ROOT DEVELOPMENT UNDER GRAZED PERENNIAL AND ANNUAL PASTURES IN SOUTHERN N.S.W, AUSTRALIA

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ABSTRACT

Root numbers, volumetric soil water contents, botanical composition and basal cover were estimated in autumn and spring in 1994 and 1995 on limed and unlimed perennial grass (*Phalaris aquatica* and *Dactylis glomerata*) and annual grass (*Lolium rigidum*) pastures containing *Trifolium subterraneum* in southern N.S.W., Australia (35° 22' S, 147° 31' E). Despite altering botanical composition and basal groundcover of perennial grasses, lime had no apparent effect on root development or volumetric soil water contents. Limed pastures were more heavily stocked than unlimed treatments Perennial pastures had higher ($P<0.05$) root numbers (roots/10 cm^2 soil) from 30-120 cm depth in autumn, resulting in a drier soil profile from 70-120 cm. In spring root numbers were similar under both pastures.

KEYWORDS

Roots, perennial pastures, southern Australia, *Phalaris*, soil water

INTRODUCTION

Major soil degradation problems of soil salinisation and acidification are occurring in temperate Australia where rainfall exceeds 500 mm/year. Inefficient use of water by shallow rooted, annual pasture plants has been a major cause of degradation. Perennial pastures, particularly *Phalaris aquatica* (phalaris), have some potential to reduce drainage, and hence soil degradation, through having a deeper and more active root system than annual pastures (Ridley, 1995). Recent detailed studies to date have been carried out on ungrazed pastures. The aims of this study were to determine whether the rooting depth (as assessed by root counts and volumetric soil water contents) was greater under grazed perennial than annual pastures in southern N.S.W. Control and lime treatments were applied on the strongly acid soil used in this study.

MATERIALS AND METHODS

The experimental site was located on a beef and sheep grazing property at Book Book, southern N.S.W. (35° 22' S., 147° 31' E.). There were four replicates of four treatments (perennial and annual pastures, with and without applied lime) in a completely randomised experimental design. The plot size was 30 x 45 m^2. The experiment was on a duplex soil derived from granite, provisionally classified as an Ultic Palexeralf (Soil Survey Staff, 1990). The A horizon (0-40 cm) was a sandy loam overlying a medium clay B horizon. The soil pH (measured in 1 soil: 5 solution 10 mmol/L $CaCl_2$) was approximately 4.2 in the top 10 cm, and generally less than 4.5 to 50 cm depth. The limed treatment was applied prior to pasture establishment, to achieve a pH of 5.5 in the top 10 cm. Perennial grasses (Australian and Holdfast phalaris and Currie cocksfoot) and Wimmera annual ryegrass pasture treatments were sown with subterranean clover (*Trifolium subterraneum*) in June, 1992. From 1993 plots were rotationally grazed with Merino hogget sheep. In 1994 the stocking rates were approximately 11 and 14 hoggets/ha for control and limed treatments, and in 1995 13 and 16 hoggets/ha, respectively. Botanical composition of pastures was visually estimated using the BOTANAL technique (Hargreaves and Kerr 1978, Tothill *et al*., 1978) at four times close to the dates of root sampling. Basal cover of perennial grasses was assessed in March, 1994 and February, 1995, based on the method outlined by Lodge (Anon, 1993). Three 1m^2 grid frames were counted per plot, each grid containing 100 cross points. Basal cover counts were scored when a part of a plant base was located directly under a cross point. In autumn and spring in 1994 and 1995 roots were counted. Six soil cores were taken to 120 cm depth from each plot using a hydraulic tractor mounted soil sampler. Autumn samples were taken 2-3 weeks after the first rains. Each depth interval was broken in half and roots were counted. Root numbers were meaned over the six cores. Roots were not distinguished between dead and live, due to subjectivity. The volumetric soil water contents % values were determined at a similar time to the four root sampling dates using a neutron moisture meter calibrated for the site. The autumn samplings were taken just prior to the opening autumn rains, when the soil was at its driest for the season.

RESULTS

The 1994 season was very dry with only 370 mm falling for the year. In 1995 there was 771 mm rainfall, and this season was much more favourable for pasture growth. There was no overall effect of lime on the content of subterranean clover or annual ryegrass, but for both species there were interactions between pasture type and time, and also between lime treatment and pasture type ($P<0.05$). Annual pastures generally contained more subterranean clover than perennial pastures in 1994, and either equal to or less clover than perennial pastures in 1995. Limed annual pastures usually contained more subterranean clover and/or annual ryegrass than control annual pastures (Table 1).

There were effects ($P<0.05$) of liming and time on both botanical composition and basal cover of perennial grasses. With lime there was generally more phalaris in both years and more cocksfoot in 1994 (Table 1). Minimal cocksfoot was present in 1995. Basal cover of perennial grasses was higher in 1995 than 1994 (average 11.5 and 5.8 %, L.S.D 2.6, $P<0.05$), and higher on the limed than control treatment (13.5 and 3.8 % respectively, L.S.D 2.6, $P<0.05$).

There was no effect of lime on root counts. Perennial pastures had more roots ($P<0.05$) in autumn than annuals (below 20 cm in 1994 and below 30 cm in 1995) as outlined in Table 2. Most roots counted in autumn on annual pastures below 30 cm depth were dead. Below 60 cm depth root numbers were always below 1 root/10 cm^2 in autumn. Spring root numbers under both pasture types were generally similar. The soil was drier from 60 cm depth under perennial pastures in spring 1994 and from 75 cm depth in autumn 1995 (Table 2).

DISCUSSION

The similar root numbers occurring in spring between grazed annual and perennial pastures confirms results of Ridley and Simpson (1994) who showed that annual ryegrass could attain a similar rooting depth to that of perennials. There was found to be a good correlation between the root counts and root density at this site (Ridley and Morrison, *unpublished data*) and calculated root densities were of similar magnitude to those measured previously on ungrazed pastures (Ridley and Windsor, 1992 and Ridley and Simpson, 1994).

Despite liming increasing perennial grass content and basal cover, root numbers were not increased and there was no effect of lime on volumetric soil water contents. This result indicates that a there may be a minimum acceptable perennial grass content and basal cover of perennial species at which the soil profile is dried to a greater depth than under annual pasture. Further work in this area would be useful.

The limed pastures were stocked with 3 more Merino hoggets per hectare than the controls, and this could account for why root numbers and soil water contents were not affected by lime despite botanical composition differences. In trying to achieve a more sustainable pasture system, production, profitability and resource conservation each need to be costed into the agricultural system. Little work has properly addressed these issues.

The responses of perennial grasses to lime shows that production was being limited by soil acidity. We believe that liming should commence before the ability to grow productive species such as phalaris is lost. At this site, the response to lime of both phalaris and the more acid tolerant species of cocksfoot indicates that lime should be applied to maintain both agricultural production and conserve the soil resource.

The dry 1994 season resulted in drought conditions for perennial grasses for 7 months over summer and autumn 1994/95. Although phalaris content declined, botanical composition and basal cover were still adequate for a productive pasture, particularly on the limed treatment. With the dry conditions cocksfoot persisted poorly. The known shallower rooting depth of this species (Ridley and Simpson 1994) and poor persistence, indicates that increased root numbers at depth in autumn were of phalaris.

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Table 1
Percentage component of pasture species in limed and unlimed pastures in 1994 and 1995

treatment	sub. clover	annual ryegrass	phalaris	cocksfoot
Autumn 1994				
annual -lime	36	5	-	-
annual +lime	34	9	-	-
perennial -lime	18	0	15	18
perennial +lime	18	1	33	41
Spring 1994				
annual -lime	15	29	-	-
annual +lime	39	52	-	-
perennial - lime	14	7	36	23
perennial +lime	11	3	46	37
Autumn 1995				
annual -lime	18	14	-	-
annual +lime	32	7	-	-
perennial -lime	37	13	10	7
perennial +lime	39	28	23	10
Spring 1995				
annual -lime	57	31	-	-
annual +lime	52	43	-	-
perennial -lime	60	16	11	0
perennial +lime	52	16	27	0
L.S.D.(P=0.05)	14	13	11	10

Table 2
Root counts and volumetric soil moisture contents under perennial and annual pastures in autumn and spring 1994 and 1995

	Mar 1994		Nov 1994		May 1995		Nov 1995	
depth (cm)	Perenn	Annual	Perenn	Annual	Perenn	Annual	Perenn	Annual
no. roots (roots/cm²)								
0-10	9.5	8.1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10-20	4.6	3.9	6.6	6.9	6.0	5.0	13.3	13.4
20-30	3.3[A]	1.6*	6.7	5.7	4.9	3.6	12.9	11.4
30-40			5.4	3.4	3.2	2.5	12.5	8.0*
40-50	1.7[A]	0.6*	3.3	2.4	2.8	1.3*	7.8	6.0
50-60			2.4	1.5	2.0	0.9*	4.4	3.1
60-80	0.5	0.2*	1.1	1.1	0.7	0.3*	2.3	2.4
80-100	0.3	0.2	0.6	0.3	0.6	0.2*	0.5	1.5*
100-120	0.2	<0.1*	0.4	0.2	0.4	0.1*	0.8	0.4
volumetric soil moisture content								
15	n.d.	n.d.	6	6	3	4	19	19
30	n.d.	n.d.	13	12	10	10	24	23
45	n.d.	n.d	20	27	20	24	31	32
60	n.d.	n.d.	31	36*	28	34	35	37
75	n.d.	n.d.	34	39*	32	37*	37	40
90	n.d	n.d.	35	40*	33	38*	38	40
120	n.d.	n.d.	37	40*	36	39*	39	40

n.d. not determined
A roots counted in the 20-40 and 40-60 cm intervals in March 1994
* values are significantly different (P<0.05) between pasture types within measurement dates