surface by, for example, earthworm activity, or, buried seeds may lose enforced dormancy through factors such as dry heat in summer, or cool, moist conditions in winter. The greater autumn germination peaks, even in bare ground, suggest that warm, dry conditions in summer may be an important stimulus.

A fallow, with or without cultivation, does not seem to be a practical way of quickly ridding the soil of nodding thistle seeds. Probably the best method is to maintain a vigorous pasture. This would ensure that nodding thistle seedlings only emerge in the autumn and they can then be controlled by a single herbicide application each year. Even so, it would be many years before the seed bank was exhausted.

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