Water use under cropping systems at Condobolin

Brett Honeysett and Neil Fettell NSW Dept. of Primary Industries, Condobolin

Key Messages

- The farming systems containing a perennial pasture phase contained 140-180 mm less soil water in the top 300 cm than the continuous cropping system.
- Soil under the two lucerne-wheat cropping rotations and the perennial pasture system were considerably drier below 90 cm, presumably due to water extraction by lucerne in previous years.
- At sowing, June 2004 and June 2005, the continuous cropping system contained 60 and 30 mm respectively more plant available water in the top 1 m than the lucerne-wheat cropping rotations. This resulted in 50% and 35% higher yields in 2004 and 2005 repectively.
- Rooting depth in 2004-5 appeared limited to the top 70-90 cm for wheat, 50-70 cm for peas and 210 cm for perennial pasture.

  Modelling indicates potential drainage of 19 mm annually under annual crops, thus a 2-3 year lucerne phase is capable of providing 7-9 years of buffering at average rainfall.

Background

The replacement of perennial native vegetation by annual crops and pastures has been blamed for causing increased deep drainage and dryland salinity. Although drainage hasn't been a problem over the last few very dry years, it can be over the longer term. Research at Condobolin is investigating whether lucerne or perennial grasses can dry the soil profile to greater depths than annual crops and pastures and therefore help balance the water available from rainfall with that used by plants. A variety of seasonal conditions typical of the Condobolin climate have identified some other management issues when integrating perennial pastures into annual cropping systems in this environment.

The project

The project "High water-use farming systems that intergate crops with perennial pastures" is jointly funded by GRDC - Sustainable farming systems and the CRC for Plant Based Management of Dryland Salinity, with contributions from NSW Department of Primary Industries and CWFS. The key outcome for this project is the integration of productive perennial pastures into annual cropping systems so as to improve the profitability and sustainability of dryland farming. This is to be done by expanding the knowledge base on lucerne and other perennial species in phase farming systems, and designing guidelines for their use across cropping environments. Collaborative work is being conducted in Victoria, South Australia and Western Australia.

The Condobolin project is using a mix of existing data, modelling and experimental sites to develop and demonstrate high water use farming systems. Detailed soil water readings to a depth of three metres as well as crop and pasture production are being recorded on the Central West Farming Systems core site at Condobolin. This trial has four treatments, namely continuous perennial pasture (PP), two lucerne-wheat cropping rotations namely reduced till (RT, 2 years lucerne and 2 crops per 5 years) and conventional tillage (CT, 3 years lucerne and 2 crops per 5 year rotation), and continuous cropping with zero tillage (ZT).

Results

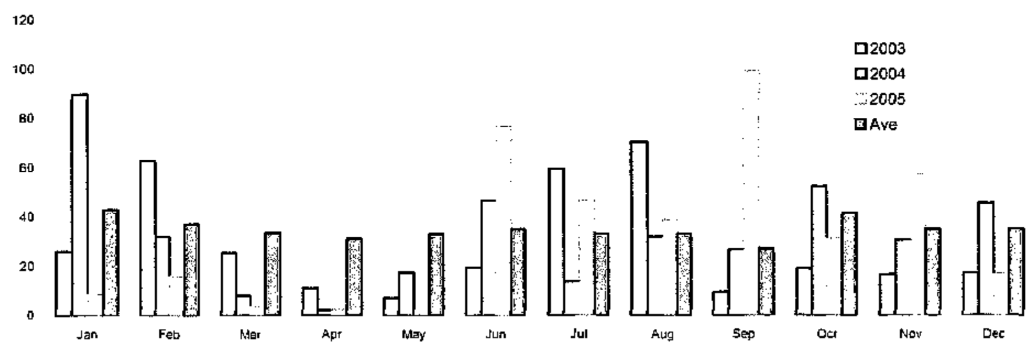
Soil moisture monitoring on the CWFS core site began in September 2003, and the period since has seen a run of below average rainfall years (Table 1). Growing season rainfall is particularly important for crop and pasture establishment, and this has also been low except in 2005. Deep drainage is more of an episodic event, dependent on large rainfall events or a sustained period of rainfall.

Table 1. Condobolin rainfall

Condobolin	Long term				
	average	2002	2003	2004	2005
Annual total	420	305	347	400	400
Growing season (April - October)	235	96	198	193	297

The last three seasons have seen little autumn rainfall, a lack of subsoil moisture, a late break delaying sowing and a combination of heat and moisture stress during flowering and grain filling. Condobolin rainfall is usually characterised by one or more major falls (greater than 60 mm/month) in each year (Figure 1). These falls play an important role in replenishing subsoil moisture; summer events are less effective due to high soil evaporation. These episodic events can also result in deep drainage particularly in autumn and winter when plant water use is low.

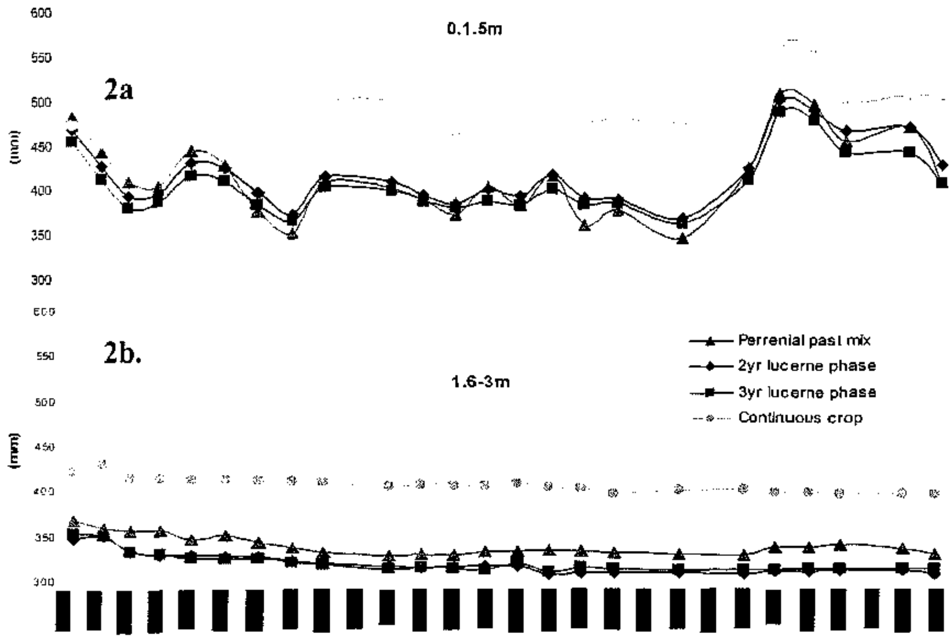
Figure 1. Condobolin monthly rainfall distribution 2003-5 and long term average.



When monitoring began in September 2003, soil water contents already differed among treatments as the trial had completed one full rotation (6^{th} year of operation). The systems with perennials (CT, RT, PP) had lower soil moisture contents in the top 3 m by between 60-100 mm compared with the continuous cropping system (ZT). In April 2005 soils reached their driest point since monitoring began and just three months later (July 2005) they reached their wettest point.

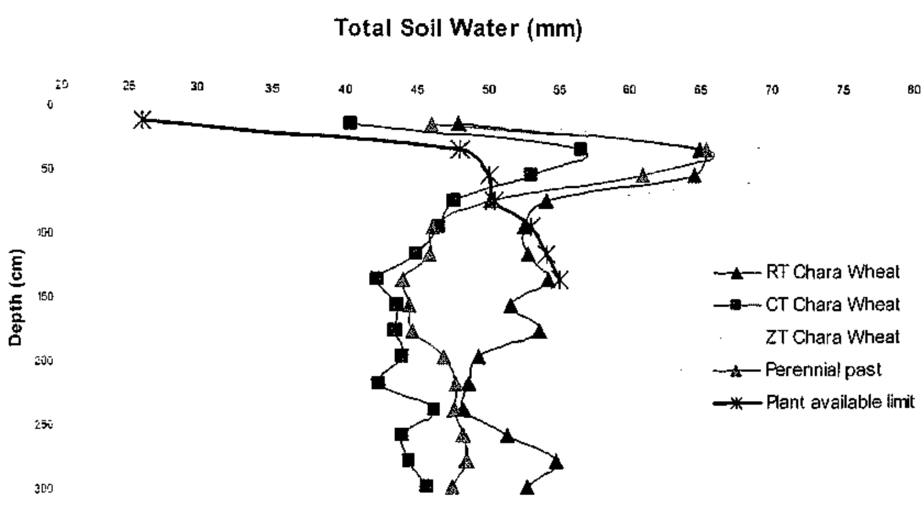
The four systems had similar soil moisture levels in the top 1.5 m in September 2003, but by May 2004 a difference of 50-80 mm between the ZT and the systems containing lucerne had developed (Figure 2a). This difference was maintained until July 2005 when substantial rainfall (120 mm June -July) partly replenished moisture in the top 1.5 m, reducing the difference to 30-50 mm.

Figure 2. Total soil water in a) top 1.5 m and b) 1.6-3 m layer under the Central West Faming Systems Core Site.



There has been little fluctuation **in** soil water content below 1.5 m, which reflects the below average rainfall in the period and hence the lack of moisture infiltration to depth but also the inability of the annual crops to use the water available in this layer (Figure 2b). The 85-90 mm lower water content below 1.5 m in the other treatments throughout the period is the result of water extraction by lucerne.

Figure 3. Soil water profiles under wheat and permanent pasture in 2005



The soil water profiles under wheat for the three cropping systems and for permanent pasture in June 2005 are shown in Figure 3, together with the lower limit of plant available water for wheat. At this time, there was plentiful available water in all treatments in the top 50 cm. However, in the 70-130 cm layer only the annual system had available water, and even there a dry later at 90 cm would likely restrict root elongation below this depth. Two of the systems with perennials (CT, PP) had soil water contents lower than the wheat lower limit, suggesting that lucerne and perhaps perennial grasses are capable of extracting more water from the soil than is wheat.

The soil moisture holding capacity and lower limits for a red brown earth at Condobolin have been estimated (Table 2) using data from a number of experiments on the Research Station. We have assumed a rooting depth for wheat of 1.3 m. We estimate that lucerne is capable of extracting 38 mm more soil water than wheat from the top 1.3 m, and a total of 425 mm more from the whole 3 m profile.

Table 2. Estimated water holding capacity, lower limits and plant available water (PAW) for lucerne and wheat of a red-brown earth soil at Condobolin

Depth (cm)	Water holding capacity (mm)	Lucerne extraction lower limit (mm)	Lucerne PAW (mm)	Wheat extraction lower limit (mm)	Wheat PAW (mm)
10	64.7	20	44.7	26	38.7
30	88.0	**44.8**	43.2	48	40.0
50	97.3	47	50.3	50	47.3
70	79.6	48.7	30.9	50.4	29.2
90	76.1	47.7	28.4	53	23.1
110	74.2	45.3	28.9	54	20.2
130	74.9	45.3	29.6	55	19.9
150	73.7	42.3	31.4		
170	70.4	41.5	28.9		
190	68.4	42.7	25.7		
210	62.1	43.3	18.8		
230	59.6	43.8	15.8		
250	58.6	43.8	14.8		
270	57.9	43.3	14.6		
290	56.4	43.3	13.1		
top 1.3 m	555	299	256	336	218
top 3.0 m	1062	643	419	**na**	na

Initial modelling of long term data suggest that in this environment (average annual rainfall 420 mm) the potential drainage rate under annual crops averages 19 mm per year. If lucerne is capable of creating a dry layer (1.3 to 3.0 m depth) of 160 mm capacity below the crop rooting zone, then this would take on average 8 years of annual crops to refill, before a further lucerne phase would be required.

Conclusions

This trial has clearly illustrated the ability of perennial pastures, particularly lucerne, to dry the soil below the rooting depth of annual crops and pastures. However, lucerne can also result in the upper 1.3 m being drier than in an annual system at sowing time of the following wheat crop, particularly when there has been a series of dry years. Modelling will be used to design farming systems that minimise both deep drainage and the risk of yield depression by the appropriate inclusion of perennial pastures.