DEPLETION AND RECHARGE OF AVAILABLE SOIL WATER UNDER THREE PASTURE LEYS AND CONTINUOUS WHEAT AT WARRA IN SOUTHERN QUEENSLAND

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Summary. Benefits to soil fertility have been recorded from grass+legume, lucerne and annual medic leys over 8 years at Warra in subtropical north eastern Australia. However, some pasture leys have depleted the soil moisture profile more than continuous wheat. Grass+legume leys of 4 years duration, at the end of the ley phase in spring had depleted soil water to 41% of that of continuous wheat. Short term lucerne and medic leys depleted soil water to 52% and 79% of continuous wheat respectively. This suggests that annual medics will have advantages over the other ley options in drier seasons and on marginal soils. Strategies to manage the deficit in soil moisture caused by grass+legume and lucerne leys are discussed.

INTRODUCTION

The initial high fertility of the brigalow soils of north eastern Australia has declined when subjected to continuous cultivation and cropping, and winter cereal yields generally have decrease with increasing period of cultivation (1). There are some 0.3 million hectares (2) which have been cultivated for more than 50 years and require a change in management if grain cropping is to be sustained. Ley pastures are recognised as an option for restoring the fertility of arable lands.

A long-term study (1986-1995) on brigalow land, at Warra in southern Queensland, has compared pasture, a grain legume, fertiliser and tillage practices for their ability to restore or maintain soil fertility (3). The types of pasture leys studied are a combination of tropical grasses and temperate legumes and some have been effective in increasing soil organic carbon status (4). However, high pasture production may be accompanied by increased use of soil water reserves. Much of the brigalow land occurs in the semi-arid region and the balance between the beneficial effects of the ley and the possible detrimental effects of depleted soil water reserves, needs to be understood.

During the period 1958 to 1968, Littler (5) studied the effect of pasture (lucerne and perennial prairie grass initially, reverting to lucerne within 18 months) on subsequent wheat crops on the Darling Downs. He concluded that adequate replenishment of soil moisture to 90 cm occurred between ploughing of the pasture in September-October and the sowing of wheat in May to mid August. Holford and Doyle (6) reported the long lasting effect of lucerne on soil water status at Tamworth in northern NSW. The Warra study provided the opportunity to study the effect of three ley pasture types (including lucerne) on soil moisture depletion and its subsequent recharge during the summer and autumn fallow period.

METHOD

A detailed description of this long term experiment is given by Dalal *et al.* (7); a brief description follows. The Warra site is located at 26? 47'S, 150? 53'E on a grey cracking clay (Typic chromustert), containing 52% clay, 0.7% organic C (after 50 years of continuous cultivation) and pH 8.5 (0-10 cm). It is typical of 2.6 million hectares of potentially arable brigalow land in southern Queensland (8) and smaller areas in northern NSW.

Three types of ley pastures were grown in rotation with wheat:

• grass+legume, grown for nearly 4 years (established January; removed October)

• lucerne, grown for 16 months (sown under wheat in June; removed October the next year)

• annual medic, grown during the winter/spring period (sown once under wheat in June, there-after self-regenerating; removed October of the year of regeneration)

These leys were grown on several occasions between 1986 and 1994 (three different years for grass+legume; seven occasions for lucerne and for medics).

Grass+legume pasture leys contained purple pigeon grass (*Setaria incrassata* Stapf cv. Inverell), Rhodes grass (*Chloris gayana* Kunth. cv Katambora), lucerne (*Medicago sativa* L. cv. Trifecta) and annual medics (*M. scutellata* L..Mill. cvv. Sava and Kelson; *M. truncatula* Gaertn. cv. Cyprus, Paraggio, Jemalong and Sephi), and were followed by continuous wheat (up to 5 years). Lucerne and medic leys contained the same legume species as the grass-legume pastures and were grown in 2 year rotations with wheat. They were part of a larger array of treatments arranged in a randomised block design (17 treatments with 4 replications).

Soil moisture was sampled prior to sowing (May) and after harvest (October-November) each year. Using a hydraulic core sampler and a 50 mm diameter tube, two cores per plot were collected at 0-10, 10-20, 20-30, 30-60, 60-90, 90-120, and 120-150 cm depths. Soil moisture was determined after drying for 24 hours at 105?C. Plant available water was calculated using bulk densities ranging from 1.25 to 1.5 mg/m^3 and the lower limit of plant available water was taken as the moisture content of the driest profile measured under wheat.

RESULTS

While most seasons had below average rainfall (Fig. 1), the four years 1987-1990 were more favourable than the period from 1991 to 1995. Only three seasons equalled or exceeded the long term mean and in two seasons (1986 and 1991) there was insufficient rainfall for wheat sowing. Thus wheat followed long fallows in 1987 and 1992.

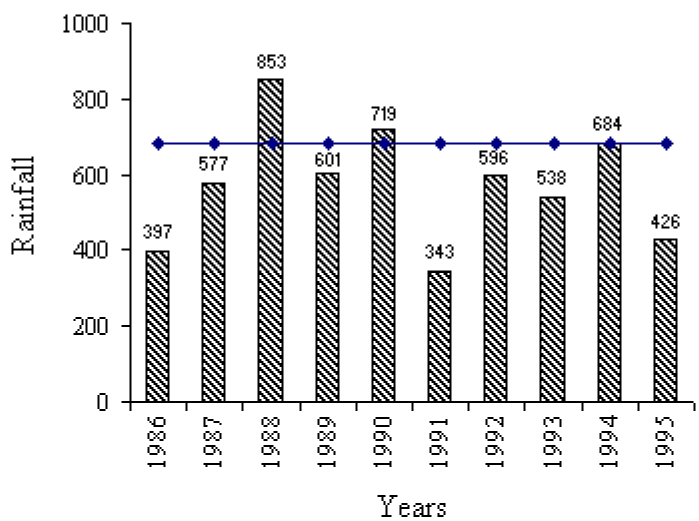

Figure 1. Seasonal rainfall (October 1 to September 30) at the Warra site and the long-term mean of 681 mm.

Removal by blade-ploughing of pasture leys in October coincided with wheat harvest (October-November) and post-crop soil sampling when useful comparisons were made of the extent of soil water depletion by different pastures and continuous wheat (Table 1).

Table 1. Plant available water (mm) measured in October-November to 1.5 m following continuous wheat and different pasture leys.

	1988	1989	1990	1991a	1992	1993	1994
continuous wheat	142	163	104	118	83	57	98
grass+legume		106	64	-37			
lucerne	64	104	81	40	44	28	37
medic	87	138	84	74	81	46	93
l.s.d. 5%	22	38	20	32	20	19	28

Notes: a. drought year, no crop planted.

Figures in bold are significantly different to those of continuous wheat.

Pasture figures are from 17 different ley situations.

Plant available water following grass+legume leys and lucerne leys was significantly lower at the commencement of fallow than that of continuous wheat in all years (Table 1). The grass+legume ley in 1991 and the lucerne leys in 1988, 1991, 1992 and 1994 had lower plant available water than annual medics. Following a summer fallow, plant available water had mostly been restored after annual medic to a level similar to that of continuous wheat but not after grass+legume nor lucerne leys (Table 2). The exception was in 1992 after the long fallow.

Table 2. Plant available water (mm) measured after fallow in May to 1.5 m following continuous wheat and different pasture leys.

	1989	1990	1991a	1992	1993	1994	1995
continuous wheat	233	201	128	186	118	214	160
grass+legume		150	88	153			
lucerne	179	162	108	153	84	195	105
medic	228	199	122	182	119	202	130

l.s.d. 5%	39	31	28	35	28	18	30

Notes a. drought year, no crop planted.

Figures in bold are significantly different to those of continuous wheat.

At the end of the first fallow after the ley, two-of-three grass+legume leys, and five-of-seven lucerne leys, still showed reduced plant available water compared with that of continuous wheat. In only one situation following a medic ley (1995) was plant available water less in May than that of the continuous wheat system.

DISCUSSION

The benefits obtained from pasture leys, which subsequently led to increased wheat yield and quality, outweighed the losses associated with depletion of soil water (9). However, the reduced supply of soil water needs to be recognised and management practices adjusted where possible.

Grass+legume leys containing deep-rooted tropical grasses and temperate legumes, when grown for four years, depleted soil water to 41% (or by 59%) of that following continuous wheat without fertiliser. Lucerne leys grown in short rotations with wheat reduced soil water to 52% (or by 48%) of that of continuous wheat, while annual medics in the same frequency rotations reduced soil water to 79% (or by 21%) of continuous wheat. Replenishment of fallow moisture after medics is therefore likely to occur more frequently. In drier areas and on marginal soils, where moisture is a major limitation to grain cropping, there is a strong argument for using the medic ley in preference to the more moisture depleting systems.

An alternative strategy is to use a forage as the first crop following grass+legume and lucerne leys. Winter grazing crops like oats have been used in this role as the reduced soil moisture has a lower impact where grain fill during the dry spring period is not required.

The time of year when the grass+legume or lucerne leys are removed will have a major impact on the water available for the subsequent crop. However. a shift of one or two months in the traditional time of removal in September is unlikely to have a major influence on soil water recharge for a following wheat crop. Subsoil moisture stores are depleted very early in the life of the lucerne leys (6) and often within the first year of growth; similarly with the grass+legume ley. Leys removed one or two months earlier or later in the dry spring period are unlikely to change the soil moisture status unless there is a significant rainfall event at this time, and this is not common in the study area. To achieve an improvement in fallow storage would require saving some of the previous seasons rainfall. This could be achieved by removing the pasture during the previous summer/autumn period.

The type of seasonal conditions experienced following pasture leys, had a major impact on the recharge of soil water. Rainfall received in the last five years of this study (Fig. 1) was average to below average and the absence of large rainfall events prevented deep moisture storage. During periods of favourable rainfall, water recharge soon after ley removal may be sufficient to produce high yielding wheat crops following grass+legume and lucerne leys. In El Nino years however, the chances of adequate recharge are greatly reduced and wheat crops have a high probability of reduced yield and pinched grain, although grain protein would be high. In the future, simulation studies using long term rainfall records and computer based process models, will allow the frequency of years of major deficits and of adequate recharge to be estimated.

REFERENCES

1. Dalal, R.C. and Mayer, R.J. 1983. Aust. J. Soil Res. 24, 265-279.

2. Weston, E.J. 1987. Proc. Trop. Grasslands Field Day. p. 24.

3. Dalal, R.C., Strong, W.M., Weston, E.J. and Gaffney, J. 1991. Trop. Grasslands25, 173-180.

4. Dalal, R.C., Strong, W.M., Weston, E.J., Cahill, M.C., Cooper, J.E., Lehane, K.J., King, A.J. and Gaffney, J. 1994. Trans. 15th Intern. Congress Soil Sci., Mexico. 5a, 62-74.

5. Littler, J.W. 1984. Qld J. Agric. Anim. Sci. 41(1), 1-12.

6. Holford, I.C.R. and Doyle, A.D. 1978. Aust. J. Exp. Agric. and Anim. Husb. 18, 112-117.

7. Dalal, R.C., Strong, W.M., Weston, E.J. Cooper, J.E., Lehane, K.J., King, A.J. and Chicken, C.J. 1995. Aust. J. Exp. Agric. 35, 903-913.

8. Weston, E.J., Harbison, J., Leslie, J,K, Rosenthal, K.M. and Mayer, R.J. 1981. Queensland Dept. of Primary Industries, Agriculture Branch Tech. Report No. 27. Brisbane.

9. Dalal, R.C., Strong, W.M., Weston, E.J., Cahill, M.J., Gaffney, J., Cooper, J.E., Lehane, K.J. and King, A.J. 1996. Proc. 8th Aust. Agronomy Conf., Toowoomba.