## Understanding Subsoil Water-Use by Cereals on Southern Mallee Soils: II. Crop Response

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### Abstract

A field survey conducted in the Southern Mallee showed large spatial variability in soil chemical characteristics. This spatial variability was expressed as difference in water-use efficiency (WUE) of cereal crops (Triticum aestivum cv. Frame) in this region. Large differences in cereal WUE at an inter-paddock level (6.2-31.2. kg $ha^{-1}mm^{-1}$) existed. The mean over all sites was 15.2 (?4.5) kg $ha^{-1}mm^{-1}$ (n=150). This variation reflects the interactions occurring between growing season rainfall, agronomic management and soil properties. Large variability in results also existed at an intra-paddock level. For site I, on a red rise/sodic swale system, WUE varied between 12.1-23.3 kg $ha^{-1}mm^{-1}$ with an average of 17.0 (?3.4) kg $ha^{-1}mm^{-1}$, (n=10). Conversely, site C on a light dune system, had a narrower range i.e. 16.3-25.8 kg $ha^{-1}mm^{-1}$ with an average of 19.2 (?2.8) kg $ha^{-1}mm^{-1}$, (n=10). Subsoil properties appear to strongly correlate with water-use of wheat.

### Keywords

Subsoil, water-use, cereal, sodicity, boron, salinity

### Introduction

Low water-use efficiency (WUE) of cereals is widespread throughout the southern Mallee and Wimmera regions of Victoria. This poor WUE is expressed as an inability of crops to utilise soil water in the subsoil, even in drier years. WUE is not only variable between paddocks (inter) but also within (intra), indicating subsoil limitations rather than inadequate nutrition are responsible for this variation. In particular, subsoil properties such as high salinity, sodicity and boron toxicity have the potential to limit crop growth. Within the alkaline soils of the Southern Mallee, these factors are likely to restrict root growth, utilisation of subsoil water and crop WUE [2]. This paper reports findings of a study to investigate the relationship between subsoil variability and crop performance in the Birchip region of the Victorian Mallee.

### Materials and Methods

A field survey [1], was conducted to assess the variability in subsoil conditions across sites near Birchip. At each profile point (n=150), crop dynamics were assessed. Gravimetric soil water (0-100 cm) was measured at sowing and maturity. Growing season rainfall (GSR) (mid-April to the end of November), was also recorded. Soil water at maturity was subtracted from soil water at sowing and added to the GSR. This was defined as evapotranspiration. Crop grain yield was determined by sampling all plants in a $1m^2$ quadrant. These samples were dried at $50^oC$ for 4 days, the grain extracted in a stationary Kingaroy thresher and weighed. WUE was calculated by dividing yield by evapotranspiration (kg $ha^{-1}$ $mm^{-1}$). Grain protein was determined using Near Infrared Spectroscopy and figures are quoted at 11% moisture.

### Results and Discussion

WUE ranged from 6.2 to 31.2 kg $ha^{-1}mm^{-1}$ (Fig 1). Importantly, for any particular evapotranspiration value in the range of 200-300 mm, grain yield of wheat varied from less than 1.5 t $ha^{-1}$ up to 6.5 t $ha^{-1}$. In explanation of this variation, disease was discounted due to good agronomic management at these sites, and no frost damage was observed. Nitrogen nutrition appears non-limiting, as the average grain protein was 12.3% (n=150) for all sites and 11.9% (n=10) and 11.4% (n=10) at sites C and I respectively. Elevated levels of grain boron (>7.00 mg $kg^{-1}$) generally correlated with low WUE (<15 kg $ha^{-1}mm^{-1}$) (Fig.

2). If it is assumed that grain B is an expression of soil B status, then this would indicate that soil B is sufficiently high to retard crop water-use.

Large ranges in WUE values were recorded for grain B concentrations between 3 to 4 mg $kg^{-1}$. This means that factors other than soil B are influencing WUE. On these soil types this is likely to be related to the effects of salinity and sodicity, although other factors may also be involved.

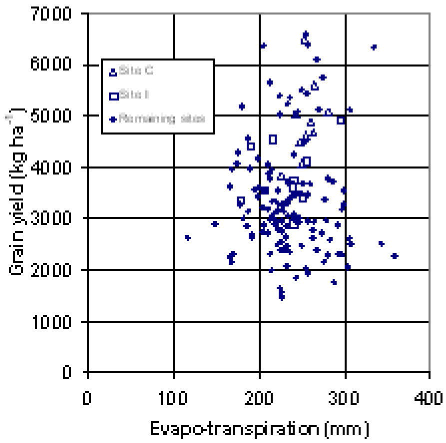



**Figure 1. Grain yield (kg $ha^{-1}$) vs evapotranspiration (mm), defining the water-use efficiency of Frame wheat at all survey points in the Birchip region. Open triangles and squares define response at sites C and I respectively.**

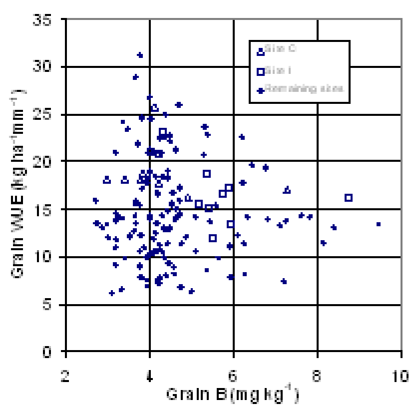
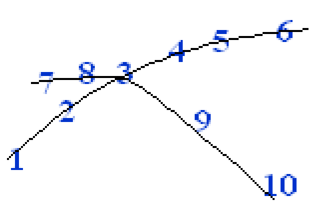



**Figure 2. Grain WUE (kg $ha^{-1}mm^{-1}$) vs grain B (mg $kg^{-1}$) of Frame wheat at all survey points in the Birchip region. Open triangles and squares define response at sites C and I respectively.**

At an intra-paddock scale, variables such as GSR and agronomic management were assumed to be minimal and it is deemed that differences in WUE are due largely to soil parameters. At site C and I, crop response is variable (Fig. 1). At site C, WUE ranged between 16.3-25.8 kg $ha^{-1}mm^{-1}$ with an average of 19.2 (?2.8) kg $ha^{-1}mm^{-1}$, (n=10). The higher WUE is associated with the rise, where as the lower terrain corresponded with suppressed yields (Fig. 3). The high grain B level at profile 10 is coupled with a low WUE, this profile being fine textured and containing higher amounts of soluble B. Overall, the yields were uniform at this site, probably due to the non-limiting nature of the subsoil [1].




| no. | WUE | Grain B |
|---|---|---|
| 1 | 18.8 | 3.8 |
| 2 | 16.3 | 4.9 |
| 3 | 20.8 | 4.2 |
| 4 | 25.8 | 4.1 |
| 5 | 18.2 | 3.0 |
| 6 | 18.2 | 3.4 |
| 7 | 18.1 | 3.8 |
| 8 | 21.3 | 4.0 |
| 9 | 17.7 | 4.2 |
| 10 | 17.0 | 7.3 |

Site C

| no. | WUE | Grain B |
|---|---|---|
| 1 | 23.3 | 4.3 |
| 2 | 21.1 | 4.0 |
| 3 | 16.2 | 8.7 |
| 4 | 16.8 | 5.7 |
| 5 | 12.1 | 5.5 |
| 6 | 18.8 | 5.4 |
| 7 | 17.3 | 5.9 |
| 8 | 13.5 | 5.9 |
| 9 | 15.7 | 5.2 |
| 10 | 15.2 | 5.4 |

Site I

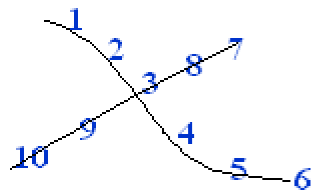



**Figure 3. Spatial position of profile points at sites C and I and the respective WUE and grain B at these points.**

At site I, WUE varied between 12.1-23.3 kg $ha^{-1}mm^{-1}$ with an average of 17.0 (?3.4) kg $ha^{-1}mm^{-1}$, (n=10). High WUE values are restricted to the high points in the landscape (profile no. 1 and 2) where soil salinity, sodicity and boron are low (Fig. 3). Low WUE at profile 5 is due to the highly sodic topsoil. The lower yields along the contour (profile points 3, 7, 8, 9, 10) were attributed to boron toxicity. Consequently the large range in soil conditions corresponded to high variability in crop response.

Within this field study, principal component analysis will be employed to define the various factors controlling the WUE of cereals in the Southern Mallee. Although it is accepted that soil salinity, sodicity and boron restrict crop growth, this study will show to what degree each modifies cereal growth and water-use.

## Conclusion

Overall, large spatial differences in WUE of wheat were evident at inter and intra-paddock scales within the Southern Mallee. Subsoil factors are likely to be the causal agents, after other agronomic factors were accounted for. Subsoil properties such as boron, salinity and sodicity are likely to restrict crop growth.

At an intra-site level, site C displays uniform characteristics across the landscape and similar trends down the profiles, for all soil variables. In contrast, site I has higher spatial variability in soil properties and this appears to correspond to larger differences in cereal WUE. Moreover, high soil B and salinity/sodicity exist independently of one another. In this instance, intra-paddock variability in soil properties is greater than at an inter-paddock level. Future work will establish an order of significance of these factors on the growth of cereals in the Southern Mallee.

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## REFERENCES

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