Why did cereal crops yield so well and pulse/canola crops so poorly, in the southern Mallee in 2001?

The aim of this investigation was to shed some light on why cereals yielded so much better compared to pulse crops and canola in the southern Mallee in 2001.

Summary: The Systems Trial established in 1999 is starting to show some interesting results. In the dry season of 2001 (197mm Growing Season Rainfall), lentils, field peas and canola yielded poorly (less than 1 t/ha) whereas wheat and barley yielded well (3.0 t/ha). Hostile subsoil conditions limited the rooting depth of pulses and canola (50-70cm) while wheat and barley were more tolerant and able to extract moisture down to 1m depth. Pulses and canola will always struggle to perform in dry springs unless they are grown on soils where their roots can extract soil water deeper than 50cm.

Background

Many soils of the southern Mallee have extremely hostile subsoils with high levels of boron, chlorine, sodicity and electrical conductivity. The Systems trial, established in 1999, on the property of Ian and Warrick McClelland, 30km north of Birchip has subsoils hostile to root growth. The information in this article deals with how the crops grew at the site and why some of the crop types yielded much better than others. The yields, gross margins and other information dealing with the Systems trial are explained elsewhere in this publication.

Methods

Detailed soil water and soil chemical measurements were taken down the soil profile under each of the crop types during the season. Soil pits were dug after flowering to assess crop rooting depth and crops were monitored throughout the season. Plant Available Water Capacity (PAWC) is the measure of how much water a particular crop is able to extract from a particular soil type. It is the difference between Drained Upper Limit (DUL) or Field Capacity (when the soil is full of water but no longer draining) and Crop Lower Limit (CLL) or Wilting Point (when the plants can no longer extract any more water from the soil). PAWC was measured for the systems trial soil in three of the Standard rotation wheat paddocks. Drained Upper Limit was measured by drip irrigating a 20m^2 area for several weeks then taking samples for soil water whilst CLL was measured using open ended rain exclusion shelters erected in September over areas of growing crop, with soil water being measured at the end of the season when the crop had matured.

Results and Interpretation

Soil water properties of the soil

The plant available water capacity (PAWC) (the amount of soil water available to plants) is presented in Table 1.

Table 1. Plant Available Water Capacity for wheat at three soil depths

Soil depth	Plant Available Water Capacity (PAWC) mm
0 – 40cm	80
0 – 60cm	114
0 – 100cm	190

The PAWC is represented for three soil depths to show what happens if a wheat crop was only extracting water from the top 40cm of the soil profile compared to if the roots went down to 60cm or 100cm. If the soil profile is full of water and roots can only grow to a depth of 40cm then they only have access to 80mm of water. If the roots grow down to a metre (100cm) then they have access to 190mm – this has a large bearing on the potential yield of a crop!

Crop rooting depth and soil chemical properties

Prior to the crops drying off, soil pits were dug to a depth of 2m and the rooting depth of each crop was measured. Soil samples were collected, at 20cm intervals down the profile, for chemical analysis. The maximum rooting depth was very different for the five crops. Lentils and canola roots stopped at about 50cm, field peas at 70cm, wheat and barley to 1m (100cm) (Table 2). The sub-soil at the systems trial site is hostile to root growth with high levels of electrical conductivity, chloride, boron and sodicity (Table 2). Wheat and barley were able to tolerate these conditions but lentils and canola appeared to be less tolerant.

Table 2. Soil conditions at the point where roots stopped growing for 5 crop types

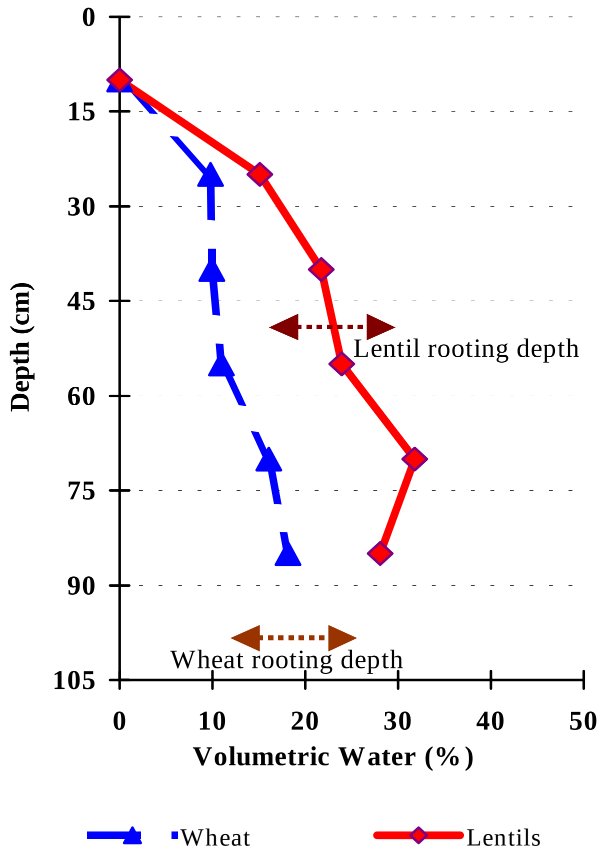
	Maximum rooting depth				
	Lentils (digger) 50cm	**Peas (dundale) 70cm**	**Canola (hyden) 50cm**	**Barley (galleon) 100cm**	**Wheat (yitpi) 100cm**
EC dS/cm	1.5	1.6	1.4	1.1	1.3
Chloride ppm	1200	1400	1200	1000	800
Boron ppm	25	17	33	34	20
ESP %	47	47	51	46	50

ESP = Exchangeable Sodium Percentage (amount of sodium as a % of the cation exchange complex)

Soil water use by each crop

The rooting depth of each of the crops was quite variable – this meant there were large differences in the amount of soil water used over the season. There was an excellent correlation between where roots were visible in the soil pits and the amount of water measured in the soil profile at harvest. Figure 1 shows that wheat had dried the soil to a much greater depth than lentils.

Figure 1. Soil moisture content at harvest for wheat and lentils



The different in rooting depths resulted in wheat being able to extract 60mm of soil water whilst lentils were only able to extract 17mm over a depth of 50cm. (Measured by the difference between the soil water content at sowing and harvest over a depth of 85cm) (Figures 2 and 3, and Table 3).

Figures 2 and 3. Soil water at sowing and harvest for wheat and lentils.

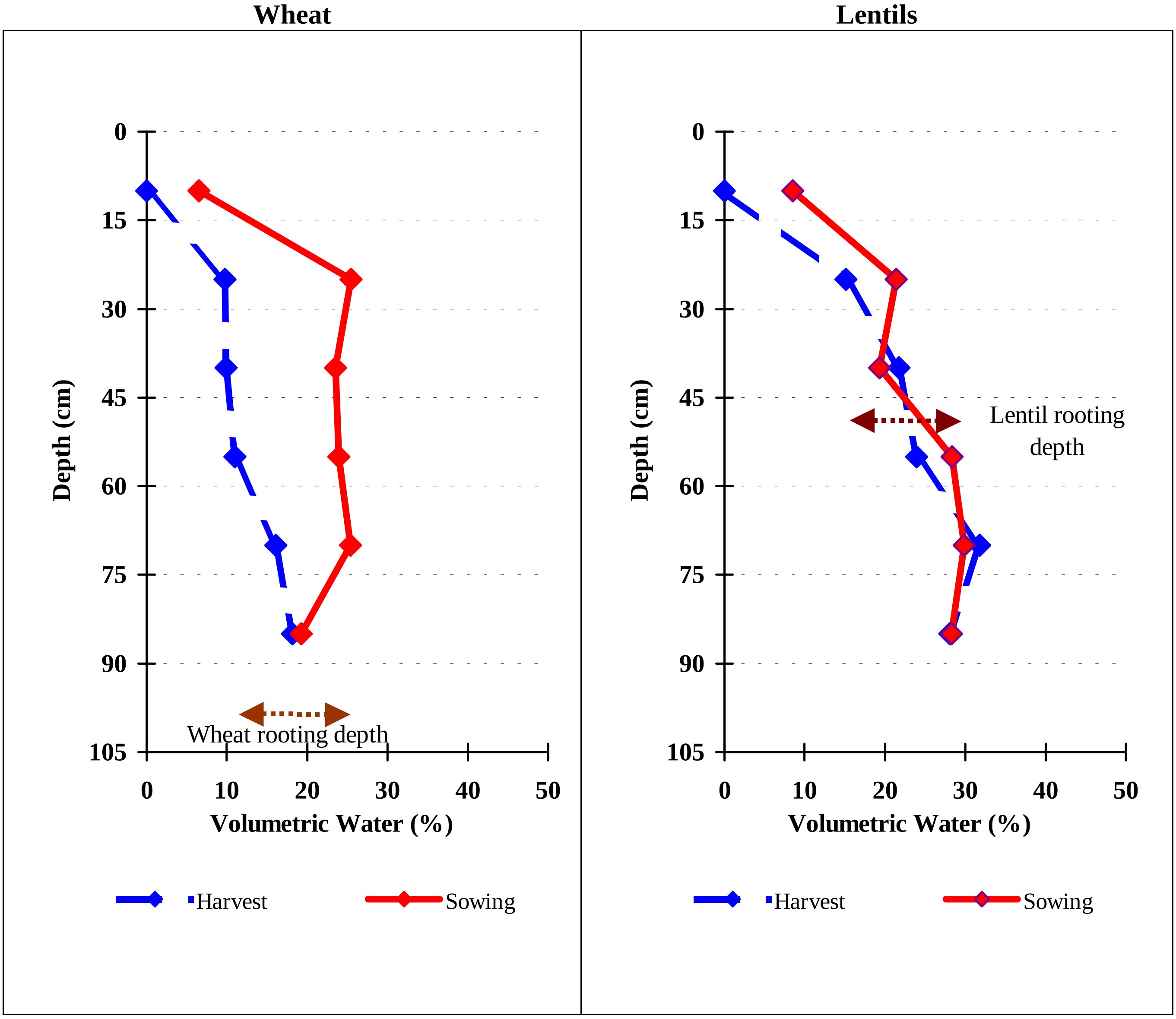


Table 3. The amount of water extracted over the rooting depth by each crop type

	Rooting Depth cm	Water used (mm)
Wheat	100	60
Barley	100	68
Canola	50	25
Field peas	70	20
Lentils	50	17

We have assumed that the Crop Lower Limit (CLL) is the same for each crop type. We will determine this year whether this assumption was valid.

Yield in relation to soil water extraction

The Growing Season Rainfall (April to October) was 197mm, which was below average (average GSR is 240mm).

Table 4. Calculations of soil water use, water use and WUE for five crop types in a season with 197mm of GSR

	Soil water used (mm)	**Estimate of evaporation (mm)**	**Water use# (mm)**	**Yield (t/ha)**	**WUE (kg/mm/ha)**
Wheat	60	110	148	3.1	21.3
Barley	68	90	156	2.9	16.5
Canola	25	110	113	0.6	5.7
Field peas	20	110	108	0.9	10.5
Lentils	17	130	85	0.5	6.4

Water use is calculated as Soil water used + GSR - Evaporation

The Water Use of the crops is directly correlated to the yield of each crop type. Because lentils and canola could not extract soil water to depths greater than 50cm they could not produce the same biomass and yield as wheat and barley, which were able to use water to 1m (100cm). Yields of the crop were in direct proportion to the rooting depth of the crop.

Discussion

In areas with hostile subsoils, lentils, canola and to a lesser extent field peas, have difficulty in getting their roots down into the sub soil to extract moisture. In seasons with a dry Spring this will create a water deficit situation for these crops, resulting in yield penalties. Wheat and barley appear to be able to extract moisture down to much greater depths (down to 1m) and in years when subsoil moisture is available (for example after a wet summer) these crops will not suffer the same yield penalties due to water stress as the pulses and canola.

It is estimated that a lentil crop with an expected yield of 1.5t/ha grown on a soil where the roots can only access soil to a depth of 40cm, will need 12 mm of rain per week during Spring to support growth. The likelihood of this occurring in the southern Mallee is remote. Whereas a wheat crop grown on the same soil type but where the roots can access soil moisture down to 1m and where there is a profile full of water has no problems achieving a yield of 3.0 t/ha even in years with marginal spring rain.

Lentils and canola can be successfully grown in the southern Mallee but to reduce the risk of failure they should only be grown on those soils where sub soil constraints are not as severe as found at the Systems trial site.