Improved crop production in response to intensively grazed improved legume pastures

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Abstract
A two year study at Minnipa Agricultural Centre compared the production of a traditional and higher input pasture wheat rotation. The 2010 pasture treatments were split for plus and minus grazing. The traditional pasture was self regenerated and set stocked, the high input pasture was a sown annual medic grazed at a much higher intensity for a shorter period. Ground cover, soil water content, soil nitrogen and soil organic carbon assessments were made to monitor any changes.

The 2011 wheat yields were increased in response to a higher seeding rate, phosphorus and nitrogen applications (2.3 t/ha to 1.9 t/ha). There was also a wheat yield benefit measured as a result of the grazing of pastures in 2010 (2.2 t/ha to 1.9 t/ha). The wheat yield was further increased as a result of the high intensity grazing compared to the more traditional system (2.4 t/ha to 2 t/ha). Increased total soil N levels were measured in 2011 in response to grazing but there were no differences in soil water content, soil organic carbon or groundcover between treatments. Increasing the inputs and management of the pasture phase resulted in increased productivity and subsequent profitability.

Key Words
Farming systems, low rainfall, pasture, legume-cereal rotation, grazing, medic

Introduction
Low input pasture and cropping systems are a widespread practice in low rainfall cropping regions of southern Australia, including the upper region of Eyre Peninsula. Medic-based pasture has been an essential component in the legume-cereal rotation in this area; however farmers are increasingly expressing dissatisfaction with the productivity of the pasture phase (Coventry *et al.* 1998). Pastures remain unimproved and most farming systems continue to rely on self regenerating medic for livestock feed and nitrogen (N) input during the pasture phase of the rotation. In these 'ley' mixed farming systems, pastures are generally set stocked and grazed at low stocking rates throughout the season with little effort to manage the grazing for optimal production. There are also concerns that grazing can damage soil structure, remove vital organic matter for the cereal phase of the rotation and induce increased weed germination.

Effective strategies to enhance annual legume pastures in these environments include control of grazing (both intensity and timing), input of exogenous nutrients and the addition of legume seed, or a combination of all of these (Ewing 1999). A study on Minnipa Agricultural Centre has evaluated an improved system using these strategies including sowing, increased fertiliser and intensive rotational grazing. The comparison was made with the traditional system of self regenerating medic, base fertiliser and set-stocked grazing. The study also examined the affect of livestock with measurements of pasture and crop performance from both grazed and ungrazed treatments.

The inclusion of pasture legumes into rotations can significantly increase cereal yields (Puckridge and French 1983) by increasing the availability of N for cereal crops (Robson 1990). To examine these benefits, a wheat cereal crop was sown in the second year of the trial under the high and low input systems and the grain yield and quality were measured to establish the perceived advantages and/or disadvantages of improved pastures and grazing livestock in the pasture-cereal rotation.

Methods
Trial design
A paddock on Minnipa Agricultural Centre was split into four 3.5 ha sections. Each section represented a grazing treatment: traditional (grazed), high input (grazed), traditional (ungrazed) and high input (ungrazed). Four sampling points were selected and marked as permanent sampling points in each section. Data presented for each treatment are a mean of the four selected permanent points in each section.

Trial management
Rainfall, sowing dates and rates of fertiliser and seed are presented in Table 1.

Table 1. Crop and pasture variety, seeding rate (kg/ha), phosphorous and nitrogen (kg/ha) applied to the traditional and high input systems, sowing dates and annual and growing season rainfall totals (mm) in 2010 and 2011

Variable	Systems	2010	2011
Crop variety		Angel medic	Wyalkatchem wheat
Rainfall	Annual	410	402
	Growing season	346	252
Sowing date	All treatments	22 April	9 May
Seeding rate (kg/ha)	Traditional	0	50
	High input	5	70
Fertiliser rate (kg.ha)	Traditional	0	7N, 8P
	High input	6N, 7P	13 N, 15P

Weed control was imposed on all treatments as required in both summer and during the growing season; broad-leaved weed control in the wheat, selective grass control in the medic.

Trial soil, plant and grain measurements
Soil for chemical analysis was collected prior to seeding in 2010 and 2011 at five sites surrounding the four selected permanent points in each section. Soil water content was measured pre sowing and post harvest in the cereal phase to calculate comparative water use efficiency (WUE).

In the 2010 pasture phase imposed on all treatments, biomass production figures were collected from 5 by 0.1 m^2 quadrats sited at each of the four permanent points in each section pre and post all grazing events. Grazing occurred in the traditional grazed and high input grazed plots at stocking rates of 3 and 8 DSE/ha respectively from 16 to the 30 August and then 23 November to the 14 December.

In 2011 an experimental plot harvester harvested two 1.8 m by 9 m plots at the four permanent points in each section and grain yield and quality was measured.

Results
Soil data
The 2011 soil analysis figures indicated increased total nitrogen contents in response to the 2010 medic pasture, with increased additions in response to the 2010 high input grazed medic treatment. Results of the Colwell P and total mineral N for the pasture and cereal phases are presented in Table 2.

Table 2. Colwell P (mg/kg 0-10 cm) and total mineral nitrogen (kg N/ha 0-60 cm) in 2010 and 2011

System	Colwell P (mg/kg)		Total mineral nitrogen (kg N/ha)	
	2010	2011	2010	2011
Traditional - grazed	25	41	93	134
High input - grazed	17	23	54	119
Traditional - ungrazed	25	29	51	99
High input - ungrazed	25	34	50	84

Soil organic carbon levels have remained constant in the study over both years. Estimated water use in 2011 was directly correlated with grain yields with each treatment having similar available water (Table 3).

Pasture phase
The biomass production measured in September following August grazing in 2010 represented the utilisation through grazing and the comparative recovering capability of the volunteer self regenerating (traditional) and sown (high input) (Table 3). The sown medic pasture carried more than double the stocking rate of the volunteer self-regenerating medic pasture with the traditional grazed system having significantly lower biomass production than the other treatments in 2010.

Cereal phase

Grain yields were higher in response to increased seeding and/or fertiliser inputs in 2011, grazing in the 2010 pasture phase also increased 2011 yields (Table 3). Wheat grain protein content did not differ significantly between treatments; the average for 2011 crop was 10.2%. There were no other significant trends in grain quality data measured post harvest 2011.

Table 3. Pasture biomass production (t/ha) from the medic pasture in 2010, grain yield (t/ha) in the cereal phase of the pasture-wheat rotation and water use efficiency (WUE) (kg/ha/mm of plant available water) in 2011

System	Pasture Biomass (t/ha)	Grain Yield (t/ha)	WUE (kg/ha/mm of H_20)
	2010	2011	2011
Traditional - grazed	1.8[b]	2.0[b]	13.5[bc]
Traditional - ungrazed	3.9[a]	1.7[c]	11.9[c]
High input - ungrazed	4.9[a]	2.1[b]	14.4[b]
High input - grazed	3.8[a]	2.4[a]	16.2[a]
LSD (P=0.05)	*1.15*	*0.24*	*1.72*

Discussion

In 2011 there was a wheat yield benefit measured as a result of the grazing of both the sown and self regenerated medic based pastures in 2010, when compared to the ungrazed sown and self regenerated medics. This benefit was considered to be due to the increased total soil N levels measured pre-seeding in 2011. N input by legumes is often likely to be the most important factor in increased yields in crops following pasture legumes (Robson 1990). The increase in crop yield could not be attributed to increased water access as soil water content measurements taken before seeding were similar in each section and soil organic carbon measurements were similar. Grazing of both the high input and traditional systems may have increased the rate cycling of nutrients in the soil and contributed to the higher N measurements in these treatments.

Conclusion

Low numbers of legumes restricts biological N fixation and hence soil fertility which in course detrimentally impacts the following cereal crop, which was portrayed in the low input treatments. Therefore, the improvement of low input pastures in traditional farming systems through sowing medic, increased fertiliser inputs and stocking rate management is a key component in subsequent crop yields. Increasing the inputs and management of the pasture phase in the 'ley' farming system in low rainfall areas can result in future benefits to the crop rotation through increased productivity and subsequent profitability.

References

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