Comparative water use of dryland crop and pasture species

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Summary. Changes in soil water content were measured under bare soil, a range of annual species and the perennials, lucerne and phalaris, growing under natural rainfall on a red-brown earth at Tatura. Soil water depletion was greatest under the perennials throughout the year, intermediate for annual species and least under bare soil. Rates of water use were similar in the annual and perennial species in spring, although lucerne and phalaris dried the profile by an additional 30 mm. Root length densities at depth were also greater for the perennial species. The data indicate that water use of phalaris and lucerne cultivars, and hence their worth in recharge control, may vary depending on their relative activity/dormancy in winter.

Introduction

Deforestation has changed vegetation water use in south-eastern Australia to the extent that large areas are now vulnerable to rising water tables and salinization. Water use of the crop and pasture systems which now dominate the region has not been able to match inputs of water as either rain or irrigation, leaving the soil more prone to drainage during major periods of rainfall. In south-eastern Australia, rainfall accessions to groundwater usually occur in winter and both the nature of the vegetation and antecedent soil water content are major variables in the extent of groundwater recharge (6,7). Soil cover in annual crops is typically poor in winter, and evaporative demand is low. Water use is therefore small in relation to rainfall and the rootzone is readily saturated depending on antecedent water content. Depending on economic circumstances, cropping will, however, continue as a major form of land use. Flexible management systems, involving a range of crops and a joint appreciation of both fertility and water balances, including antecedent soil water conditions have been suggested elsewhere (2,5). The general aim is to use water as it becomes available and to maximise the transpiration component in the water balance. A major project was therefore initiated at Tatura in 1988 to investigate and compare biomass production and water use of a range of crops and pastures grown on a red-brown earth. Treatments included wheat, *Triticum aestivum,* barley, *Hordeum vulgare ,* canola, *Brassica napus,* safflower, *Carthamus tinctorius,* pea, *Pisum sativum,* and lupin. *Lupinus angustifolius,* annual pasture (Wimmera ryegrass, *Lolium rigidum,* plus sub-clover, *Trifolium subterraneum)* and phalaris, *Phalaris aquatica,* and lucerne, *Medicago sativa.* Phalaris and lucerne are widely used in recharge situations but are not universally accepted in cropping systems. Wheat, barley, pea and lupin collectively account for most of the dryland cropping activity in south-eastern Australia and annual pasture, usually Wimmera ryegrass/sub-clover prevails as the dominant improved pasture in grazing enterprises and rotations. Canola production has increased significantly and the crop is additionally known to tolerate a range of salinities (3). Safflower develops roots deep in the soil profile and is noted for its ability to dry soils to depth (1). This paper reports one year of data from a longer-run experiment, investigating differences in seasonal soil water content of the range of crops in 1990.

Materials and Methods

The experiment was conducted on a red-brown earth (classification Dr 2.33 (9)) at Tatura, using a randomised block design of 10 treatments with four replicates. Plot size was 14x28 m. Pasture treatments including phalaris (cv. Sirosa), lucerne, (cv. Valador) and an annual pasture mix of Wimmera ryegrass and sub-clover (cv. Woogenellup) were sown in 1988 and were well established by the beginning of 1990, the start of the experimental period considered here. Wheat (cv. Rosella) and canola (cv. Marnoo) were sown on 22 May 1990 at 100 kg seed/ha and 10 kg seed/ha, respectively. Lupin (cv. Gungaroo) was sown at a rate of 80 kg/ha on 1 May 1990. Pea (cv. Dundale) and barley (cv. Schooner) were sown at 80 kg/ha and 100 kg/ha, respectively, on 20 June 1990. Safflower (cv. Sironaria) was sown at 40 kg seed/ha on 1 August 1990. All annual crops were sown in plots which had been sown to an annual but different crop the previous year. Banks of soil were established around the periphery of plots soon after sowing and maintained at regular intervals to minimise run-on and run-off.

Measurements of soil water content (SWC) were made to a depth of about 1.5 m using a neutron probe (503 DR Hydroprobe, CPN Corporation, Martinez, Ca., USA). Two access tubes had already been established in each plot in 1988 and were monitored throughout 1990 at approximate intervals of 14 days.

Soil cores were taken over a period of about one week beginning 19 October to measure root distributions. Coring was delayed until 29 November in safflower to coincide with anthesis. Otherwise coring coincided with rapid pod growth in the lupin, canola and pea and anthesis in the barley, wheat and annual pasture treatments. Three sample cores (diameter, 42 mm) were taken at random using an hydraulic and percussion driven sample tube after scraping surface material from the soil surface. Cores were taken to a depth of 1.45 m depending on soil conditions and divided into 11 subsamples depending on depth. Samples were stored at -16?C until washed. Roots were washed from the cores using an elutriator. Residual organic matter and other debris were removed by decantation. Washed samples were stored at 2?C for less than 14 days before root length was measured using a root length scanner (Comair, Hawker de Havilland Vic., Ltd, Melbourne, Australia).

Rainfall was recorded daily at a weather station approximately 500 m from the experimental site.

Results and discussion

Rainfall

Other than the somewhat wetter months of August and September, Table 1 shows that total rainfall and its distribution in 1990 was reasonably similar to that expected on the basis of long- term records at the site.

Table 1.Monthly rainfall distribution at Tatura in 1990 as compared with long-term average monthly rainfall.

	Rainfall (mm)											
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	30	31	37	35	47	41	48	50	44	51	38	33
1990	6	50	7	48	35	35	42	82	62	17	26	8

Soil water content

Effects of treatments on S WC are shown in Figure 1. Note that SWC varied between treatments at the start of the year because of different crops in the preceding year. Data for pea and barley have been omitted for purposes of presentation. These were very similar to those presented for lupin and annual pasture after day 150. Figure 1 shows that lucerne and phalaris consistently maintained a lower SWC than other treatments and were able to extract water to the lower limit of plant extractable water seen in this soil type (i.e., 310 mm). Rain after day 150 (Fig. 2) increased SWC in most treatments to the upper limit of about 510 mm (Fig. 1). However, SWC in phalaris and lucerne did not reach this value and the soil remained relatively dry in the period, day 200 to day 280. The maximum SWC in phalaris was 450 mm and a maximum of approximately 470 mm was seen in lucerne. The lowest SWC in the bare ground treatment was *circa* 450 mm, seen in both autumn and spring (Fig. 1). The unsatisfied SWC or buffer capacity of this treatment was therefore least, with the soil having a maximum soil water depletion of only *circa* 60 mm to be replenished before the onset of runoff and/or deep drainage. SWC of the annual crops, canola, lupin, safflower and wheat generally fell between the extremes exhibited by the bare ground and perennial pastures, although SWC was clearly more akin t that of the bare ground treatment rather than that of the perennial pastures in the autumn. Onc the crops had established maximum leaf area index (data not presented), they were able t deplete SWC at a rate similar to that of lucerne and phalaris in spring, but to a lesser total exten SWC of wheat, canola and safflower was a minimum of *circa* 350 mm at the end of the ye. as contrasted with minima of *circa* 320 mm in phalaris and lucerne. Whilst not significant, appeared that annual pasture and lupin (also pea and barley) were unable to use the same amour of water as the other annuals, although they used significantly more than the bare ground treatment (Fig. 1).

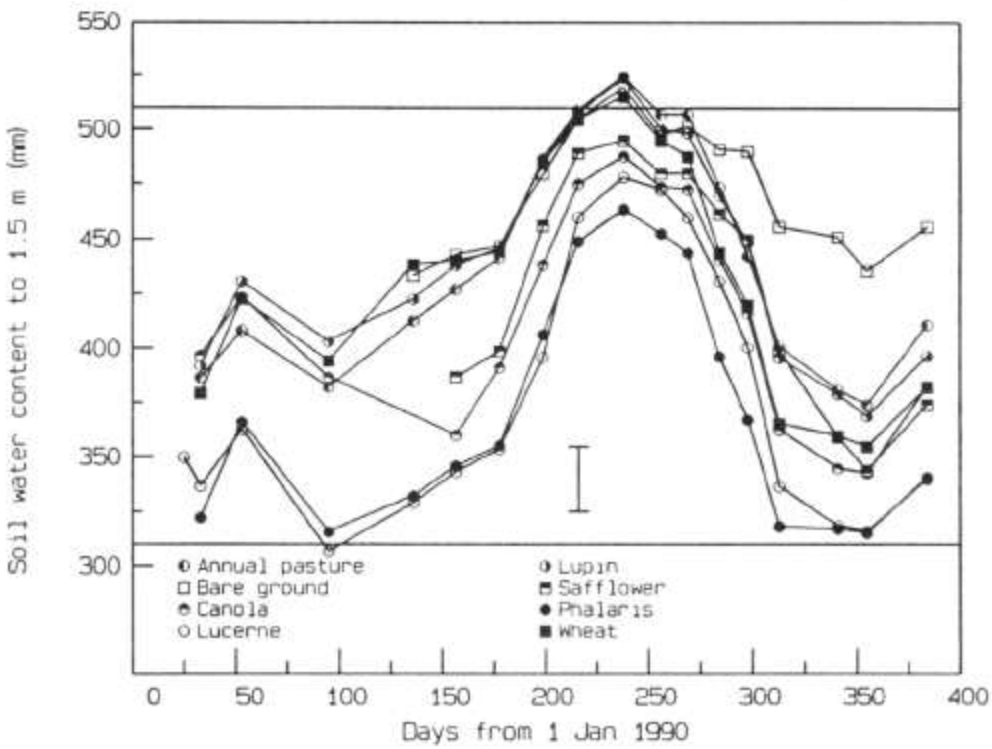

Figure 1. Changes in soil water content of treatments with time. The error bar represents a typical l.s.d. (P=0.5) appropriate to SWC data for a given day.

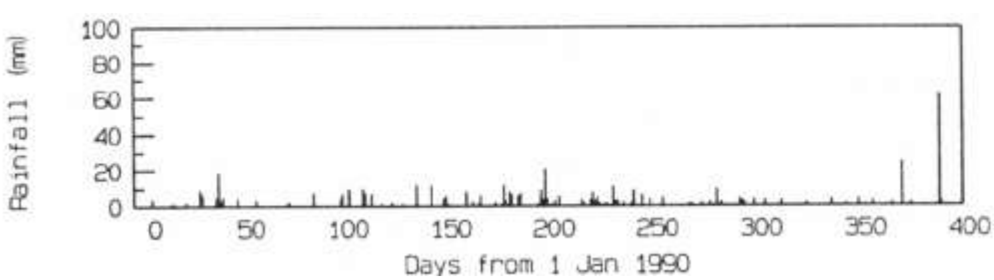

Figure 2. Seasonal rainfall distribution in 1990.

Root density distributions

Root length density distributions (Fig. 3) primarily showed the extent to which phalaris maintained a high root length density throughout the depth of the soil profile. Lucerne also showed a similar pattern in comparison with other treatments although the distribution with depth in canola was not significantly different to that of lucerne. These data are in general accord with the SWC data measured after day 300 (Fig. 1) although safflower, which had depleted SWC extensively at this stage, did not show consistently high root length densities with depth. The data of Figure 3 also suggest that depth of rooting was not a major factor that distinguished treatments Few roots were found below 125 m in all treatments

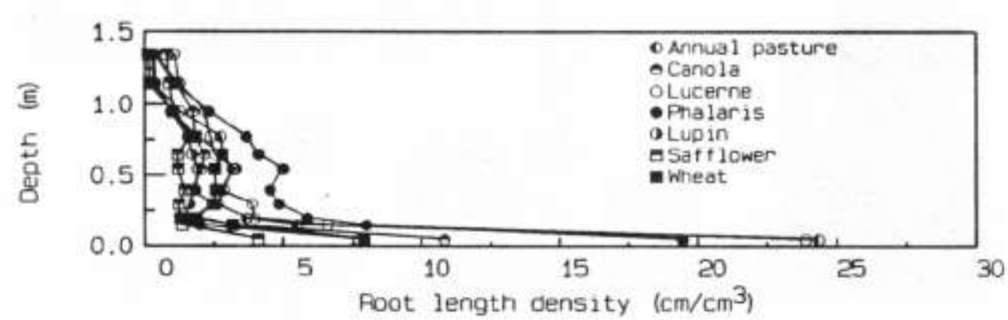

Figure 3. Change in root length density with depth in the soil profile.

The SWC data, although taken over only one year, show the vulnerability of bare ground (fallow) to saturation and similarly, that of the annual crops in comparison with lucerne and phalaris. It should be noted, however, that the efficacy of the latter species in this context may be expected to vary with management practices affecting leaf area and also with the relative winter activity of the particular cultivar. In this experiment, phalaris has consistently made better growth in the autumn and winter than lucerne, presumably accounting for the difference in SWC seen here after day 200. Both lucerne and phalaris were allowed to develop full cover before cutting and the recovery of lucerne after autumn was less than that seen in phalaris (data not presented). The extent of cover developed during and after autumn *(circa* day 100) was therefore dependent on winter activity in these species and on the experimental management procedures. Annual pasture was not able to deplete SWC to any significant extent over and beyond that seen in bare ground in autumn and winter, as a result of its inactivity over the summer and its relative inactivity in autumn. Although data for only one year are not sufficient to distinguish overall species performance, these data clearly demonstrate the major differences in soil water balance that may be achieved through existing management options and reinforce arguments against practices such as fallowing and non-productive land use in general.

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