FIELD STUDIES OF RAGWORT ESTABLISHMENT

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SUMMARY

To help understand the factors influencing the establishment of ragwort (*Senecio jacobaea*), a field trial was conducted on a bull beef farm in hill country near Woodville. A number of different treading and defoliation treatments were imposed during August and the subsequent germination of ragwort seedlings was monitored. Grazing and treading both caused large increases in ragwort germination compared with ungrazed control plots, though many of the seedlings subsequently died over summer. In a separate experiment, removal of pasture cover at monthly intervals from August to February suggested that germination is markedly reduced by pasture cover and summer dryness but apparently not by cool winter temperatures.

Keywords: ragwort, *Senecio jacobaea*, pasture density, defoliation, germination.

INTRODUCTION

As ragwort is a biennial species, understanding factors affecting its germination and establishment are important when developing control programmes. The presence of pasture cover has been shown to strongly inhibit the successful germination and establishment of ragwort (Poole and Cairns 1940; Phung and Popay 1981). The effects of low fertility and previous herbicide applications on pasture density are two factors which have been identified as allowing ragwort to successfully establish (Rahman *et al.* 1993). This paper discusses a study to determine the influence of defoliation and treading by cattle on ragwort germination and establishment within a pasture.

If germination is inhibited by low temperatures or dry soil conditions, there might be times of the year when disturbance of the pasture cover is less likely to result in successful ragwort establishment. Poole and Cairns (1940) found that ragwort seeds sown into cultivated soil germinated well throughout winter in Waikato, but germination declined during drier months of the year. The influence of temperature and moisture on the germination of naturally occurring soil populations of ragwort seeds were investigated under the cooler conditions of a hill country site near Woodville to confirm this observation.

METHODS

Treading and defoliation trial

A hillside pasture dominated by browntop (*Agrostis capillaris*) at the bull beef unit on the AgResearch Ballantrae Research Station near Woodville was split into three blocks. Within each block, six treatments applied to the pasture involved various combinations of treading or not treading, grazing or not grazing, and removing all pasture or leaving the pasture cover intact (Table 1). Treading and grazing was done by 27 heifers run at the equivalent stocking rate of 205 heifers/ha. Grazing involved defoliation from a pasture cover of 2100 kg DM/ha (12 cm height) down to 700 kg DM/ha (2.5 cm height). Treading was estimated (by recording the proportion of ground covered by hoof marks using point analysis) to have occurred on 72% of the ground, which at the time had a soil moisture of 42%. Grazing without treading was achieved

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by heifers grazing underneath electrified wires. Treading without grazing was achieved by walking animals around the plot without letting them stop to graze. Areas which were not grazed or trodden were protected by cages. For treatments where the pasture cover was removed, foliage was clipped to ground level once then left to regrow. The dimensions of plots varied between treatments because of the difficulty in imposing some of these treatments over large areas. All treatments were imposed over a 3 day period commencing on 28 August 1993, apart from the treatment involving treading without grazing which occurred for 1 hour on 31 August 1993.

The site selected for the trial had ragwort seeds already present in the soil from plants which had flowered in previous seasons. Two quadrats 0.4 x 0.4 m were randomly selected within each treated area when treatments were imposed and ragwort seedlings already present were removed. Seedling numbers within the quadrats were counted 5, 15 and 22 weeks after treatment. All plots were grazed with bulls 8, 14 and 19 weeks after treatment imposition and with ewes after 21 weeks for 3 day intervals at 95 stock units/ha as part of the normal pasture management. Ragwort seedlings within quadrats were not defoliated by the livestock. After the final count, four soil samples (each 5 cm diameter and 2 cm deep) were taken from each quadrat and placed for 30 days in thin layers under an automated mist irrigation system in a glasshouse with an average temperature of 20°C to encourage all remaining ragwort seeds to germinate. Seedling emergence in each quadrat was then expressed as a percentage of total seeds estimated to be present in the soil at the start of the trial. Results for both this and the next experiment were analysed by the non-parametric Wilcoxon sum-rank test.

Periodicity of emergence

At the same site as the first experiment, ten 0.4 x 0.4 m quadrats were randomly selected each month from August 1993 until February 1994 and enclosed by cages to prevent access by livestock. Half the quadrats had all vegetation removed by spraying on a 4.8 g/litre solution of glyphosate (Roundup) then clipping to ground level 1 week later. Pasture was left intact in the other quadrats as a comparison. Each treatment was replicated five times. Seedling emergence was counted 4 weeks after clipping of vegetation. Soil moisture at the site was monitored weekly by calculating the gravimetric water content of soil samples. The average soil temperature at 10 cm was recorded daily at a nearby weather station.

RESULTS AND DISCUSSION

Fewest seedlings emerged where pasture was not disturbed, while all three forms of disturbance caused significant increases in ragwort seedling emergence (Table 1). Complete removal of the pasture cover caused the greatest increase in seedling emergence, while treading and grazing also stimulated germination of ragwort seeds but to a lesser extent.

The stimulation of ragwort germination for all three forms of disturbance could be explained entirely by the removal of pasture cover. The reduced cover allowed seeds in the soil to be exposed to light at a higher intensity and with an increased red/far red ratio which would affect the phytochrome system within seeds (Phung and Popay 1981). Light is known to stimulate ragwort germination (van der Meijden and van der Waals-Kooi 1979), and it has been suggested that a phytochrome system exists within ragwort seeds to allow light quality to influence germination (Wardle 1987).

Apart from causing damage to pasture cover, treading also results in some movement of the soil, especially under moist or wet conditions. Ragwort seeds buried below 4 mm will not germinate (van der Meijden and van der Waals-Kooi 1979), so soil movement by hooves may result in seeds previously buried too deep to germinate becoming exposed to light. Treading might also bury seeds that were previously shallow enough to germinate, so the net effect of treading on seedling germination may depend on whether ragwort seed densities were highest at the surface or deeper in the soil.

An average ragwort seed population of 2955 seeds/m^2 was estimated following the 30 day exposure of soil to light in the glasshouse. The maximum population estimate was 14,543 seeds/m^2, though this assumes that all seeds had germinated in the glasshouse. Actual seed numbers per square metre were probably higher than this as only the surface 2 cm of soil was tested.

TABLE 1: Emergence of ragwort seedlings 5 and 15 weeks after pasture disturbance, and seedling mortality between the 15th and 22nd weeks after treatment.

Treatment			% seeds which germinated		% seedling mortality by late January
Grazing	Treading	Cover	After 5 weeks	After 15 weeks	
o[1]	+	o	27.5 a[2]	25.5 a	68 *[3]
o	o	o	20.1 ab	20.6 ab	75 ns
o	+	+	10.9 bc	14.9 ab	58 *
+	+	+	7.8 bc	12.3 b	66 *
+	o	+	6.0 c	11.1 b	74 *
o	o	+	0.1 d	1.2 c	100 ns

[1] Symbols signify presence (+) or absence (o) of grazing, treading or cover for each treatment
[2] Mean values within a column sharing the same letter are not significantly different (P>0.05).
[3] Asterisks denote significant (P<0.05) decreases in seedling numbers; ns = decrease in seedling number not statistically significant.

Phung and Popay (1981) sowed ragwort seeds into pasture and compared percent germination of seed in pasture with that from bare soil. They obtained 30.8% germination from their bare soil, which was similar to our estimate of germination percentage from uncovered soil. However they recorded 15.2% germination from pasture trimmed weekly to a height of 6-7 cm, suggesting the presence of pasture cover only halved the germination of ragwort seeds. Although pasture may have been longer in our undisturbed plots, results from this trial suggest pasture cover reduces emergence by over 99%, much more than the 50% reduction measured by Phung and Popay (1981). Poole and Cairns (1940) recorded an average germination of 4.1% of seeds sown into pasture, and many of these seedlings subsequently died.

There were no significant changes in seedling numbers between 5 and 15 weeks after imposition of the treatments (Table 1). However there was high seedling mortality in all treatments over the following 7 weeks (late December and January), and observations suggest this was mainly due to competition from pasture plants which had recovered fully from all treatments. As soil moisture was decreasing over this time (Table 2), competition for water may have been more important than competition for light or nutrients. Thus although severe pasture disturbance can result in greatly increased germination of ragwort, good pasture management in following months may allow the seedling populations to be reduced again.

The effect of pasture cover on ragwort seed germination was again clearly illustrated in results obtained from the periodicity of emergence experiment (Table 2). Differences between the covered and uncovered plots in seed germination was significant at all times except in February when very few seeds emerged in either treatment. Prior to February, seed germination from the plots covered by pasture was on average only 3.7% of that from bare ground.

Variability in results meant that differences in seedling emergence between months were not significant (P>0.05) for plots covered in pasture. However where ragwort seed germination was not being inhibited by pasture cover, there was a gradual decline in emergence from spring through to late summer (Table 2). The decline can be explained by the strong relationship between seedling numbers and soil moisture

(Pearson correlation coefficient = 0.89, P<0.01). Poole and Cairns (1940) also noted this correlation when they conducted a similar trial sowing ragwort seeds into cultivated soil throughout the year.

TABLE 2: The effect of time of year on ragwort seedling emergence from bare and pasture-covered soil.

Month when cover removed	Soil moisture (%)	Soil temperature (°C) at 10 cm	Number of seedlings/m² Bare ground	Pasture intact	Difference[2]
August	48.7	8.4	446 a[1]	6.2	**
September	51.5	9.5	600 a	21.8	*
October	46.0	13.8	466 a	5.0	**
November	49.9	15.0	264 ab	12.5	**
December	34.5	17.0	169 b	11.2	**
January	31.9	19.9	50 b	2.5	*
February	25.3	20.3	3.7 c	2.5	ns

[1] Means sharing the same letter are not significantly different (P>0.05)
[2] Differences between bare and covered ground with ** differ significantly at P<0.01, those with * differ only at P<0.05 but not P<0.01, those with ns do not differ at P>0.05

There was also a highly significant negative correlation (r = -0.93, P<0.01) between soil temperature and seed germination. However it appears unlikely that high temperatures were inhibiting germination as laboratory studies have shown that ragwort germination improves as temperature rises from 10°C to 20°C (van der Meijden and van der Waals-Kooi 1979).

Despite lower germination in the laboratory under cooler conditions, the soil temperature was still high enough at Ballantrae in August to allow large numbers of ragwort to germinate in the trial. The seedling periodicity trial is continuing at Ballantrae to investigate germination earlier in winter.

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