Simulation of deep drainage under continuous cropping at Harden

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Key messages

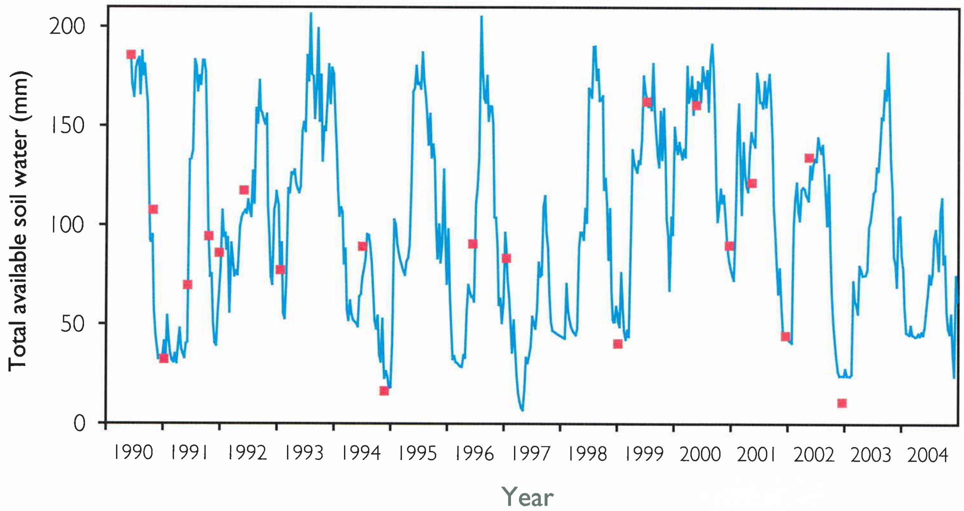
- Average annual drainage below 1.6m at the site was 45 mm in the period 1990-2004.
- Drainage was increased by 24 mm (from 45 to 69 mm) by strict summer weed control and high drainage occurs in winter during above average rainfall years following wet fallows.

Background

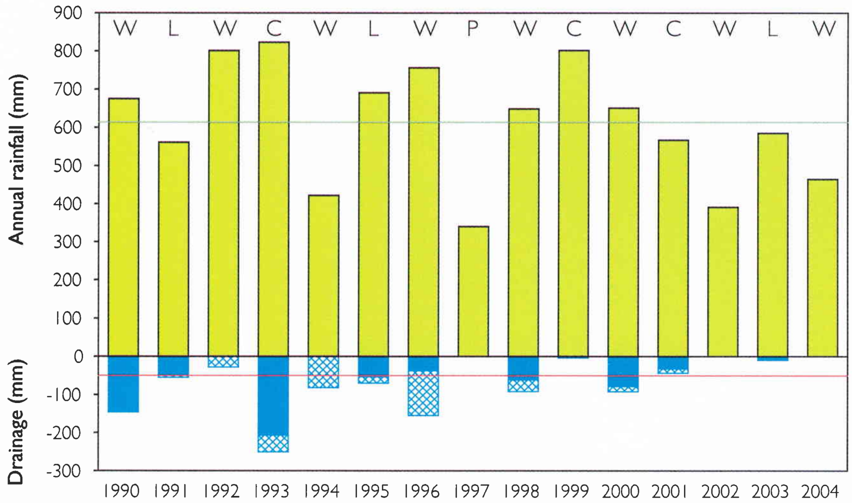
During the 1990s there was concern regarding the drainage of water below annual crops and its effect on dryland salinity. The Jugiong Creek sub-catchment has the highest incidence of dryland salinity outbreaks in the Murrumbidgee catchment, with 6,915 ha of salinity, or 3.2% of the catchment. The salinity outbreaks drew attention to the potential drainage losses from farming systems in this catchment. Estimates of the annual average drainage plus runoff ranged from 37 to 100 mm, depending on crop management, but direct measurements of drainage were rare. At the Harden long-term site the combination of high rainfall and a permeable soil increased the drainage risk and our data suggested that conservation cropping may exacerbate the problem further due to increased water infiltration, reduced evaporation and improved soil structure. Our long-term measurements of water content at the site provided an opportunity to determine the magnitude of drainage at the site.

Soil water monitoring and simulation study

Soil water content was measured at sowing and harvest to a depth of 1.6 m in several crops for the 15-year period from 1990 to 2004 (Fig. 1 – red squares). The detailed soil description, crop agronomy and climatic data available from the site allowed the APSIM crop simulation model to be validated at the site and utilised to simulate crop growth and the soil water balance of the burn/cultivate treatment in the study. Deep drainage was calculated as water drainage below 1.6m, the maximum rooting depth for wheat observed during the experiment. The model simulations of above-ground biomass and yield compared well with the observed data (data not shown) and the simulated soil water content for the whole profile agreed closely with measured data during the 15-year period of the experiment (Fig. 1).



> Figure 1. Simulated (line) and actual (squares) available soil water content for 15 years of the experiment at Harden in the Burn-Cultivate treatment (1990 to 2004).



> Figure 2. Annual rainfall (green bars) for each of 15 years of the crop sequence experiment at Harden and simulated annual drainage below 1.6 m depth ('data-based' - blue bars; 'weed-free' – blue+hatched bars) for the burn-cultivate treatment of the experiment. Horizontal lines indicate mean annual rainfall (613 mm) and drainage (45 mm) for the 15-year period of the experiment. Crops sown in each year are shown (W=wheat, L=lupin, C=canola, P=field pea).

Estimates of deep drainage with and without summer weeds

Drainage was simulated based on actual summer weed control "data-based" and compared with a "weed-free" scenario assuming complete weed control over the summer fallow for the entire 15-year period (Fig. 2). The average annual drainage during the 15-year period ranged from 0 to 207 mm, with an annual mean of 45 mm. Drainage occurred in all but two of the eight years when rainfall was above average, and in only two of the five years when rainfall was below average (Fig. 2) but the correlation between rainfall and drainage in any year is low (r^2=0.16). The timing of the simulated drainage was generally in late winter. In the 'weed-free' simulation higher soil water over the fallow in 1992, 1994, 1996, 1997, and 1998, led to increased drainage in those years of 28, 82, 117, 0 and 30 mm, respectively (Fig. 2). In other years the difference in drainage was small (<15mm). The episodic nature of drainage is demonstrated by the high rainfall years of 1992 and 1993 (801 and 823 mm, respectively). The large drainage in 1993 (207 mm) occurred after a wet summer in 1992/93 and 190 mm of rain in July 1993 and a canola crop which used little soil water during winter. No drainage was predicted in 1992 as the profile was relatively dry in January and an 8 t/ha wheat crop grew on timely rainfall.

Practical implications

Drainage was largely associated with above average rainfall and conditions leading to a full profile in autumn (high summer rainfall, effective summer weed control, poor soil water extraction by crops). Drainage concerns have diminished during the dry period since 2002 and the current focus has shifted to water capture and storage. Continuous cropping using conservation cropping and careful weed management leads to increased water storage and may lead to higher drainage risk. Longer season dual purpose crops will reduce the drainage risk, along with phased perennial pastures.

Further reading

Lilley, J.M., Kirkegaard, J.A., Robertson, M.J., Probert, M.E., Angus, J.F. and Howe, G. (2003). Simulating crop and soil processes in crop sequences in southern NSW. Proceedings of the 11th Australian Agronomy Conference, Geelong. http://www.regional.org.au/au/asa/2003/c/12/lilley.htm

Lilley, J.M., Probert, M. and Kirkegaard, J.A. (2004) Simulation of deep drainage under a 13 year crop sequence in southern NSW. Proceedings 4th International Crop Science Congress, 26 Sept – 1 October 2004 Brisbane Australia. 4p. http://www.cropscience.org.au/icsc2004/poster/1/6/1306_lilleyjm.htm