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SOME EFFECTS OF SPRING DEFOLIATION AND DROUGHT ON PERENNIAL RYEGRASS SWARDS

D.J. BARKER[1], A.C.P. CHU and C.J. KORTE[2]
Agronomy Department, Massey University, Palmerston North

Abstract

An automatic rain-out shelter and an oscillating sprinkler irrigator were used to give contrasting wet and dry soil moisture regimes during summer in ryegrass swards, which had been differentially mown (7.5 cms vs 2.5 cms) during spring to create differences in tiller density. Swards with a higher tiller density before drought had a higher tiller density after drought. Although there was no effect of spring defoliation on summer production, there was a trend for pastures with a higher tiller density to recover more quickly after drought. The effect of water stress was to reduce herbage yield to only 8% of that of irrigated treatments. This was attributed to reductions in tiller density and rates of leaf extension and appearance. Water stress also increased the levels of lamina soluble sugars. Rewatering after moisture stress resulted in compensatory growth which partly offset the yield loss incurred during stress.

Keywords: Spring grazing management, dryland, water stress, perennial ryegrass, sward dynamics, lamina soluble sugars.

INTRODUCTION

New Zealand has a humid climate ideally suited to pastoral agriculture, however, although annual rainfall in most areas exceeds 1000 mm variability between years is high, with 20% of years being considered "wet" and 15% of years being considered "dry" (Salinger 1979). Furthermore, the increased prevalence of drought since 1968 (based on a 58 year average 1920-78) (Salinger 1979) combined with the uneven geographical distribution of rainfall, tending to be drier in the east than the west, necessitates investigation of the effects of water stress on pastoral production in New Zealand.

In some areas of New Zealand relief from summer droughts can be achieved by irrigation, however, large areas of the country must continue to rely on a system of dryland farming. In such cases grazing control is a management tool which may be employed in an attempt to offset the effects of drought.

There is evidence that hard cutting and grazing treatments in summer will reduce subsequent pasture productivity (Jantti & Kramer 1958, Brougham 1960, Hunt & Brougham 1967), and this has been attributed to reduced root development (Garwood & Sinclair 1979). However, in contrast to these results obtained under relatively moist conditions. Vartha & Hoglund (1983) found that on dryland, provided grazing did not bare the pasture, summer grazing did not affect subsequent production. Similarly Korte & Chu (1983) observed that drought reduced leaf expansion and tillering, and that plants in this "dormant" state were unresponsive to defoliation. They went on to predict that to prepare a pasture for summer drought, spring management should encourage root growth to increase the capacity to absorb soil moisture, and a higher tiller density to ensure a denser sward after drought. This trial examined the possibility of using spring defoliation treatments to *prepare* a pasture for dought.

[1] Present Address: Grasslands Division, DSIR, Palmerston North
[2] Present Address: MAF, Gisborne

MATERIALS AND METHODS

Site

The experiment was conducted from 16 April 1981 to 12 July 1982 on the Pasture and Crop Research Unit of Massey University, Palmerston North. The soil type was a Tokomaru silt loam (Cowie et *al.* 1972). The site, which was in permanent pasture for at least five years prior to this experiment, was cultivated and sown (22 April 1981) with "Grasslands Nui" ryegrass (*Lolium perenne* L.) at a rate of 30 kg/ha. Initially the pasture was grazed with sheep, and subsequently was mown.

Treatments

(a) Spring defoliation

Two defoliation treatments, mowing to 2.5 or 7.5 cm at 3 week intervals, were imposed from 5 October until 28 December 1981. After this date a single mowing height of 2.5 cm was used.

(b) Moisture

Two moisture treatments i.e. stressed and irrigated were imposed from 28 December 1981 to 14 April 1982. Initially both treatments were irrigated to field capacity to ensure they were at a common, non-limiting soil water content; the stressed treatment therefore began with no soil water deficit (SWD) and became stressed during the experiment. Rainfall was excluded from the stressed treatment by an automatic rainout shelter (Green 1980). The irrigated treatment was watered using an oscillating sprinkler. Plots were irrigated to field capacity whenever the predicted SWD (Scotter *et al.* 1979) exceeded 60 mm. Water was added on days 0, 29, 48, 92 and 110 after the onset of moisture treatments.

Plot layout

The plot layout was that for a "Combined Experiments" model (Le Clerg *et al.* 1962). Moisture treatments were applied to two adjacent "experiments" each of 8 plots, comprising the two defoliation treatments as randomized complete blocks replicated 4 times.

Measurements

Herbage yield was determined by mowing to 2.5 cm at approximately monthly intervals during moisture treatment and recovery (15 April 1982 – 12 July 1982) periods.

During the treatment and recovery periods 20 tillers per plot were marked along a transect. Leaf appearance (leaves1100 tillers/day) and extension rates (mm/leaf/day) were measured at 2-4 day intervals; leaf extension rates were calculated as a mean for all leaves of the sward i.e. as the daily gross increase in lamina length divided the number of leaves.

Ryegrass tiller density and tiller appearance and death rates were measured monthly in 3 permanently placed frames (no measure of other grass tillers was made). At each observation new tillers appearing were tagged with acoloured plastic ring and tags from dead tillers were removed.

Lamina (methanol) soluble sugar concentrations were determined according to the method of Haslemore & Roughan (1976) on days 32, 70 and 107 of the moisture treatment period.

Soil moisture deficits in the top 1 m were measured during the moisture treatment period. (Barker, Chu & Korte unpubl.).

Full details of this experiment are given by Barker (1983).

RESULTS

Soil moisture

Stressed plots began with no deficit on 28 December 1981 and had decreased to 180 mm deficit by 14 April 1982, while irrigated plots did not exceed 76 mm deficit.

There were no significant differences in soil moisture between spring defoliation treatments at any time.

Harbage yield

Spring defoliation treatments did not significantly affect herbage yield (Table 1) during the moisture treatment period, except for the first cut when plots differentially mown to 7.5 and 2.5 cms during spring were all mown to 2.5 cms. During the recovery period there were also no significant differences between spring defoliation treatments, however, when data from stressed plots only were considered (figures in parenthesis in Table 1) there was a trend for lax cutting in spring to result in a faster recovery in autumn,

Water stress did not significantly affect herbage yield (Table 1) until after 35 days of the moisture treatment period. At the conclusion of the moisture treatment period, stressed plots yielded only 8% of irrigated plots. Upon rewatering, regrowth from previously irrigated plots was initially greater than from stressed plots, however, by the final cut growth from stressed plots was greater. While it was not determined how long this compensatory growth period lasted for, it was unlikely to have fully compensated for production lost during the moisture treatment period.

Table 1: HERBAGE YIELD (kg DM/ha) FOR SPRING DEFOLIATION AND MOISTURE TREATMENTS. (Figures in parenthesis are for the stressed treatment only).

	Moisture treatment period				Recovery period	
Cut	28 Dec	1 Feb	8 Mar	14 Apr	27 May	6 Jul
date days	0	35	70	107		
(a) Sprlng defoliation						
7.5 cm cutting	3590	1056	567	264	409 (308)	434 (503)
2.5 cm cutting	831	1247	608	240	369 (270)	425 (430)
	*	ns	ns	ns	ns (0.1)	ns (0.1)
(b) Moisture						
stressed	2248	1040	109	37	326	467
irrigated	2173	1263	1067	467	453	393
	ns	ns	**	**	0.1	0.1

ns = non significant at 10% of probability
0.1 = $P \leqslant 0.10$
* = $P \leqslant 0.05$
** = $P \leqslant 0.01$

Tiller denslty

The different spring cutting heights of 7.5 and 2.5 cms failed to induce a difference in ryegrass tiller density, however, once all plots were cut to a common height, a flush of tillering in previously laxly cut plots resulted in a greater tiller density which continued until the end of the experiment (Table 2).

Ryegrass tiller density was significantly reduced by moisture stress during the latter half of the moisture treatment period (Table 2), when densities on irrigated plots exceeded those on stressed plots by 61% and 107%, 79 and 109 days respectively after the onset of moisture treatments. During this stress period the rate of tiller appearance on stressed plots decreased to 5-14 tillers/m^2/day while the rate of tiller death remained high (34-46 tillers/m^2/day). On irrigated plots, rates of tiller appearance and death were relatively high and approximately equal (20-40 tillers/m²/day).

During the recovery period rates of tiller appearance on previously stressed plots (40-60 tillers/m²/day) were greater than on previously irrigated plots (10-30 tillers/m²/day), while the rates of tiller death were low but similar for both treatments. As a consequence, the tiller density of previously stressed plots increased rapidly to approximately equal that of previously irrigated plots.

Table 2: RYEGRASS TILLER DENSITIES (m²) FOR SPRING DEFOLIATION AND MOISTURE TREATMENTS.

	Moisture treatment period				Recovery period	
Observation dates	29 Dec	3 Feb	17 Mar	16 Apr	31 May	12 Jut
Days	1	37	79	109		
(a) Spring defoliation						
7.5 cm cutting	4505	5920	3910	3780	5845	7000
2.5 cm cutting	4449	336%	2521	2261	4062	5296
	ns	• ⊠⊠	***	[illegible]	• ⊠	*
(b) Moisture						
stressed	4720	4235	2465	1970	4485	6255
irrigated	4234	5023	3966	4071	5422	6004
	ns	ns	*	**	ns	ns

ns = not significant at 5% level of probability
* = PQ0.05
** = $P \leq 0.01$
***= $P \leq 0.001$

Leaf dynamics

Mean rates of leaf extension and leaf appearance for 3 intervals during the moisture treatment period and one interval during the regrowth period (Table 3) showed no significant differences between the defoliation treatments. Data given are for the moisture treatments only.

Table 3: MEAN RATES OF a) LEAF EXTENSION AND b) APPEARANCE FOR 3 INTERVALS DURING THE MOISTURE TREATMENT PERIOD AND 1 INTERVAL IN THE RECOVERY PERIOD.

	Moisture treatment period			Recovery Period
Observation dates	30 Dec-16 Jan	2 Feb-5 Mar	10 Mar-6 Apr	16 Apr-25 May
Days	2-30	36-67	72-99	
(a) Leaf extension rate (mm/leaf/day)				
stressed	4.21	1.28	0.88	2.16
irrigated	3.84	3.50	3.23	1.77
	ns	***	• ⊠⊠	*
(b) Leaf appearance rate (leaves/100 tillers/day)				
stressed	11.53	4.98	3.95	9.96
irrigated	13.07	12.07	7.95	7.76
	ns	***	*	*

ns = not significant at 5% level of probability
• = $P \leq 0.05$
● et= $P \leq 0.001$

The effect of water stress and recovery from water stress is similar for both leaf extension and appearance rates. Initial differences between stressed and irrigated treatments were not significant, but subsequently as water stress developed, leaves of irrigated tillers were both appearing and elongating faster than those in stressed treatments. During the recovery period rates of leaf appearance and elongation in the previously stressed treatment were greater than for the previously irrigated treatment.

Lamina soluble sugar concentration

The lamina soluble sugar concentrations (% of lamina dry weight) (Table 4) of the irrigated treatment exceeded those of the stressed treatment except at the end of the moisture treatment period when the concentration of the stressed treatment was 18% greater than for the irrigated treatment.

Table 4: LAMINA (METHANOL) SOLUBLE SUGAR CONCENTRATIONS (% OF LAMINA DRY WEIGHT)

sampling date	29 Jan	8 Mar	14 Apr
day of moisture treatment period	32	70	107
stressed	il.43	11.73	20.63
irrigated	14.05	13.85	17.54
	***	**	**

** = $P \leqslant 0.01$
*** = $P \leqslant 0.001$

DISCUSSION

Spring defoliation

This trial has demonstrated that spring defoliation treatments which give a higher tiller density before the onset of severe water deficits, can be expected to result in a higher tiller density after drought, in agreement with the prediction of Korte & Chu (1983). The greater tiller density under lax than hard cutting (the reverse of what was expected) was attributed to a flush of tillering in these plots after they were cut to a shorter height of 2.5 cms. This greater density was maintained for the 3 months of drought and also for 3 months during the recovery period, inspite of faster rates of tillering on stressed plots after drought.

There was no evidence that higher tiller densities resulted in any yield advantage during drought, however, there was some evidence (although only significant at the 10% level) that there might be an advantage in yield during recovery from drought. Korte et a/. (1984) found this to be so under grazing, with regrowth in autumn after a drier than average summer being 29% greater for swards which had been hard grazed during spring. The yield advantage in this case was positively correlated with tiller density.

Drought

Drought severely reduced the yield of stressed plots in two phases, as was also observed by Korte & Chu (1983). The first phase occurred during the latter part of the moisture treatment period, when water was limiting. Yield of stressed plots was reduced to 8% of that on irrigated plots due to lower tiller appearance rates, greater tiller death rates and slower rates of leaf extension and appearance. Leaf senescence (die back from lamina tip) and leaf death rates of surviving tillers were not increased by drought (Barker 1983). The second phase occurred during the first interval of regrowth after rewatering, and yield reductions were attributed to a reduced tiller density, despite adequate water and the relatively greater rates of leaf extension, leaf appearance and tiller appearance.

During the second interval of the regrowth period, yields from previously stressed swards were greater than from previously irrigated swards. This compensatory growth was attributed to faster rates of tiller appearance, leaf appearance and leaf extension, a finding similar to that observed in tall fescue by Horst & Nelson (1979). The duration of the compensatory response was observed to last for 6 weeks by Korte & Chu (1983), much shorter than the 8 month response of Horst & Nelson (1979). The duration of the response was not measured in this study, and although offsetting some of the advantages of irrigation, compensatory growth was unlikely to have recovered all of the lost yield.

It is uncertain whether compensatory growth is dependant on higher concentrations of soluble sugars. This study and others (e.g. Barlow et *al.* 1976, Horst & Nelson 1979) have found compensatory growth upon relief from drought occurred in association with higher concentrations of soluble sugars, and such levels of soluble sugars may be a prerequisite for compensatory growth to occur.

In this study the increase in lamina soluble sugar concentration of stressed relative to irrigated plots occurred relatively late in the moisture treatment period. Horst & Nelson (1979) observed this same effect but found that the levels of soluble sugars were greater in stem bases than in leaves, and that the increases in soluble sugar concentration of stem bases in stressed relative to irrigated treatments occurred sooner in the stress period. The stressed : irrigated ratio of soluble sugars in stem bases may be a useful indicator for predicting whether compensatory growth will occur.

CONCLUSIONS

1) Spring managements to increase tiller density can result in a greater tiller density "at the end of drought, however, in dryland, any benefit is unlikely to be in summer production but may be in the potential for faster recovery after drought.
2) Accelerated growth after drought can compensate for some lost production, however, this may be dependant upon a rise in lamina soluble sugar concentration during the drought. Further investigation of the potential for manipulation of the compensatory mechanism to advantage is necessary.

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