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Regeneration and survival of *Desmanthus virgatus* 78382 in grazed and ungrazed pastures

D.M. BURROWS[1] AND F.J. PORTER[2]
[1]*Department of Primary Industries, Gayndah, Queensland, Australia*
[2]*Biodynamic Research Institute, Powelltown, Victoria, Australia*

Abstract

Soil seed reserves, hard seed breakdown, seedling recruitment and plant longevity of *D. virgatus* CPI 78382 were measured under grazing and in exclosures. Soil seed reserves averaged 150 seeds/m^2 in grazed and ungrazed areas for most of the study, but increased to 450 seeds/m^2 in the grazed areas after 3 years. Seed lots placed in the field showed a 40% decrease in hard seed levels over 3½ years. Seedling recruitment was higher under grazing as were adult plant populations. Although plant survival was marginally higher in the exclosures, more than 50% of plants had died 6 months after establishment.

Introduction

Desmanthus virgatus (desmanthus) has shown promise as a pasture legume suitable for clay soils in the subcoastal and semi-arid grazing lands of Queensland (Cook *et al.* 1993). However, very little information exists on the population dynamics of the species under grazing.

Populations of any species are governed by longevity of established plants and/or the ability to recruit from seed. The importance of these two survival strategies varies with species and environmental conditions.

By studying individual plants in a pasture, the longevity of the plant under both grazing and environmental stresses can be determined (Orr and Evenson 1991). Monitoring the soil seed bank over several years indicates the potential of the plant species to regenerate under favourable conditions. Most legumes have a hard seed coat, which prevents all viable seeds from imbibing moisture and germinating in the first year following seed set. For example, the persistence of annual temperate legumes depends on seed survival during the summer months as hard, impermeable seed (Taylor and Ewing 1992). The value of hard seed is also apparent for sown legumes in northern Australian grazing lands (Jones and Carter 1989). Thus, if dry conditions arise before newly established seedlings are able to flower and set seed, the residual population of hard seed will persist until favourable conditions return. However, extreme hardseededness may limit the ability of a species to exploit favourable establishment conditions in newly established pastures, thus leading to poor recruitment of second-generation plants. Hard seed levels in excess of 90% have been found in some desmanthus seed lots (Loch and Harvey 1992) but no information is available on rates of desmanthus seed softening under field conditions.

This paper reports on 2 experiments. The first measured plant longevity, seedling recruitment and soil seed reserves of desmanthus under grazed and ungrazed conditions. The second measured the effect of scarification, seed burial and pasture mowing, to simulate grazing, on the breakdown of desmanthus hard seed in the pasture.

Materials and methods

Both experiments were located at Brian Pastures Research Station (25°39′S, 151°45′E, 720 mm AAR) on a moderately self-mulching and cracking brown clay soil of pH 6.5 with an alkaline trend at depth (Reid *et al.* 1986) (Ug 5.32, Northcote 1979).

A grazing trial to assess productivity of desmanthus 78382 when sown with purple pigeon

Correspondence: Mr D.M. Burrows, Brian Pastures Research Station, Gayndah, Qld 4625, Australia

grass (*Setaria incrassata* cv. Inverell) was established in November 1987. 78382 originates from north-west Argentina (24 °S, 65 °W) (Reid 1977), and is morphologically similar to cultivar Marc (78373) which was released in August 1991. Seed was sown at the rate of 4 kg/ha of desmanthus and 3 kg/ha of purple pigeon grass into a fully cultivated seedbed. The desmanthus seed was scarified by hot water treatment at 80 °C for 5 minutes, and inoculated with a peat culture of *Bradyrhizobium* strain CB 1397.

Paddock size was 2.7 ha with 2 replications and the stocking rate was 3 weaner heifers/paddock which is 0.5 adult equivalent/ha. A 14 x 30 m exclosure was placed in each of the desmanthus paddocks in January 1988, to allow comparison of grazed and ungrazed areas for the 2 experiments.

Experiment 1

Individual desmanthus plants were monitored by randomly locating 10 permanent quadrats within the grazed area of each paddock, and 6 permanent quadrats within the ungrazed exclosure in each paddock. The 0.5 m^2 quadrats were recorded approximately 4 times a year from the initial charting in June 1988–1992. The number and location of plants in each quadrat were charted using a technique described by Orr and Evenson (1991). By comparing successive pairs of charts, it was possible to determine those plants which had survived or died, and to identify new recruits, recorded within a quadrat for the first time. At subsequent recordings those plants were defined as adults.

Soil seed reserves were measured each year in early spring by taking 20 randomly selected cores from each of the 2 grazed and ungrazed areas. Each core had a surface area of 21 cm^2 and was 7.5 cm deep. The soil cores were washed through a fine (1.2 mm mesh) sieve with water, leaving behind seed, small stones and organic material.

Desmanthus seed was hand-extracted from this material and counted. Germination tests (21 days) were carried out on the 1990 and 1991 samples to determine percentage hard seed.

Experiment 2

The rate of hard seed breakdown was determined by studying 100 desmanthus seeds placed in fine weave (0.5 mm mesh) nylon bags, similar to those used by Mott *et al.* (1981).

There were 2 replications of a split-plot experiment with a combination of the following treatments: scarification (hot water (80 °C) treated and untreated seed) and seed burial (seed placed on the soil surface and buried 2 cm below the soil surface) as subplots within mown or unmown main plots.

To measure the effect of annual climatic variation, the nylon bags containing the seed samples were placed in the field in mid-summer each year for 2 years from 1988–1989. The same batch of seed was used for the entire experiment, and was held in cold storage between plantings. An inital germination test gave hard seed levels of 33% and 60% for treated and untreated seed, respectively. Bags placed in the field in February 1988 were recovered in 1988, 89, 90 and 91 with 2–4 recoveries within each year. Similarly, bags placed in the field in October 1988 were recovered in 1989, 90 and 91, and bags placed in October 1989 were recovered in 1990 and 1991.

No attempt was made to remove the material from the mown plots as this may have dislodged some of the seed bags. Within each block, bags were placed randomly on a 6m^2 grid pattern marked every 0.5 m by small pegs.

Recovered bags were opened and any seeds remaining were germination-tested to determine the proportion of hard seed. Analyses of variance were used to test the main effects of scarification, planting depth, pasture mowing, recovery time, and their interactions. An individual nylon bag was the experimental unit. The 3 plantings were analysed separately. Treatment means were compared using the protected LSD procedure at the 5% level of significance.

Results

Monthly rainfall is presented in Figure 1. Significant episodes included a wet winter in 1988 followed by good rain in December, a wet autumn in 1990, and drought conditions in mid-1991. The paddocks were de-stocked from November 1989–January 1990.

Experiment 1

Adult plant populations (Figure 2) declined from an initial 11.9 and 9.5 plants/m^2 in the grazed and ungrazed quadrats, respectively, to 2.8 and 3.5 plants/m^2 in January 1991. Seedling recruitment (Figure 3) in the grazed quadrats declined from 1988 (4.8 plants/m^2) to 1990 (1.4 plants/m^2). In January 1991, a new flush of seedlings (5.5 plants/m^2) in the grazed quadrats contributed to the existing adult plant population to give 8 plants/m^2 in the subsequent recording. Another larger recruitment event in November 1991 (13.4 plants/m^2) led to 9.6 adult plants/m^2 in the grazed quadrats at the final recording. The ungrazed quadrats had fewer seedlings than the grazed quadrats at each recording.

Plant survival is depicted for the initial cohort (Figure 4) and for those subsequent cohorts (bulked data) which had the highest populations at establishment (Figure 5). Although some desmanthus plants survived for up to 4 years, plant mortality was generally high, with greater than 50% of plants in the initial cohort dead 4 months after establishment. Subsequently, ungrazed plants had higher survival than grazed plants. This trend was also apparent for other cohorts (Figure 5), but survival data from the ungrazed cohorts is based on lower plant numbers.

Field observations indicated that cattle trampling occasionally led to individual plant death, particularly when the soil was moist.

Soil seed reserves were *c.* 150 seeds/m^2 throughout the study except for the grazed paddocks in 1991, when soil seed reserves increased to 450 seeds/m^2. The recovered seed was consistently over 80% hardseeded.

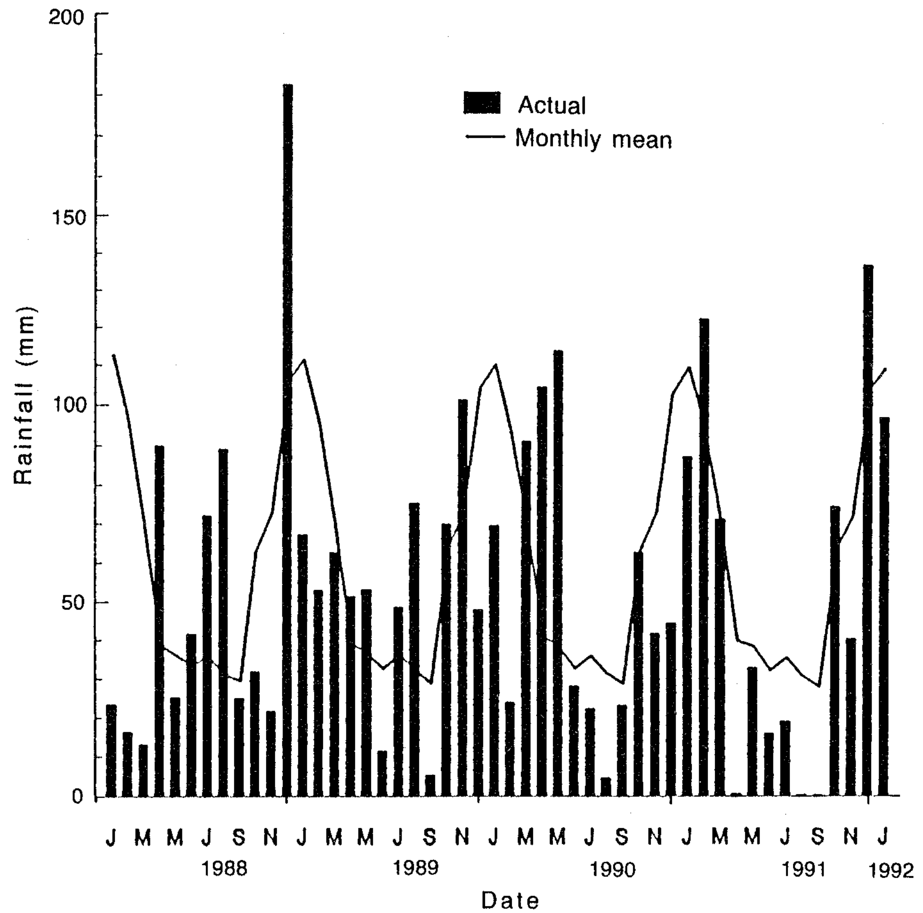

Figure 1. Monthly rainfall for Brian Pastures during the study.

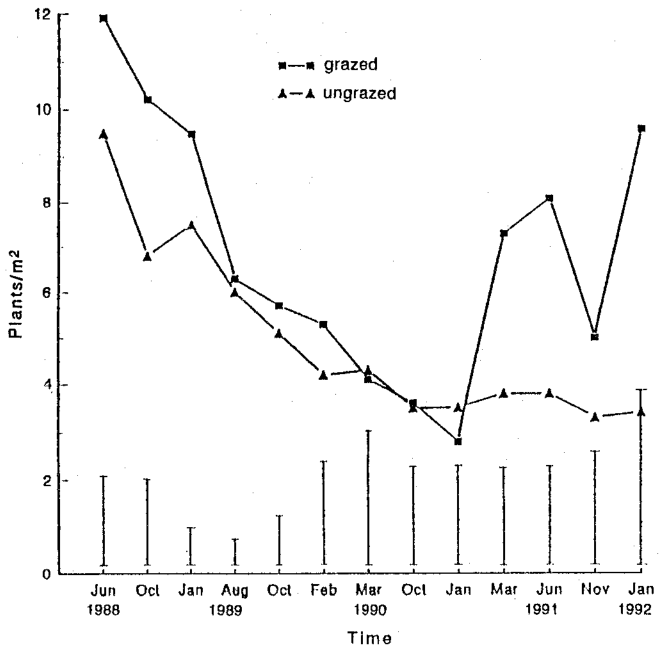

Figure 2. Changes in adult *D. virgatus* plant populations in grazed and ungrazed quadrats (Experiment 1). Vertical bars represent standard errors of means.

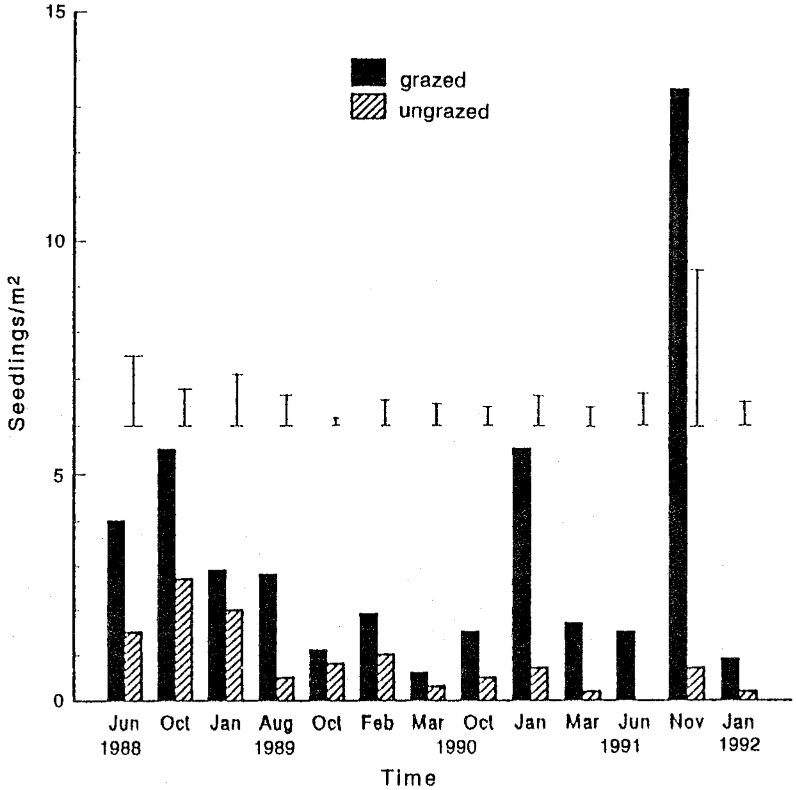

Figure 3. Recruitment of *D. virgatus* seedlings in grazed and ungrazed quadrats (Experiment 1). Vertical bars represent standard errors of means.

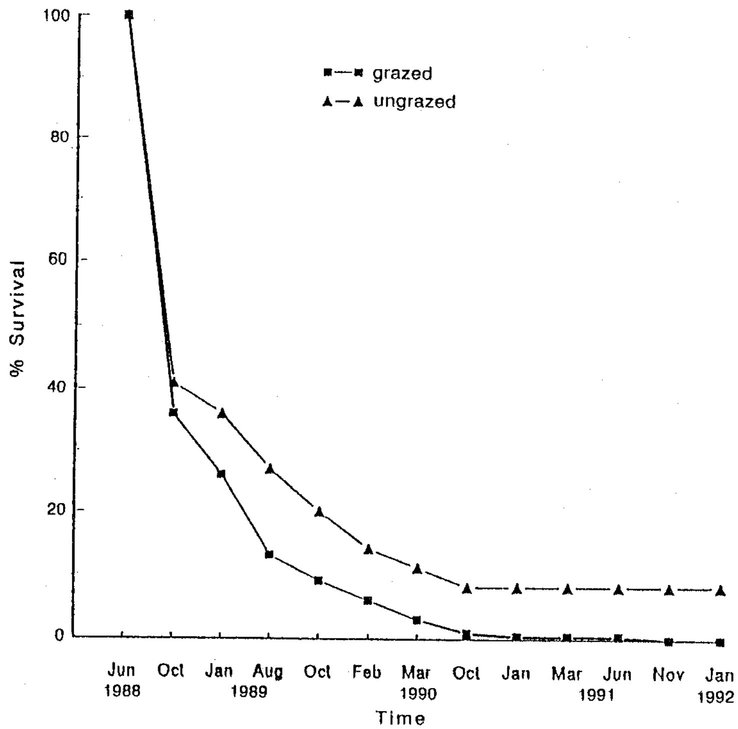

Figure 4. Percent survival of initial *D. virgatus* cohorts in grazed and ungrazed quadrats (Experiment 1).

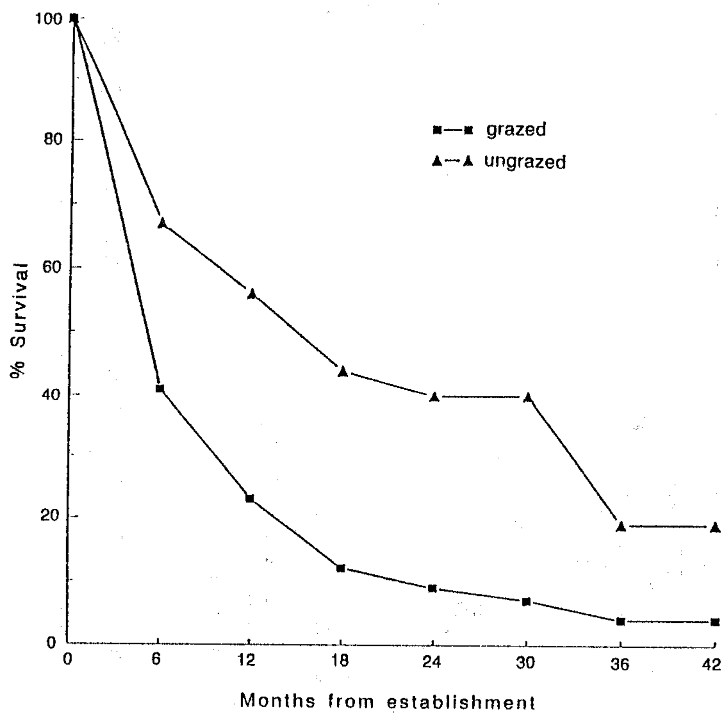

Figure 5. Percent survival of subsequent *D. virgatus* cohorts (bulked) in grazed and ungrazed quadrats (Experiment 1).

Experiment 2

The seed scarification treatment significantly reduced hardseededness in all 3 plantings (Table 1). Seed burial significantly reduced hardseedness by 14 and 20%, respectively, in the first 2 plantings. Pasture mowing had no effect on hardseededness. Table 2 shows significant reductions in hardseededness over time for the first 2 plantings.

Table 1. The main effects of seed scarification, seed burial and mowing treatment on residual hard seed percentage averaged over all retrieval dates.

Treatment	1st planting (Feb. 1988)	2nd planting (Oct. 1988)	3rd planting (Oct. 1989)
		(%)	
Seed scarification			
Untreated seed	58.6[a1]	52.8[a]	57.4[a]
Hot water scarified	25.2[b]	23.4[b]	16.3[b]
LSD (P = 0.05)	3.3	2.3	8.6
Seed burial			
Surface sown	45.1[a]	43.1[a]	37.6
Buried at 2 cm	38.7[b]	33.1[b]	36.1
LSD (P = 0.05)	3.3	2.3	8.6
Pasture mowing			
Unmown	42.7	38.7	36.6
Mown	41.1	37.4	37.1
LSD (P = 0.05)	49.5	23.2	38.4

[1]Within main effects, column means followed by a different letter are significantly different.

Table 2. The main effect of retrieval time on hard seed percentage (initially 47%).

Retrieval time (month/year)	1st planting (Feb. 1988)	2nd planting (Oct. 1988)	3rd planting (Oct.1989)
		(%)	
Feb. 1988	—	—	—
June 1988	49.0[a1]	—	—
Oct. 1988	47.7[ab]	—	—
Feb. 1989	43.3[b]	40.0[a]	—
May 1989	42.9[b]	40.3[a]	—
July 1989	42.5[b]	40.8[a]	—
Oct. 1989	36.6[c]	41.4[a]	—
Jan. 1990	—	38.2[a]	33.4
May 1990	—	36.4[a]	—
Oct. 1990	—	—	42.2
June 1991	—	—	39.1
Nov. 1991	31.6[c]	29.9[b]	32.6
LSD (P = 0.05)	5.8	5.2	10.6

[1]Column means followed by a different letter are significantly different.

There were no significant 2 or 3-factor interactions involving scarification, seed burial or retrieval time, so these data are not presented. However, in the first planting, the decrease in hard seed levels over 42 months was larger with scarified seed (48%) than with untreated seed (30%).

Discussion

Seedling recruitment of desmanthus was much higher under grazing. Significant recruitment events can be related to rainfall (Figure 1). Good rains in September–December 1990 probably boosted germination as shown by the January 1991 grazed cohort (Figure 3). Similarly the large recruitment in November 1991 occurred following very dry conditions from July–September, and good rainfall in October. However this trend was not apparent in the ungrazed quadrats. Given that the soil seed reserves in 1990 were *c.* 150 seeds/m^2 in both the grazed and ungrazed plots, the level of recruitment in January 1991 in the ungrazed quadrats should have been similar to the grazed quadrats if rainfall were the only determining factor. Likewise, seedling recruitment following the 1991 drought was much higher in the grazed quadrats, although by this time, soil seed reserves in the ungrazed area were considerably less than in the grazed area.

The lack of new plants in the ungrazed quadrats was due to fewer seeds actually germinating and/or seedlings emerging but dying before they were recorded. Moisture/light competition from overstorey grass may have killed these shallow-rooted plants. However, any remaining seedlings which grew into adults had higher survival rates than grazed adult plants. This could be because the ungrazed plants were not being regularly defoliated and trampled by cattle, and the shading afforded by overstorey grass may have reduced evapotranspirational stress, particularly in dry times.

Shading from the overstorey grass may have been responsible for higher residual levels of hard seed in the ungrazed quadrats. It is known that legume seed softening in the paddock is due to diurnal temperature fluctuations (Quinlivan 1961). The diurnal temperature range may be less under a canopy of grass than in the open, thus leading to faster rates of seed softening under grazed conditions. However this assertion is not supported by data from experiment 1, which showed that levels of hard seed were very high in soil cores taken from both grazed and ungrazed areas. The soil core data do not account for that reserve of seed that has softened and germinated before the samples were taken. In addition, even at the stocking rate of 0.5 adult equivalent/ha, presentation yields of purple pigeon grass reached 6 700 kg/ha, with an annual average of 3 800 kg/ha (M. Quirk, personal communication). The ungrazed areas had an accumulated grass dry matter yield of 14 500 kg/ha at the end of the trial. It is unlikely that diurnal temperature ranges at the soil surface would have differed greatly between grazed and ungrazed treatments under these conditions, which may explain the high levels of hard seed in soil cores taken from grazed areas.

Experiment 2 also showed no significant treatment differences with simulated grazing. No attempt was made to remove cut grass from the plots, and consequently a layer of mulch developed on top of the seed bags, thus reducing diurnal temperature fluctuations on the seed.

The first 2 plantings showed significant reductions in % hard seed over time (Table 2), but the rate of seed softening was surprisingly slow. For example, the hard seed level in untreated seed from the first planting declined from 66–46 percent over 3½ years. Experiment 2 also showed greater breakdown of hardseededness in buried than in surface-sown seed. Burial markedly reduces the temperature range to which seeds are exposed (Taylor and Ewing 1988), so presumably higher seed softening rates in buried seed are due to other factors, such as moist conditions surrounding the seed, or seed coat breakdown from soil micro-organisms.

Soil seed reserves in this experiment compare poorly with those in other *D. virgatus* pastures, where levels in excess of 2 000 seeds/m^2 have been found (R.M. Jones, personal communication). However, the desmanthus plants in this experiment have not shown the green leaf colour and vigour the senior author has observed in other desmanthus pastures, particularly on brigalow soils. A consequence of this may be reduced seed production leading to low soil seed reserves. Lack of plant vigour and yellow leaves in leucaena have been observed on a similar soil type (Prinsen *et al.* 1992) where a plant response to sulphur has been measured.

The main finding of this study is that grazing stimulates seedling recruitment of *D. virgatus*. This is in accord with Reid (personal communication) who stated that numerous *D. virgatus* accessions were collected from heavily grazed pastures in Argentina. Similarly, De Carvalho and De Mattus (1974) found that native stands of *D. virgatus* in north-east Brazil showed a "remarkable capacity for regeneration under heavily grazed conditions".

More research is required to quantify the effects of different grazing intensities on both recruitment and survival of desmanthus. The stocking rate in the current grazing trial has been increased by 33%, and changes in plant populations and soil seed reserves will continue to be monitored in the permanent quadrats.

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