IMPROVED PASTURES AND THEIR EFFECTS ON SUBSEQUENT CROPS

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Summary. A range of management strategies were imposed on an existing annual pasture to evaluate their effects on pasture production and subsequent crops. These were compared with perennial pastures containing lucerne and/or a phalaris-cosksfoot mixture. Lucerne was more productive than perennial grasses and both produced more than annual pastures. Depletion of subsoil water reflected production, and wheat and canola crops grown after lucerne yielded less than after the other pastures in a dry season because of less residual soil water. Wheat growing after the perennial grasses also had less take-all infection than after annual pastures or lucerne, suggesting that these species are not hosts of the pathogen. Removing grass from annual pastures greatly increased soil mineral N in the following autumn and led to increased crop N-uptake. In the drought conditions of this experiment the consequence of the extra N was reduced crop yield, but in average seasons increased yield is expected.

INTRODUCTION

The role of improved pastures in ley farming systems has traditionally been to boost yield and protein of subsequent crops, as well as to increase animal production and improve soil fertility (2,5,8). However pasture-crop rotations are being replaced by continuous cropping in many parts of southern Australia because of apparent shortcomings in the system (1). These include a perception of lower pasture productivity than in the 1950s and a generally low and fluctuating legume content. Grain protein levels of cereals grown in rotation are decreasing and the soils are acidifying rapidly, particularly during the annual pasture phase (6,11). The pasture-crop system does not use all the rainfall and there are increasing problems of waterlogging, rising watertable and dryland salinity.

These shortcomings suggest that productivity of both pastures and crops could be increased through better pasture management. Low-cost methods include grass removal with herbicides to reduce soil-borne disease and make space for legumes. More expensive options include supplying more P, liming and introducing perennial grasses (3). Lucerne has long been recognised as a superior grazing legume (12) and a recent study has shown an extraordinarily high N-fixing potential (4). Surprisingly, there have been few comparisons of different pastures in pasture-crop systems (10). The general hypothesis tested in this project is that investment in pastures is economically justified by increased production of pastures and subsequent crops. This paper presents preliminary results of the project.

MATERIALS AND METHODS

The experiment was on a 10ha paddock on 'Waerawi', Junee (lat. 35?S, elev. 100m, mean annual rainfall 500 mm). The paddock was selected for a soil type, fertility and acidity typical of the mixed crop-pasture land of southern NSW [red-brown earth, Dr 2.42; 0-10cm N=0.10%, pH ($CaCl_2$) = 4.5, increasing with depth]. The paddock had grown an annual pasture consisting of subclover, barley grass and silver grass since 1989. In 1992, the treatments shown in Table 1 were imposed on square plots with 48m sides. The annual treatments were randomised in an incomplete 2^3 factorial arrangement with 2 replicates but without fences between the plots. Perennial pastures were established and arranged as a 2^2 complete factorial design with 2 replicates, also without fences but separated from the annual pastures. The perennial plots were grazed rotationally and the annual plots were set stocked while there was sufficient feed.

In 1994 the cropping phase commenced with wheat (cv. Janz) and canola (cv. Oscar) growing on portions of the pasture plots. The crops were managed with good weed control and P nutrition so that yield differences reflected management of the previous pastures. The system was monitored for pasture growth, soil water, soil mineral N, soil-borne disease and the growth, yield and grain protein content of the following crops.

Table 1. Pasture treatments

Treatment	Description
Control	Existing annual pasture
+P	Topdressed 15kg P/ha (1992), 10 kg P/ha (later years) as single super
+Lime	Topdressed 1.5 t/ha 8/1992
Grass removal (GR)	Selective herbicides 8/92 and 7/93
Lucerne[a]	Sodseeded 8/92: 3 kg/ha Aurora, 1 kg/ha Siriver. First grazed 4/93
Perennial grass (PG)[a]	Sodseeded 8/92: 3 kg/ha Sirosa Phalaris, 1 kg/ha Australian Phalaris and 1kg/ha Currie Cocksfoot
Lucerne + PG[a]	Half the seeding rates of the pure lucerne and PG

[a]Perennials received the +P and +lime treatments; n.a.: not available

RESULTS AND DISCUSSION

Pastures

Addition of P increased dry matter production of annual pastures in all years, mainly by boosting grass at the expense of clover (Table 2). Lime had no effect on either pasture production or composition. Grass removal reduced annual dry matter production but improved the percentage of legume in spring. However it also led to growth of unpalatable weeds following summer rain. These were generally absent from grassy pastures.

Table 2. Dry matter production of pasture (t/ha) and legume percentage (*in italics)*

Pasture	Annual pasture				Lucerne	PG	Luc.+PG
treatment	Control	+P	+Lime	GR	+P+lime	+P+lime	+P+lime
1992	4.00 *(88)*	5.85 *(71)*	3.82 *(81)*	4.12 *(100)*			
1993	4.23 *(35)*	7.30 *(18)*	5.00 *(29)*	3.99 *(49)*	7.43 *(51 luc.)*	4.10 *(n.a.)*	5.62 *(43 luc.)*

1994	2.03	3.70	2.08	1.20	7.46	5.22	7.46
	(52)	*(27)*	*(51)*	*(n.a.)*	*(58 luc.)*	*(n.a.)*	*(58 luc.)*

n.a.: not available

Lucerne consistently produced more dry matter than any annual pasture or the perennial grass. Most of lucerne's advantage was in summer when rain gave immediate growth responses.

Soil mineral nitrogen

Grass removal from the annual pasture in winter 1992 led to an additional 100 kg/ha of mineral N by the following autumn (Fig. 1a), apparently because the fixed N was labile and mineralised rapidly following summer and autumn rainfall.

The rapid availability of fixed N in this situation contrasts with the slow release of fixed N to subsequent crops over several years in a winter-rainfall environment (7). After winter rainfall in 1993 the additional 100 kg/ha of mineral N had been leached to 40-70cm but in subsequent samplings there was shrinkage of this 'bulge', possibly through incorporation into organic matter in the subsoil (Fig. 1b). Soils under the lucerne and PG contained uniformly low levels of mineral N (data not shown).

Figure 1. Soil profiles of mineral N (a) in December 1993 (b) for the grass-removal treatment at four samplings. Error bars represent SEM.

Soil water

Lucerne dried the soil profile to the depth of sampling in December 1993 (Fig. 2a) whereas perennial grass and annual pastures left water in the subsoil (Fig. 2a). In September 1994 the soil water under wheat crops following these pastures continued to show the differences (Fig. 2b). Wheat growing after annual pastures continued to extract soil water from September until late November but by September all available water had been extracted by wheat after lucerne.

Figure 2. Profiles of soil water (a) under lucerne, perennial grass and annual pasture in December 1993 (b) under wheat in September 1994, for crops grown after the same pastures.

Soil-borne disease

The incidence of take-all in the 1994 wheat crops grown following different pastures is shown in Table 3. Take-all was increased by liming (9) but reduced by grass control in the previous annual pasture. Surprisingly, wheat after lucerne contained significant levels of take-all, presumably carried over in the roots of annual grasses. The absence of take-all after the perennial grass suggests that neither phalaris nor cocksfoot is host to the take-all fungus.

Table 3. Percentage of seedlings with take-all symptoms in wheat after different pastures.

Pasture	Control	+Lime	GR	Lucerne	PG
	16	36	2	14	0

Crop growth

Late sowing (6 June) and low rainfall (120mm during crop growth) led to low yields of wheat and canola (Table 4). Nevertheless there were significant effects of treatments, the most striking of which was the very low yields following lucerne, reflecting the lack of stored soil water. Yields after perennial grass were greater, because of more residual soil water. There were significant yield increases in response to liming by canola (32%, $P<0.05$) and surprisingly by wheat (34%, $p<0.07$), possibly due to increased root activity and soil-water extraction. Grass removal led to reduced crop yields (wheat 15%, n.s; canola 34%, $P<0.001$) because the additional N led to increased early growth and soil-water depletion.

Table 4. Yields of wheat and canola (t/ha) in 1994 in relation to previous pasture management

	No lime		+ Lime		Lucerne	PG	L + PG
	Grass	- Grass	Grass	- Grass			
Wheat							
Low P	2.59	1.60	3.38	2.07			
High P	2.26	1.63	1.86	3.35?	0.62	1.39	2.15
Canola							
Low P	0.12	0.22	0.32	0.10			
High P	0.25	0.15	0.22	0.22	0.02	0.06	0.03

CONCLUSIONS

These preliminary results do not provide clear conclusions about the value of different pasture types for subsequent crops. Nevertheless the additional dry matter production by lucerne and the rapid mineralisation of N fixed by annual pastures with grass removed provide encouragement for investing in pastures. The depletion of subsoil water by lucerne needs further research to evaluate the risks in the pasture-crop system.

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