Measuring soil water content to indicate the ability of different pasture species to dry the soil profile

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Currently, about 3000 hectares of land in the Namoi catchment is estimated to have the water table within 2 m of the surface. This area is expected to increase to about 28000 ha by 2050 (Littleboy *et al.* 2001) since water tables are increasing by 0.06 m per year under current land management practices. Typically, native pastures and annual crops that commonly occur in the region have roots to about 1.2 m (Lodge and Murphy 2002), with deep drainage estimated to occur mostly in wet winters, and ranging from 0-200mm/year under native pasture (Lodge *et al.* 2002). Therefore the drier the soil profile the larger the likely "buffer" against a recharge event occurring. The ability of different species to dry the soil profile depends on their green leaf area, rate of transpiration and root distribution. However, these are difficult to measure and so estimates of soil water content (SWC) or soil water deficit are often used as an indicator of the differing abilities of species to dry the soil profile.

In the high rainfall zone of southern Australia several studies have shown that annual pastures use less water (25-40%) than perennial pastures (e.g. Dolling 2001). In the Liverpool Plains, Abbs and Littleboy (1998) also found that perennial pastures had higher evapotranspiration and less deep drainage compared with annual cropping systems. However, few comparative data are available for other perennial legumes, grasses and browse shrubs, particularly in northern New South Wales.

This paper reports preliminary SWC data (November 2003 to September 2004) for a range of perennial pasture species and shrubs to examine any short term seasonal or soil depth differences in the drying of the soil profile.

Materials and methods

The experiment was located at the northern NSW recharge site for the Cooperative Research Centre for Plant-based Management of Dryland Salinity, about 12 km west of Manilla in the Namoi Catchment on a Brown Vertosol soil at an elevation of 400 m. Long term average annual rainfall at Manilla is 650 mm.

The main study was on a previously cropped area and compared 6 different species types sown in 3 replicates in May or December 2003. The species types were: oldman saltbush (*Atriplex nummularia*), lucerne (*Medicago sativa* cv. Venus), perennial ryegrass (*Lolium perenne* cv. Skippy), phalaris (*Phalaris aquatica* cv. Atlas PG), a mixture of the phalaris and lucerne (all sown in May) and digit grass (*Digitaria eriantha* cv. Premier, sown in December). Plots (5 x 5m) were handsown, except for oldman saltbush which was sown as transplants in jiffy pellets (5 per plot). Data was also collected on an adjacent native pasture dominated by plains grass (*Stipa aristiglumis*) and a fallow plot in the cropped area that was kept free of weeds by regular herbicide application.

For all plots, SWC was estimated by using a calibrated neutron moisture meter (NMM) and access tubes that were installed in the centre of each plot to a depth of 210 cm in late October 2003. NMM counts (16 s duration) were taken at 10 depths (initially at 20 cm below the soil surface and then in 20 cm increments corresponding to soil depth layers of 0-30, 30-50, 50-70...190-210cm) every 3 weeks from 13 November 2003 to 2 September 2004. For each soil depth NMM counts were converted to Θ_{vol} using the calibration procedures described below (Θ_{vol} =0.0036*16s count – 10.291), with Θ_{vol} being converted to millimetres of stored soil water (SWC mm) for each depth layer.

In November 2003, soil bulk density (Mg/m^3) was determined using the ring method of Blake and Hartge (1986), with duplicate samples taken at 14 depths (Table 1) from a freshly excavated soil pit. These values were used to convert gravimetric SWC

(Θ_g g/g) to Θ_{vol} values for each depth. NMM counts were calibrated to a range of Θ_{vol} values (11.38-45.23%) by linear regression ($R^2 = 0.8146$, $n = 41$) and for each depth SWC values were expressed as millimetres of water.

Table 1. Bulk density and SWC (Θ_g %, Θ_{vol} % and mm for the Brown Vertosol at the experimental site in November 2003

Depth (cm)	Bulk density (Mg/m^3)	Θ_g %	Θ_{vol} %	SWC (mm)
0-5	1.35	18.3	24.8	12
5-10	1.45	19.4	28.1	14
10-20	1.52	18.7	28.3	28
20-30	1.54	18.9	29.2	29
30-40	1.46	21.2	31.1	31
40-50	1.53	22.4	34.3	34
50-70	1.51	19.9	30.0	60
70-90	1.57	19.3	30.4	61
90-110	1.66	19.0	31.5	63
110-130	1.63	18.6	30.3	61
130-150	1.64	19.2	31.5	63
150-170	1.61	18.5	29.8	60
170-190	1.61	20.2	32.6	65
190-210	1.64	21.0	34.3	69

Results and discussion

Rainfall from October 2003 to September 2004 (inclusive) was 17% below average, with only 1 month being above average (January 2004, 155 mm, Fig. 1*a*). From autumn to the end of winter 2004 rainfall was 34% below average (Fig. 1*a*) and so there was little increase in total SWC (Fig. 1b).

Soil bulk density tended to increase with depth and was always >1.50 Mg/m^3 at a soil depth >40 cm with SWC (Θ_g and Θ_{vol} %) also tending to increase with soil depth (Table 1). In November 2003, total SWC (0-210 cm) estimates from the soil pit and from calibrated NMM counts were in reasonable agreement (650 *v.* 669 mm, respectively).

Perennial ryegrass and phalaris in the lucerne-phalaris mix failed to survive summer 2003-2004 and so no data have been presented for these treatments. All plots, except those of the fallow, native and lucerne treatments were invaded by summer-growing annual liverseed grass (*Urochloa panicoides*), which grew from November 2003 to March 2004. Phalaris plots declined markedly in stand density after autumn 2003.

Highest SWC (0-210 cm, Fig. 1*b*) was maintained in the fallow treatment, ranging from 698 to 708 mm. Lowest SWC was in the permanent native pasture (range 536-568 mm, Fig. 1*b*). Above average rainfall in January 2004 had little apparent effect on the SWC of the fallow treatment, but increased the SWC of the native pasture and saltbush treatments by around 27 and 62 mm, respectively (Fig. 1*b*). Six months after sowing (November 2003) lucerne had dried the soil profile to a greater extent than all of the other species. Digit grass was sown in December 2003 and started to reduce SWC in February 2004 (Fig. 1b). By September 2004, the total SWC (0-210cm) under lucerne and saltbush was similar to that of the native perennial grass. Also, SWC values for these treatments were substantially lower than those for phalaris and digit grass, which in turn were markedly lower than those in the fallow (Fig. 1*b*).

Six months after sowing, lucerne had reduced SWC in the upper 80 cm to a greater extent than the other species. However, below 80 cm soil depth SWC values were similar for all sown species. Native perennial grass had a similar SWC to lucerne to a depth of about 40 cm, but at lower depths the native grass had markedly lower SWC values compared with all other species (Fig.2*a*).

By September 2004 all sown species had reduced SWC to 110cm compared with the fallow treatment (Fig. 2*b*), with the native pasture being driest at the lower depths. There was also some indication that the oldman saltbush and lucerne treatments had lower SWC at soil depths >120 cm compared with the other sown species, which were similar to the fallow.

Up to sixteen months after establishment differences in soil moisture are developing. Preliminary data indicates that SWC data may be a useful means of indicating both seasonal and soil depth differences in the drying of the soil profile among different species.

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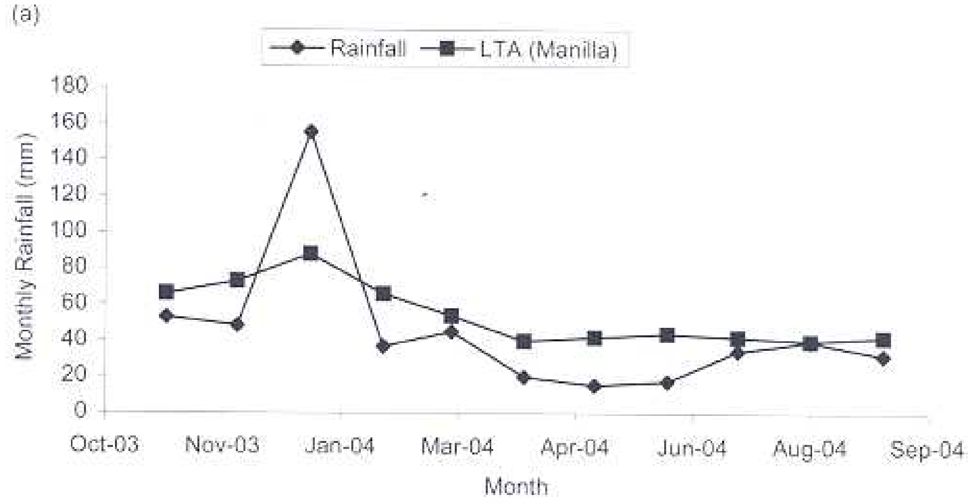
Figure 1. (*a*) Monthly rainfall (mm) recorded at the experiment site and long term average for Manilla (LTA), and, (*b*) total soil water content (SWC 0-210 cm) from November 2003 to September 2004.



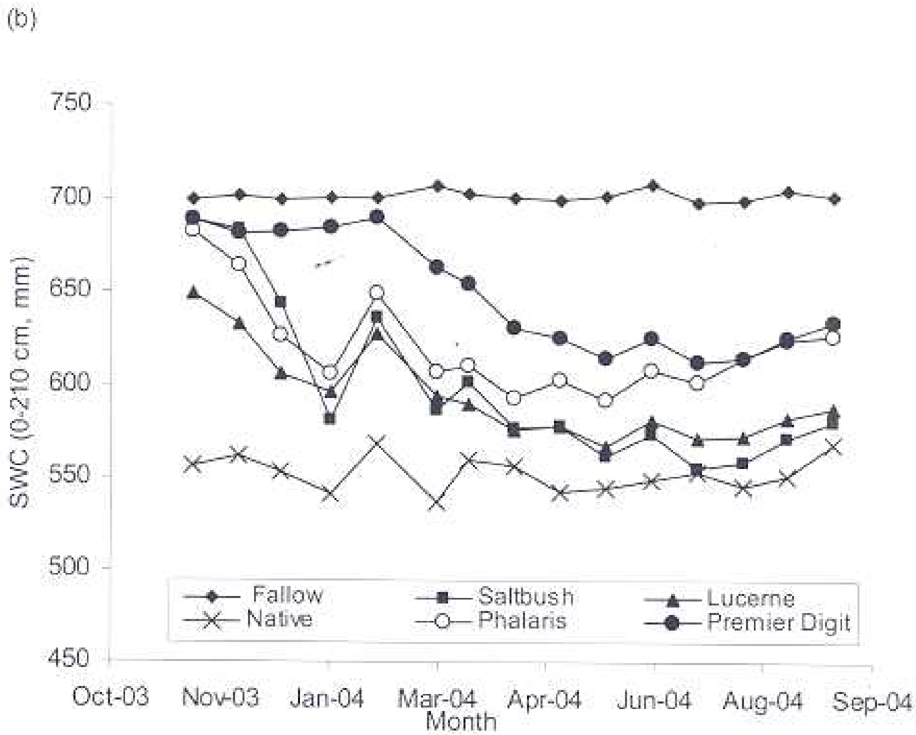
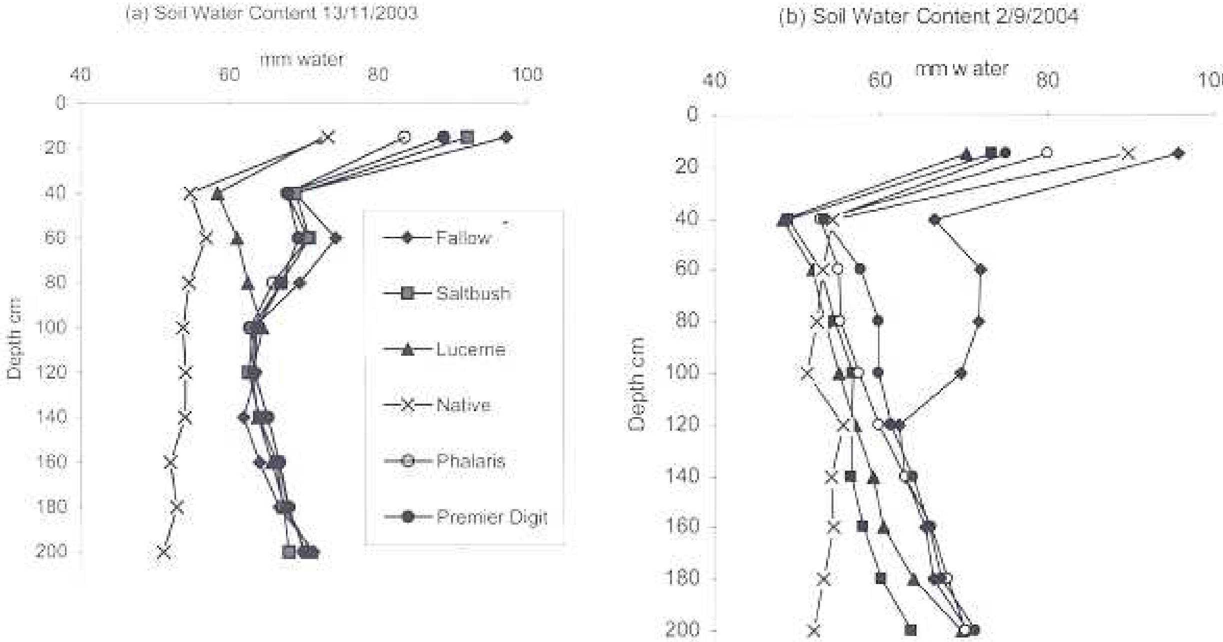


Figure 2. SWC (mm) for each soil depth for 5 pasture treatments and a fallow treatment on (*a*) 13 November 2003, and, (*b*) 2 September 2004.



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