EFFECT OF SHORT TUSSOCKS ON INTER-TUSSOCK COCKSFOOT GROWTH

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SUMMARY: The effect of different densities of tussocks *(Festuca novae-zelandiae, Poa laevis)*in short tussock grassland associations was studied using transplanted cocksfoot *(Dactylis glomerata)* seedlings as indicators of inter-tussock plant growth. The dense tussock associations considerably modified the microclimate, reduced frost damage and initially promoted cocksfoot growth. Sparse tussock associations did not generally promote cocksfoot growth unless plants were near the tussock base and sheltered from the prevailing wind.

INTRODUCTION

In New Zealand there are about 3,000,000 ha of short tussock grassland, mostly below 1,000 m elevation where the dominant tussocks are the native hard tussock *(Festuca novae-zelandiae)*, silver tussock *(Poa laevis)* and blue tussock *(Poa colensoi)*. Much of this country is extensively grazed and pastorally unimproved, but an increasing proportion is being developed with smaller subdivisions for grazing control, regular topdressing and oversowing with legumes and sometimes grasses. In Canterbury we are measuring pasture growth as part of a study in developed short tussock grasslands, and within this programme knowledge of whether short tussocks affect the productivity of inter-tussock grass species is a matter of some importance.

Research workers in New Zealand have mostly studied tall or snow tussock grasslands (dominated by *Chionochloa* species) which occur where the climate is more severe and tussocks are likely to make an appreciable difference to microclimate. Little attention has been paid to the role of short tussocks in developed pasture although it is important to evaluate their use in land development. Mark and Rowley (1969) found that large non-defoliated snow tussocks (*Chionochloa* species) accumulated greater reserves of soil water than did burnt or clipped tussocks. Zotov (1938) and Sewell (1952) discussed the beneficial sheltering effect of hard tussocks in reducing frost damage and promoting survival of palatable plants, and Scott (1961) demonstrated the spatial zonation of grassland species surrounding hard tussocks. It is a common observation that tussocks affect the grazing behaviour and distribution of dung and urine from sheep and cattle and that tussock plants may be eliminated under severe grazing pressure.

This paper reports results from six preliminary trials in which the effect of tussocks in short tussock grasslands in Canterbury was studied using transplanted cocksfoot *(Dactylis glomerata)* seedlings as indicators of inter-tussock plant growth.

METHODS

Seedlings of 'Grassland Apanui' cocksfoot were raised at Lincoln in topsoil brought from the field site. They were transplanted in the autumn into tussock areas at two experimental sites. One of these was at Ashley Gorge, seven kilometres west of Oxford (43° 18'S, 172°05'E) on a steep north-west facing slope on a Hurunui hill soil (Soil Bureau 1968) dominated by silver tussocks. The other site was at Broken River (43° 09'S, 171° 43'E), 22 km west of Porters Pass on a flat upper river terrace on Craigieburn silt loam (Soil Bureau 1968) dominated by hard tussocks.

At each site there were two series of trials (A and B) in which frost damage to leaves, plant survival, tiller numbers, length of tallest tiller and dry weight were assessed. (For dry weight each plant was clipped to three centimetres above ground except at the final harvest when all growth above ground level was harvested). Each series had three trials which were protected from grazing at all times.

1. *Series A*

In Series A the effect of tussock density on cocksfoot was studied. Details are given in Table 1 and cocksfoot seedlings were transplanted and

TABLE 1. *Details of Tussock Density Experiments (Series A)*

	Ashley Gorge 1971-72		Broken River 1971-72		Broken River 1972-73	
Tussock Density	No. of tussocks /m²	No. of cocksfoot plants	No. of tussocks /m²	No. of cocksfoot plants	No. of tussocks /m²	No. of cockfoot plants
Absent	0	25	0	25	0	20
Sparse	0.4	25	0.3	25	0.3	20
Dense	4.0	25	Not used		5.0	20

identified into existing pasture within each of three categories of tussock density, absent ("no tussocks"), "sparse" and "dense". Each tussock density treatment occupied at least 400 m^2 but was not replicated. The resident pasture species were mainly sweet vernal *(Anthoxanthum odoratum),* browntop *(Agrostis tenuis),* Yorkshire fog *(Holcus lanatus), Agropyron scabrum* and white and suckling clovers *(Trifolium repens* and *T. dubium).* Transplanted seedlings were kept hand weeded to minimise competition from resident vegetation. All tussock densities occurred naturally, except the "sparse" and "absent" densities at Ashley Gorge where tussock cover was eliminated by clipping.

2. *Series B*

In the Series B trials the effects of distance and direction from the tussock base on cocksfoot seedlings were studied. Details of the three trials are as follows:

1. *Ashley Gorge.* Pairs of cocksfoot seedlings were transplanted on 14 April 1971 at positions 100 mm and 500 mm from the tussock base in north (downslope) west, south, and east directions, with 12 tussock replicates.
2. *Broken River 1971-72.* This trial was planted on 3 May 1971 and was identical to the Ashley Gorge trial.
3. *Broken River 1972-73.* This trial was planted on 13 April 1972 using single cocksfoot seedlings transplanted 100 mm from the tussock base in north, west, south and east directions, with 10 tussock replicates.

RESULTS

1. *Series A: Effect of tussock density on growth of cocksfoot*

Some measurements from Ashley Gorge are given in Table 2. Good growing conditions followed mid-April transplanting and sheltered sites within dense tussock induced an erect growth habit in cocksfoot with a small number of taller tillers. On the more exposed parts of sites where tussocks were "sparse" or "absent" cocksfoot growth habit was prostrate or semi-erect with plants having a larger number of shorter tillers. There was no frost damage in any tussock density. Dry matter production was significantly higher in the first spring harvest but not in subsequent harvests in the "dense" tussock plots.

At Broken River in the 1971-72 trial, cold conditions after transplanting curtailed growth, and cocksfoot plants in all tussock densities were frosted during the winter. Subsequent spring and summer growth was slight. At the end of November cocksfoot survival was higher (72%) in plots where tussock was "sparse" than in those where tussock was absent (40%) and these differences were significant at $p < 0.05$. In February 1972 all plants were harvested and dry weights were 0.27 g in the "no tussock" treatment and 0.11 g in the "sparse tussock" treatment. These differences were not significant ($p > 0.05$) from analyses based on logarithmic transformations of the figures.

In the 1972-73 trial at Broken River plants grew better after April transplanting and, as at Ashley Gorge, they developed a more erect

TABLE 2. *Ashley Gorge. Measurements of Cocksfoot Plants in Three Densities 1971-72 Trial*

Measurements	None (N)	Tussock density Sparse (S)	Dense (D)	Significance	C.V. %
Length of tallest tiller (cm)					
27 May 1971	4.4	4.9	7.2	D > N,S**	40
7 Oct. 1971	11.9	14.3	18.6	D > N,S**	36
No. tillers/plant					
27 May 1971	11.1	14.8	11.6	S > N,D**	28
7 Oct. 1971	21.6	23.8	16.5	S > D**	41
Dry weight/plant (g)					
7 Oct. 1971	0.40	0.52	0.72	D > N**	68
3 Feb. 1972	1.77	2.11	1.98	n.s.	66
2 March 1972	0.22	0.26	0.18	n.s.	103
Total[1]	2.42	3.09	2.88	n.s.	52

[1]Plants which survived 3 harvests
Significance n.s. $p > 0.05$);

growth habit with taller tillers in "dense tussock" associations. Some measurements are given in Table 3. A harvest at the end of the growing season showed the superior dry weight of the bigger cocksfoot plants growing among dense tussock. Frost damage was observed in each of the three treatments as winter progressed but plants in the "dense tussock" plots were least severely affected and those in the "sparse tussock" plots were most affected (Fig. 1).

2. *Series B: Effect of distance and direction from the tussock base.*

At Ashley Gorge in May and October, cocksfoot plants occupying positions east of the tussock base were taller than all others ($p < 0.01$) and those at 100 mm from the tussock base compared with those at 500 mm had fewer but taller tillers $p < 0.01$. No frost damage was observed in the winter. Results of three harvests (Table 4) show that plants growing east and south of the tussock base were most productive in harvests 1 and 2 respectively.

In the Broken River 1971-72 trial no differential frost damage due to direction or distance of plants from the tussock base was observed. In early December 1971 counts of surviving healthy plants showed 58 percent

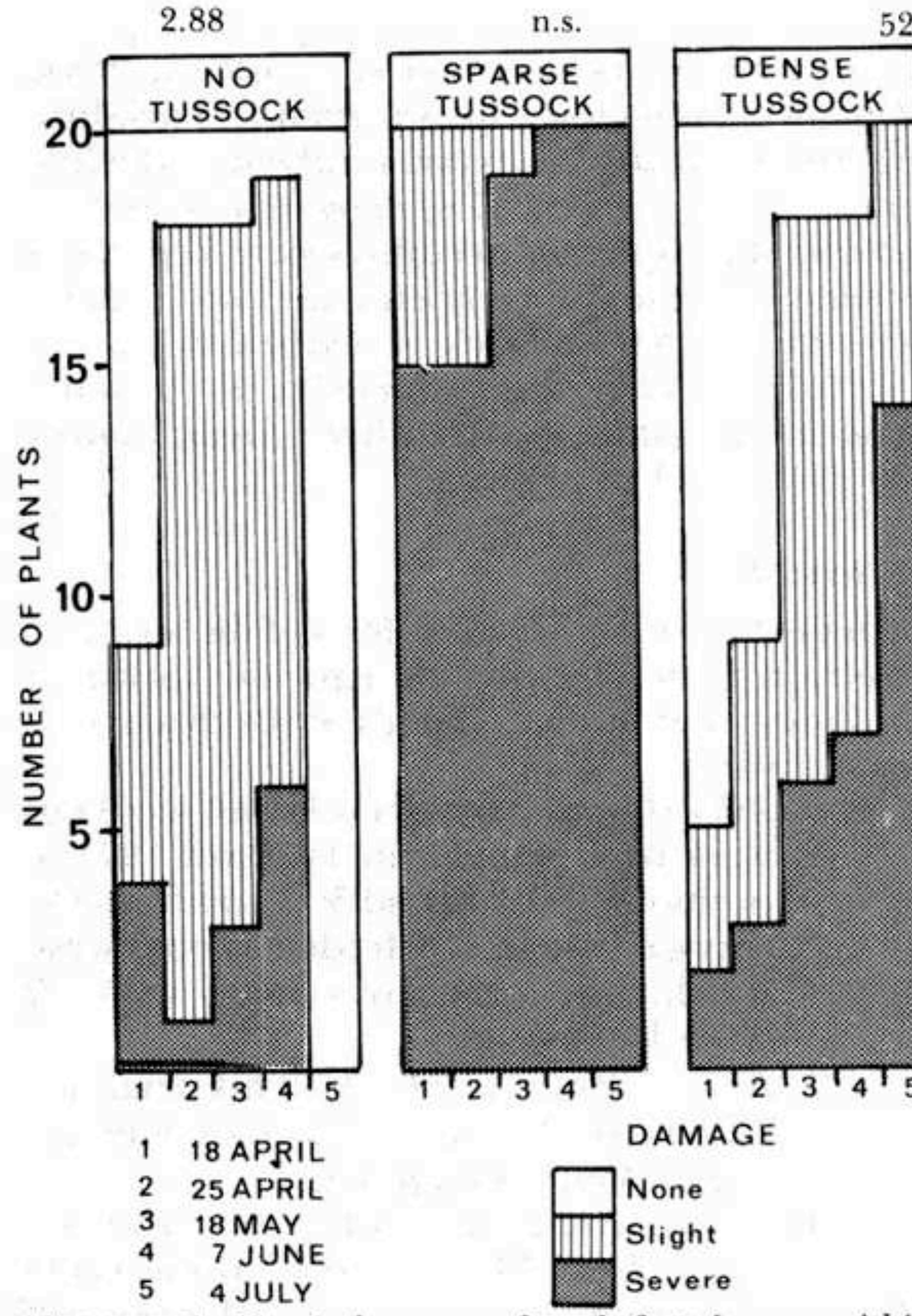

FIGURE 1. *Frost damage of cocksfoot leaves within three tussock densities, Broken River, Winter 1972.* (Date 5. Data are not available for the "no tussock" treatment.)

TABLE 3. *Broken River. Measurements of Cocksfoot Plants in Three Tussock Densities 1972-73 Trial*

Measurements	None (N)	Sparse (S)	Dense (D)	Significance	C.V.%
	Tussock density				
Length of tallest tiller (cm)					
30 Nov. 1972	13.1	13.9	26.4	D > N,S.**	44
19 Jan. 1973	18.9	15.8	29.1	D > N,S.**	42
15 Mar. 1973	17.6	15.3	29.9	D > N,S.**	42
No. of tillers/plant					
4 July 1972	6.6	6.9	6.9	n.s.	29
30 Nov. 1972	5.2	4.1	6.0	D > S**	37
19 Jan. 1973	5.1	4.0	5.5	n.s.	61
Dry weight/ plant (g)					
15 March 1973	0.21	0.16	1.07	D > N,S**	215

Significance n.s. $p > 0.05$
** $p < 0.01$

survival in north and east positions, 21 percent survival in the west and 29 percent survival in the south positions. Plants at 100 mm distance from the tussock base had 77 percent survival, and those at 500 mm had 65 percent survival ($p > 0.05$). Plant dry weights in February 1972 for all positions did not differ significantly (Table 4).

In the 1972-73 trial at Broken River as in the 1971-72 trial no differences in frost damage due to distance and direction from the tussock base were noted. Similarly no significant differences ($p > 0.05$) in tiller number or tiller length were measured in winter, spring or summer. However a harvest in March showed that plants in the west position were most productive (Table 4).

TABLE 4. *Mean Dry Weight (g) of Cocksfoot Plants at Various Directions and Distances From the Tussock Base*

Position	Ashley Gorge 14 Oct. 1971	Ashley Gorge 3 Feb. 1972	Ashley Gorge 2 March 1972	Ashley Gorge Total	Broken River 1 Feb. 1972	Broken River 15 March 1973
Direction						
North (N)	1.15	2.72	1.03	4.91	0.17	0.87
West (W)	0.98	3.84	0.69	5.51	0.14	1.63
South (S)	1.31	4.47	1.01	6.78	0.11	0.34
East (E)	1.75	2.97	0.95	5.67	0.17	0.60
Significance	E > NW** E > S*	S > N*	n.s.	n.s.	n.s.	W > S*
Distance						
100 mm	1.37	3.32	0.92	5.61	0.16	*x*
500 mm	1.22	3.68	0.92	5.82	0.13	
Significance	n.s.	n.s.	n.s.	n.s.	n.s.	
C.V.%	47	68	77	51	101	142

x only 100 mm position was examined

Significance n.s. $p > 0.05$
* $p < 0.05$
** $p < 0.01$

There were no significant interactions at $p < 0.05$

Effect of tussock density on temperature

Daily air temperatures were obtained for periods in winter and summer at Broken River (Table 5). In winter temperatures in the "sparse tussock" treatment had the widest diurnal fluctuations caused by higher daily maxima and lower minima. In the "dense" compared to the "sparse tussock" treatment maximum temperatures were generally lower and minimum were higher. These effects were more marked in winter than in summer.

TABLE 5. *Mean Daily Air Temperatures(°C) at 30 mm Above Ground in Three Tussock Densities Broken River.*

Mean daily temperature	Tussock Density	Winter 1971 June	Winter 1971 July	Summer 1971-72 Dec.	Summer 1971-72 Jan.
Maximum	None	6.9	5.6	—	—
	Sparse	9.5	9.1	34.3	37.3
	Dense	4.1	5.4	29.0	36.3
Minimum	None	−1.0	−1.0	—	—
	Sparse	−6.2	−4.1	7.2	2.4
	Dense	−5.1	−2.6	3.5	4.0
Range	None	7.9	6.6	—	—
	Sparse	15.7	13.2	27.1	34.9
	Dense	9.2	8.0	25.5	32.3

Mean daily soil temperatures at 25 mm depth from May to July 1971 (Fig. 2) showed that soil in the "sparse tussock" treatment was generally one to two degrees Celsius colder than that within the "dense tussock" treatment.

Effect of distance and direction from tussocks on temperature and soil nutrients

Spot soil temperature readings near tussocks at Broken River at similar positions occupied by cocksfoot plants were made on a clear calm winter day. Results show that temperatures were warmest near the tussock base and coldest on the south side (Table 6).

Soil nutrients determined by quick-test methods (Mountier *et al.* 1966) are given in Table 7. Topsoil on the south side of tussocks at Broken River contained significantly more K, P, C and N, and there were no significant interactions between distance and direction measurements ($p > 0.05$). At Ashley Gorge similar but

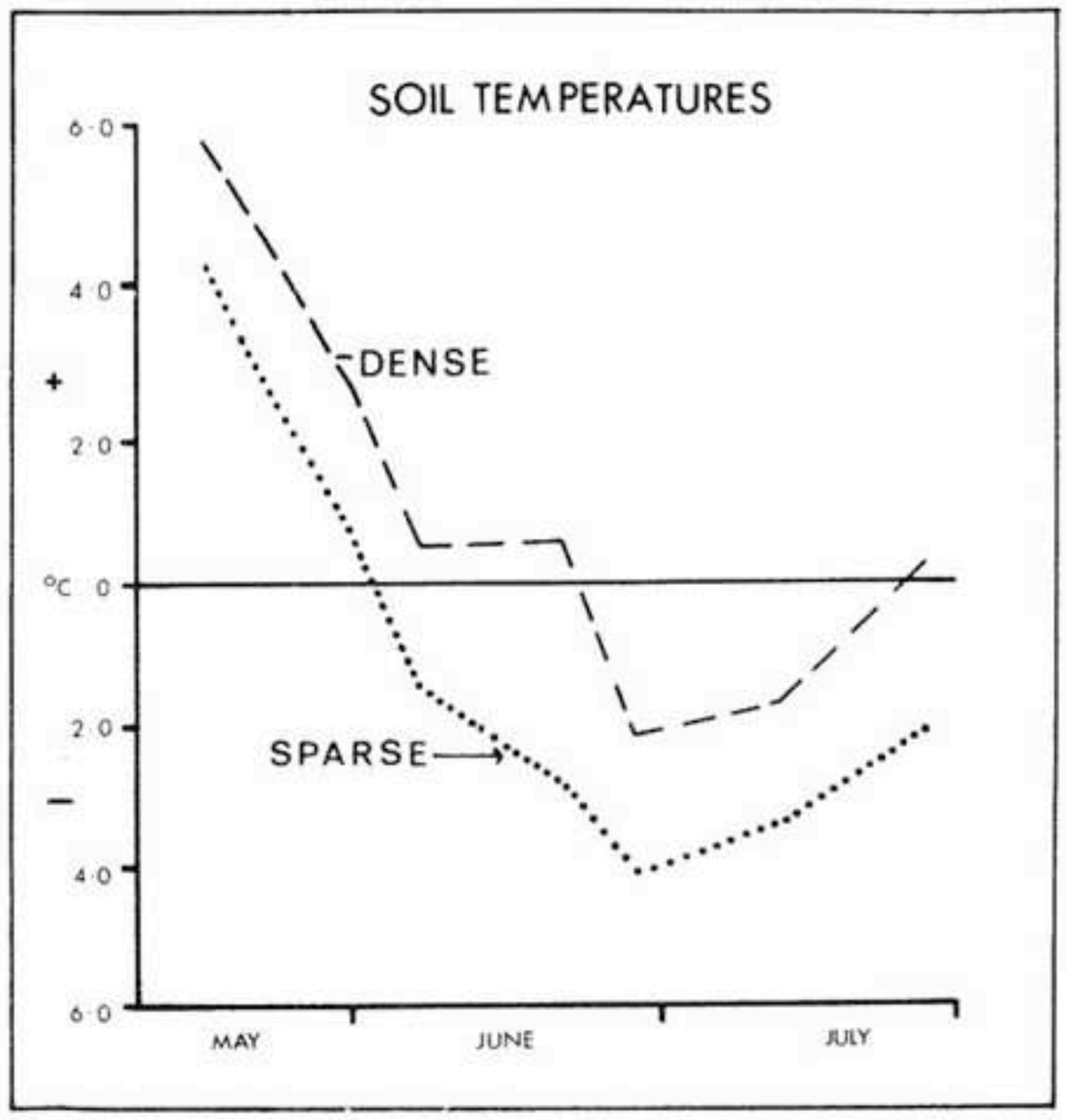

FIGURE 2. *Mean daily soil temperatures (°C) at 25 mm depth, Broken River, Winter 1972.*

non-significant trends were found in the cooler east position compared with the west.

DISCUSSION

These trials have shown that dense short tussock associations may induce an erect growth habit in cocksfoot plants growing between tussocks, and these plants may be initially more productive than those in less dense tussock associations or in pastures without tussocks. Although the lower tussock densities examined here did not promote cocksfoot growth they are similar to sparse tussock associations induced by years of grassland development with sheep or

TABLE 6. *Broken River Soil Temperatures (°C) at 20 mm Depth at 1100 hours in Winter in Various Positions From a Tussock Base.*

Direction	Distance 100 mm	Distance 500 mm
North	7.0	5.0
West	7.5	5.0
South	1.5	0.5
East	6.5	6.0
Mean	5.6	4.1

TABLE 7. *Soil Quick Tests at Four Positions Near the Tussock Base*

Broken River[1] (June 1971)	pH	Ca	K	P	%C	%N
North (N)	6.7	12.9	5.6	11.4	9.9	0.74
West (W)	6.7	12.4	4.3	9.3	8.9	0.65
South (S)	6.8	12.4	6.6	12.0	11.9	0.89
East (E)	6.8	13.0	5.6	10.7	8.9	0.71
C.V.%	2.9	14.4	42.2	21.4	22.4	23.7
Significance	n.s.	n.s.	S>W*	S>W*	S>E,W**	S>E,W*
Ashley Gorge[2] (Sept. 1971)						
West	4.3	4.2	8.8	13.1	4.9	0.36
East	4.4	4.6	10.4	13.7	5.2	0.38
C.V.%	1.8	7.9	22.8	25.7	11.7	6.9
Significance	n.s.	*	(*)	n.s.	n.s.	n.s.

[1] Mean of 100 mm and 500 mm positions, 0 to 40 mm depth.
[2] 100 mm position only, 0 to 80 mm depth.

Significance n.s. $p > 0.05$
* $p < 0.05$
** $p < 0.01$
(*) approaching significance at $p < 0.05$

sheep and cattle grazing. It is likely that in any environment there is an optimum tussock density which promotes growth of inter-tussock plants but we do not know how the present results from indicator plants relate to production from inter-tussock swards. Perhaps the extra growing space between sparse tussocks may compensate for the reduced growth of individual plants in the more exposed and less favourable growing sites of these inter-tussock areas. Only in the Broken River 1971-72 trial was cocksfoot higher in the "sparse tussock" association and more work is needed in a wider range of environments to determine the optimum and lowest tussock densities which will promote inter-tussock grass production.

Temperatures at Broken River, Table 5, showed that dense short tussocks considerably modified the microclimate, especially in winter. This finding agrees with Scott (1962) who studied tall tussocks in winter at Palmerston North. In the "sparse tussock" association at Broken River the greater diurnal temperature range probably contributed to the more severe frost damage of cocksfoot leaves. However, temperature measurements were of necessity confined to one position within these unreplicated tussock plots, and results need confirmation from other areas. Soil temperatures from a hill site near Ashley Gorge (Radcliffe, unpublished data) showed that differences in temperature between aggregated tussocks and adjacent pasture on a sunny slope were greater in summer than winter, but on a nearby exposed ridge crest largest differences occurred in winter. Therefore both site exposure and season can influence the effect of tussock on microclimate.

The effect of distance and direction from the tussock base on transplanted cocksfoot appeared less important than the effect of tussock density. Neither distance nor direction from the base affected frost damage although plants near the tussock on the side sheltered from the prevailing wind were more erect and initially more productive. This effect was associated with slight increases in soil nutrients and organic matter, probably caused by differences in leaching, weathering, previous grazing patterns and windblow of soil.

ACKNOWLEDGMENTS

I wish to thank Mr M. Davis and Mr G. McTainsh for field work and N.Z. Forest Service staff at Craigieburn for servicing climatic records from Broken River. Biometrics Section, Ministry of Agriculture and Fisheries, Wellington, carried out the statistical analyses, and Invermay Agricultural Research Centre, Mosgiel, analysed the soil samples.

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