FARM MANAGEMENT 500 AND SUSTAINABLE TECHNOLOGY (FAST) PROJECT, ROOTING DEPTH, CROP WATER USE AND NITROGEN CONSIDERATIONS

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Introduction

The FAST project aims to link financial management to the environmental and production aspects of a variety of farming systems in south eastern Australia. This will provide guidelines on how to optimally use the available resources such as soil, climate, plant and labour to sustain productivity and profitability without environmental degradation. The project uses principally FM500 farmers, private consultants Neil Clark, Tim Hutchings, Harm van Rees and Phil O'Callaghan, CSIRO Division of Plant Industry, Charles Sturt University and the Department of Conservation and Natural Resources.

The DCNR component of the FAST project involves detailed monitoring of 27 cropping paddocks for soil physical, chemical and biological properties, soil water balance and crop growth. These factors will be used to highlight the limiting aspects to sustainable production on differing soil types within climatic zones. In Victoria, monitored paddocks are located at Birchip, Donald, St Arnaud, Charlton, Marnoo, Raywood and Lake Bolac. The 1993 season had a good range of crop types in the programme including wheat, barley, canola, safflower, lupins, chickpeas and faba beans. This paper presents some of the results from three southern Mallee wheat paddocks, John Jones at the Demonstration site, the Smith brothers west of Birchip and Peter Martin at Lah.

Crop Water Use

Crop water use by wheat in 1993 was similar across the paddocks. The typical response was for the soil profile to become wetter from the end of July through to September due to the higher than average rainfall for those months, the juvenile crop stage which had not reached maximum water use which normally occurs at flowering, and the high level of stored water in the profile due to the summer rains. As the season progressed, the soil profile began to dry due to lower rainfall and the crop using water. At harvest, most of the paddocks under wheat had a soil profile to 1 m slightly dryer (approximately 20 mm) than at sowing. This indicates that the 1993 crops grew mainly on the GSR but did use some of the stored water.

Although the over all crop water use response was similar between the wheat paddocks, the amount of water used varied due to three main factors; 1) soil nitrogen status, 2) time of sowing and 3) the rooting depth of the plant. Three typical soil water balance plots for wheat are presented for Smith, Martin and Jones paddocks in Figures 1, 2 and 3 respectively. Details of the paddocks are presented in Table 1.

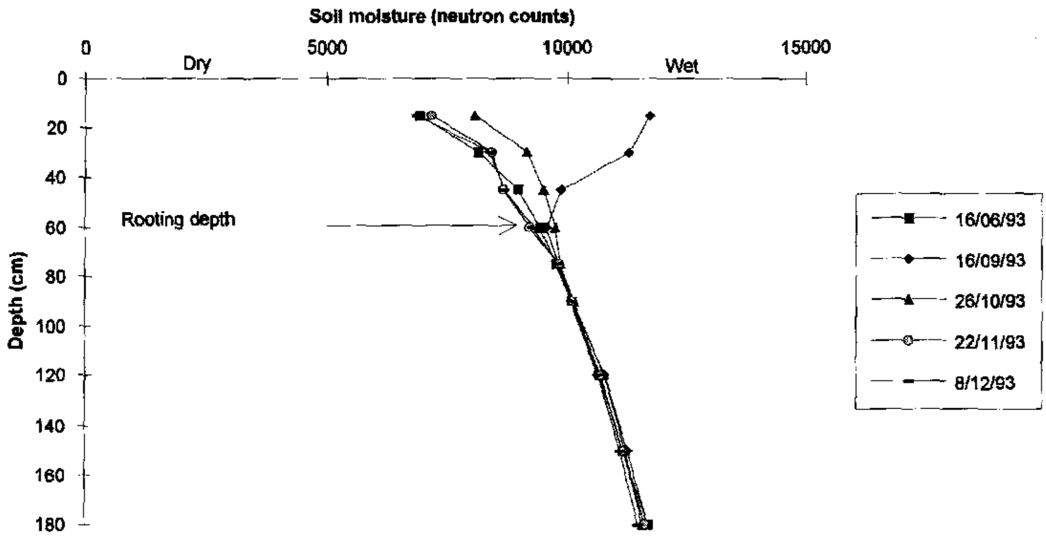

Figure 1 Temporal change in soil water to 180 cm for the Smith paddock

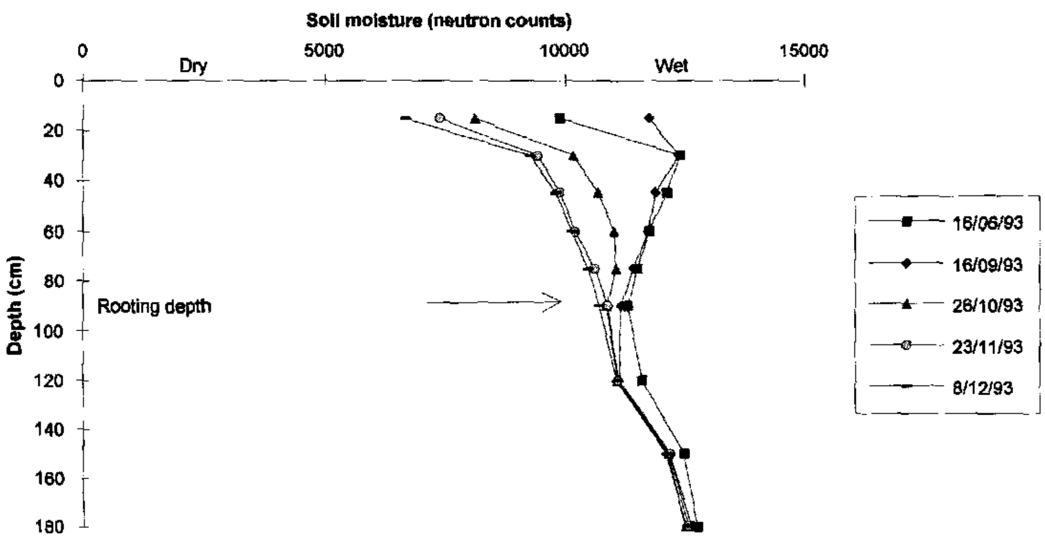

Figure 2 Temporal change in soil water to 180 cm for the Martin paddock

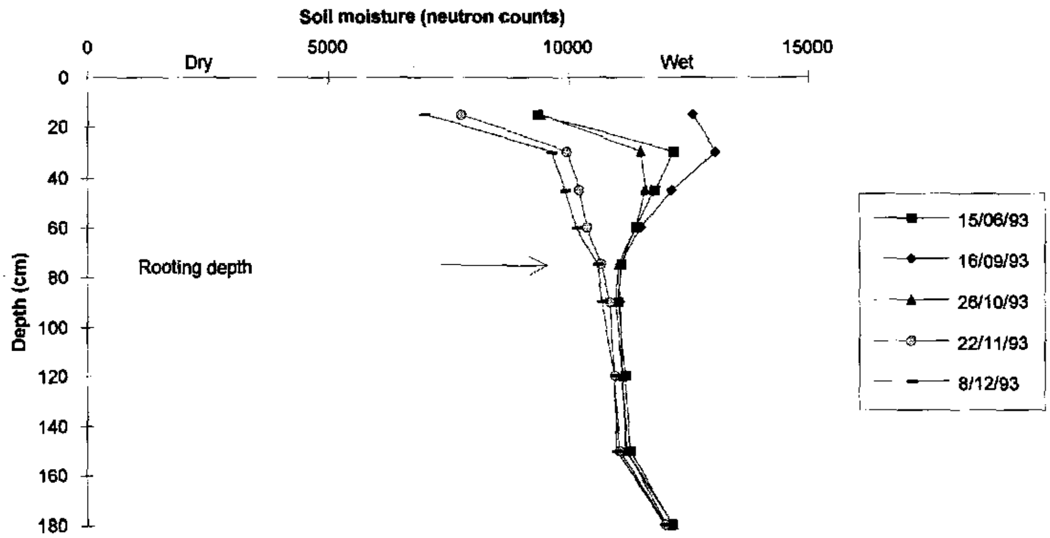

Figure 3 Temporal change in soil water to 180 cm for the Jones paddock

On the Jones paddock (Figure 3), the cropping season began with a high stored soil water level of close to 400 mm. At this level it is likely that the subsoil was close to saturation and movement of water through the subsoil could therefore not be detected using our measuring equipment. Following the above average spring rains, it appears that water was bypassing the root zone as

1. the soil was becoming dryer down to 150 cm from late November

2. the high harvest soil moisture to 1 m (334 mm), and

3. high quantity of water available to the crop also indicating that the soil was close to saturation (Table 1).

The amount of water bypassing the root zone cannot be determined at this stage.

Water did not appear to bypass the root zone on either the Smith (Figure 1) or particularly the Martin paddock (Figure 2). Both of these paddocks started the season with much lower stored soil water levels as compared to the Jones paddock. On the Martin paddock, at no stage during the season did the soil water content below 30 cm surpass the level on 16/6/93. From this we can assume that the crop was able to use the water and little if any water by-passed the root zone.

Table 1 Crop, paddock and water use details for three contrasting wheat paddocks

	Soil Type	Date of Sowing	Rooting depth (cm)	Avail. N[a] (kg/ha)	Yield (t/ha)	H_20 avail. for crop (mm)	WUE (kg/mm/ha)	Crop H_20 use as % of Avail. $H_2O^{\#}$
Smith	Sdy clay	26/5	60	100	2.9*	480	20	53
Martin	Sdy clay	19/5	90	153	4.1*	439	25	60
Jones	Sdy clay	13/6	75	101[a]	1.8**	568	12	32

\# Estimated crop water use based on 20 kg grain /mm/ha (yield / 20 in mm). Available H_2O = (soil water at sowing to 1m + GSR) - (110 for evaporation + 100 for unavailable soil water)

a nitrate nitrogen at sowing + mineralised N (based on GSR) + fertiliser additions

* Yield was reduced by frost by less than 10%

** Yield was reduced due to frost and would have been closer to 3 t/ha, WUE and %GSR water use are calculated on 3 t/ha.

Estimated crop water use as a proportion of the Available water (Table 1) also supports the assertion that water bypassed the root zone on the Jones paddock. The Smith and Martin crops used 53% and 60% of the Available water while the Jones crop used 32%. The early sowing date of 19/5 and 26/5 for the Martin and Smith paddocks respectively put the crop three to four weeks ahead of the Jones. Sowing date along with the adequate supply of nitrogen enabled the crop to establish and grow more strongly and therefore able to take advantage of the higher rainfall during late July to September. On the Smith and Martin paddocks, less water would have bypassed the root zone and the higher water use is reflected in the yield. For every 25 mm of water not used by the crop, an optimum of half a tonne of grain is missed given good management.

Crop rooting depth and limitations to yield

Plant rooting depth varied between the three paddocks. The Martin paddock (Table 1) had the deepest rooting depth of the paddocks due to the early sowing date (longer growing season), higher nitrogen status, minimum tillage regime and the incorporation of deep rooted crops in the rotation (chick peas 1992). In spite of this, the crop still only used 60% of the soil moisture available the remainder of the water being stored in the profile. The yield on this paddock was limited by the amount of nitrogen available. A 4.1 t crop requires 164 kg/ha of nitrogen and the approximate available nitrogen was 153 kg/ha. Therefore nitrogen was limiting not water.

The Smith paddock had the shallowest rooting depth of the three paddocks and root growth appears to be limited by a compact soil layer at 30 cm deep having high soil strength and therefore limiting plant root growth to lower depths. This is likely to be exacerbated by a conventional tillage programme. Although the depth of soil which roots could exploit was shallow, the crop utilised water and nitrogen very efficiently. A 2.9 t crop requires approximately 116 kg/ha of nitrogen and with 100 kg/ha of nitrogen available, nitrogen became the limiting factor and not water. This crop was able to utilise the available nitrogen because like the Martin paddock, the crop was sown on time. This gave the crop a longer growing season and therefore more time for roots to pass through the compact layer, utilise more water and thus produce higher yields. Further yield enhancements should be able to be made through higher nitrogen inputs, the incorporation of deep rooted crops into the rotation to help break into the compact subsoil and a reduction in tillage

The Jones paddock had a good rooting depth of approximately 75 cm however the late sowing date decreased the length of the growing season. The crop was unable to utilise as much of the water available decreasing the WUE. Water bypassing the root zone would have carried with it nitrate nitrogen therefore decreasing the amount of nitrogen available for the crop. A corresponding reduction in yield would have occurred.

For all of the wheat crops in the FAST project, rooting depth showed a positive correlation with yield (Figure 4) and highlights the importance of plant roots being able to exploit a large soil volume for water and nutrients. Insufficient plant rooting depth is one of the key reasons why WUE are not closer to the optimum and is a factor of soil structure deterioration, nutrition, disease, weed control and sowing on time.

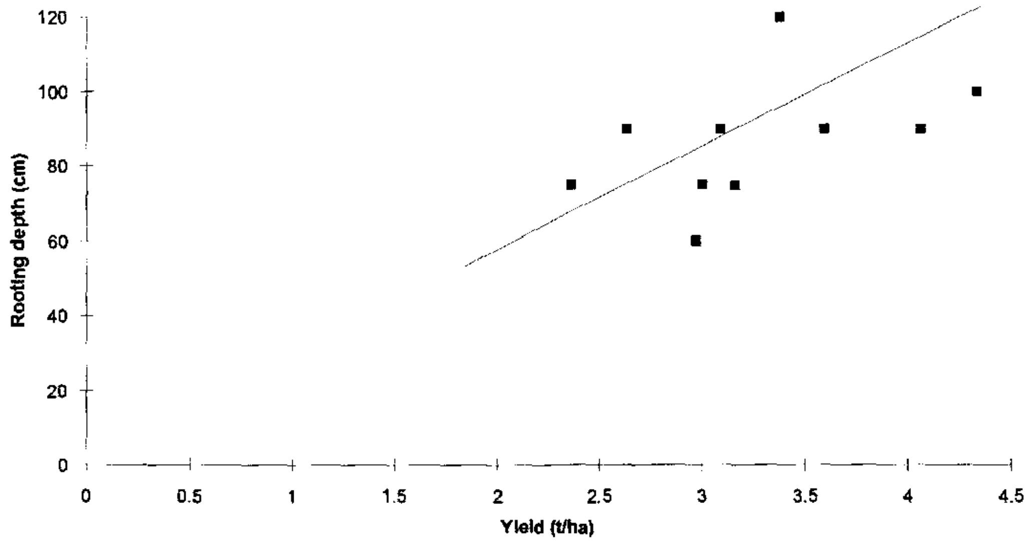

Figure 4 Wheat rooting depth in relation to yield for the FAST wheat paddocks

Yield is related to the available moisture and nitrogen levels and is therefore a factor of plant rooting depth. All of these can be increased through:

- sowing on time
- adequate nutrient levels
- minimum tillage
- stubble retention
- appropriate rotations including deep rooted crops

These are the factors that are often highlighted as required for sustainable and productive crop production and consideration of all points is required not just one or two.

Conclusion

Sustainable and productive farming practices will require that water be used where it falls and this entails that water be used by plants and not access the water table through either surface run-off or permeating below the root zone. This may be difficult to achieve due to seasonal influences, however by adopting farming practices that combine the above factors and consider the likely nitrogen use of the crop, high water using and yielding cropping systems can be implemented.

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REMEMBER: BCDS Field Day - 14 September