Combating Sodic Subsoils -Is plant growth affected by sodic subsoils?

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Key Points

- Under the current dry conditions there is limited water in the subsoil which makes this project difficult.
- Soil sampling throughout the year on various paddocks showed plants using what little subsoil moisture was available.
- Since subsoils were not very wet, it is unlikely that the sodic nature of the subsoils was expressed.

Background Information

The dominant soil types used for dryland cropping in central-western NSW are the red earths (Kandosols) and red brown earths (Chromosols); gradational and duplex soils often with sodic clay subsoils. Central western NSW soils have less hostile subsoils than areas in Victoria, South Australia, Queensland and other areas of NSW.

Sodicity is the major problem associated with the subsoils of central-western NSW. Previous research in the region (McKenzie *et al.,* 1993, Aust. J. Soil Res. 31: 839-868) has documented that NSW has far above the national average of sodic soils and estimated that sodic soils cover 47% of the state. They estimated that over 80% of soils in NSW central mixed farming systems had sodic sub-soils. They also suggested that yield increases of up to 200% could be expected after amelioration of sodic soils. A more conservative estimate came from a collation of soil test results across CW NSW as part of an earlier project and estimated that about 50% of sub-soils in CW NSW are sodic below 60 cm (Evans, Bowman and Scott, 2003, 11th Australian Agronomy Conference).

Sodic sub-soils can cause a restriction to plant root growth and water uptake. The dispersive nature of sodic soils cause soil pores to become blocked which restricts water infiltration and aeration of the soils, which in turn also affects plant growth. There have been studies conducted on sodic soils in central-western NSW - one study investigating dryland cropping soils (Valzano, Murphy and Greene, 2001, Aust. J. Soil Res. 39: 1307 - 1331.) and another investigating sodic irrigated soils (McKenzie *et al,* 2002, Aust. J. Exp. Agric. 42: 363-368.) - but they have focussed primarily of surface issues.

Some soils in central-western NSW also have increasing salinity with depth (80-90 cm, 55% were < 0.1 dS/m; using criterion that > 0.1 dS/m affects salt-sensitive plants; Evans *et al,* 2003). The salinity issue for subsoils in central-western NSW is quite minor compared with subsoils in Victoria and South Australia (P. Rengasamy, pers. comm.). Central-western NSW does not have a problem with sub-soil acidity (< 5% of soils have acidic sub-soils; data from Evans *et al.,* 2003), nor toxic concentrations of aluminium or boron (as with Victoria and South Australia).

The effect of sodic subsoils on crop production has not been quantified, even though estimates have been suggested. In the 2001 growing season CWFS, through the Crop Monitoring Program, identified that some crops in the region were not reaching their water limited yield potential. In some circumstances the reasons for this could be identified but there were many crops where there appeared to be no obvious reason for this low yield. In some cases, soil constraints, particularly subsoil constraints may be the issue.

Methods

Crop and soil monitoring was conducted in farmers' paddocks (seven paddocks) across central-western NSW in 2004. These paddocks were identified from previous work and after discussion with the farmers. These particular paddocks were chosen because of their varying ranges of sodic subsoils (Table 1) and other possible constraints. The spread of paddocks across the region was also considered.

The Tottenham soils are quite benign soils, with some sodium at depth but not at a concentration that it is thought would be detrimental to plant growth. There is some salt at depth in the Tottenham Back paddock but this is not thought to cause much damage to most plants (salt sensitive plants may be affected below 50 cm). The Tottenham Back paddock has more clay in the soil at depth than the Tottenham Spring paddock (indicated by the higher eCEC of the back paddock).

The Parkes soils offer a range of issues. The Parkes Mine paddock has salinity at depth and salt sensitive plants may be affected. There is also sodic subsoils in this paddock, so we have a combination of sodicity and salinity. This paddock also has quite a heavy clay subsoil. The Parkes Tank paddock has some sodic subsoils but with only half the amount of sodium present as in the Mine paddock. The Parkes Silo paddock is similar to the Tank paddock but also has an acidic surface soil to 30 cm, with aluminium (Al%) almost at a concentration where plant growth may be affected.

The Condobolin and Forbes paddocks have sodic subsoils and some salinity at depth. The Forbes site has a heavier clay soil than the Condobolin paddock.

The seven paddocks were monitored at four times over the year gathering information to determine crop and soil relationships. The seven sites were located at Tottenham (2 sites), Parkes (3 sites), Forbes and Condobolin. In 2004 five of the seven sites were cropped and the other two were pastures. Sampling dates were June/July prior to sowing where soil samples were collected to determine initial soil moisture. August sampling was to measure the number of plants/m^2. Sampling in October was at about mid-late tillering and measured plant growth and soil moisture and noted weeds and other potential problems. The fourth sampling occurred before harvest on all sites where plant cuts to determine yield were taken and soils were sampled to measure soil moisture after the growing season.

Soil moistures were measured in an oven at 110°C for at least 48 hours and are calculated on a percentage basis. Grain was threshed from the hand cuts to determine yield. Fanners paddock records gave yield, protein, screenings and their impressions of the year and the crop perfonnance.

Table 1. Average soil chemistry results of the 7 paddocks prior to monitoring in 2004.

	EC (dS/m)	pHca	eCEC meq/100g	Ca %	Mg %	Na %	K%	Al %	Ca:Mg
Tottenham - Back									
0-10 cm	0.09	5.2	10.2	60.2	26.0	1.0	12.7	0.1	2.3
10-20 cm	0.05	5.3	9.6	55.5	32.0	2.7	9.6	0.2	1.7
20-30 cm	0.06	5.7	15.4	48.4	39.2	5.8	6.6	0.0	1.2
30-40 cm	0.08	6.4	19.0	47.1	40.0	7.3	5.6	0.0	1.2
40-50 cm	0.13	7.3	21.8	48.5	39.0	7.5	5.0	0.0	1.2
50-60 cm	0.24	7.9	23.6	49.2	36.8	9.6	4.4	0.0	1.3
Tottenham - Spring									
0-10 cm	0.12	5.2	9.4	70.0	17.2	0.9	12.0	0.3	4.1
10-20 cm	0.07	5.1	8.2	68.8	19.6	1.1	9.9	0.6	3.5
20-30 cm	0.05	5.3	7.4	66.5	23.5	2.4	7.3	0.3	2.8
30-40 cm	0.05	5.7	10.2	60.6	30.3	4.8	4.3	0.0	2.0
40-50 cm	0.06	6.2	13.7	55.9	33.9	7.3	2.9	0.0	1.7
50-60 cm	0.09	6.7	16.2	51.7	36.2	9.7	2.5	0.0	1.4
Parkes – Silo									
0-10 cm	0.15	4.6	8.2	58.8	21.7	3.3	12.4	3.9	2.7
10-20 cm	0.05	4.6	6.9	58.4	27.5	2.2	7.0	4.9	2.1
20-30 cm	0.04	4.9	5.4	54.7	34.1	3.3	5.2	2.8	1.6
30-40 cm	0.06	5.5	11.2	36.8	53.9	7.0	2.3	0.0	0.7
40-50 cm	0.08	5.8	17.4	31.1	58.6	8.5	1.8	0.0	0.5
50-60 cm	0.08	5.8	20.7	29.0	60.4	9.0	1.6	0.0	0.5
Parkes - Tank									
0-70 *cm*	0.07	5.0	10.6	69.9	18.1	1.5	10.4	0.1	3.9
10-20 cm	0.05	5.1	8.8	64.7	25.1	1.9	7.3	0.9	2.6
20-30 cm	0.04	5.8	9.5	53.2	36.4	5.4	5.1	0.0	1.5
30-40 cm	0.06	6.6	18.0	44.5	43.8	8.0	3.8	0.0	1.0
40-50 cm	0.07	6.7	19.9	41.9	45.6	9.0	3.5	0.0	0.9
50-60 cm	0.08	7.3	21.0	39.8	46.4	10.5	3.3	0.0	0.9
Parkes - Mine									
0-10 cm	0.10	4.9	10.3	52.7	32.3	5.0	9.0	1.0	1.6
10-20 cm	0.11	6.6	22.5	43.5	44.0	9.5	3.0	0.0	1.0
20-30 cm	0.34	7.9	31.2	41.5	44.8	11.6	2.0	0.0	0.9
30-40 cm	0.45	8.3	32.0	39.9	44.3	14.0	1.8	0.0	0.9
40-50 cm	0.59	8.5	30.7	34.7	47.0	16.6	1.6	0.0	0.7
50-60 cm	0.64	8.6	31.7	32.7	47.4	18.3	1.6	0.0	0.7
Condobolin									
0-70 *cm*	0.04	4.7	7.9	52.5	29.6	2.8	12.0	3.0	1.8
10-20 cm	0.05	5.2	9.6	47.3	35.8	8.8	7.6	0.4	1.3
20-30 cm	0.08	6.2	15.1	38.1	43.3	13.1	5.6	0.0	0.9
30-40 cm	0.12	6.7	18.5	33.3	46.5	15.1	5.1	0.0	0.7
40-50 cm	0.19	7.2	22.0	31.5	47.8	15.9	4.8	0.0	0.7
50-60 cm	0.34	7.9	23.4	31.8	47.0	16.7	4.5	0.0	0.7
Forbes									
0-10 cm	0.10	5.8	26.4	42.1	50.6	4.3	3.0	0.0	0.8
10-20 cm	0.18	5.7	28.4	41.2	50.6	5.9	2.4	0.0	0.8
20-30 cm	0.18	6.3	30.4	42.1	49.2	6.9	1.8	0.0	0.9
30-40 cm	0.14	6.8	32.8	41.7	48.2	8.6	1.6	0.0	0.9
40-50 cm	0.17	7.0	29.2	38.7	48.3	11.1	1.9	0.0	0.8
50-60 cm	0.21	7.2	30.1	37.8	47.5	12.7	2.0	0.0	0.8

Results and Discussion

The growing season in 2004 across central western NSW started quite late with sowing rains not occurring in most places until May. The season was quite dry towards spring when grain fill was occurring, which reduced yield in many places across the central west. Rainfall is shown in Table 2.

Crop yield results

Paddock yields have been obtained for 3 crop paddocks - Forbes, Parkes and Tottenham. These results are shown in Table 3.

Soil moisture results

Soil moisture was quite low over much of the year due to the dry seasonal conditions. There was little subsoil moisture at any of the sites. Figure 1 (a - g) give an indication of the soil water and the use of that soil water through the growing season.

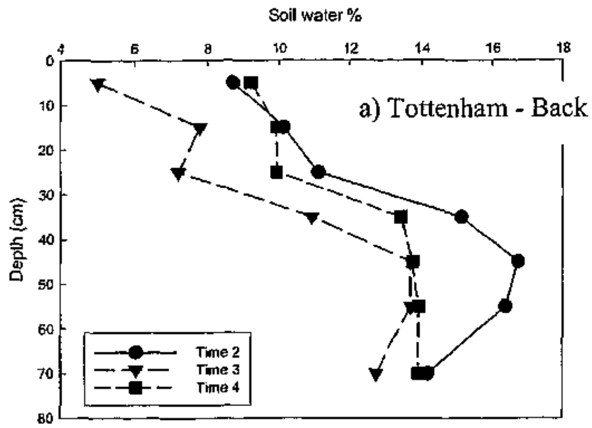
Table 2. Rainfall at some of the localities.

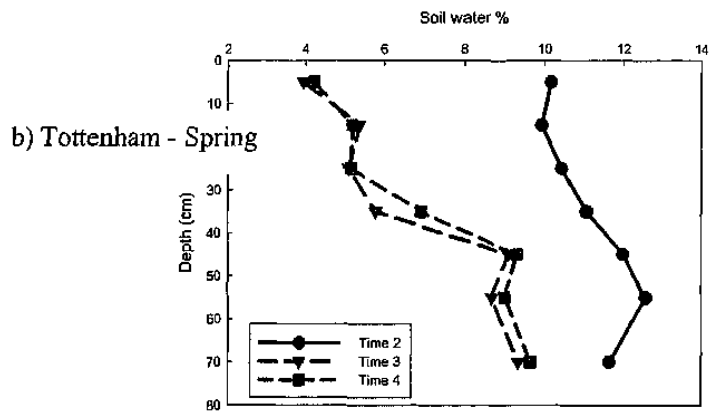
	J	F	**M**	**A**	**M**	**J**	**J**	**A**	S	**O**	N	**D**	**Ann**
Forbes	51	73	22	24	32	58	21	32	44	57	44	116	574
Parkes	150	70	23	3	25	54	29	42	30	51	44	67	588
Tottenham	120	29	13	16	42	32	27	31	27	50	42	42	471
Condobolin	90	32	8	2	18	47	14	32	27	53	31	46	400

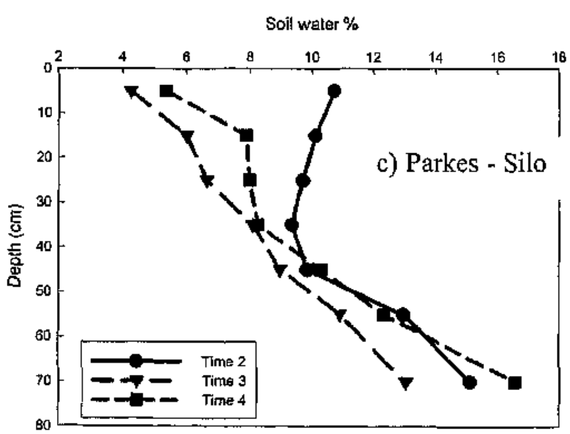
Table 3. Paddock information, and yield results where relevant, for the 7 paddocks in 2004.

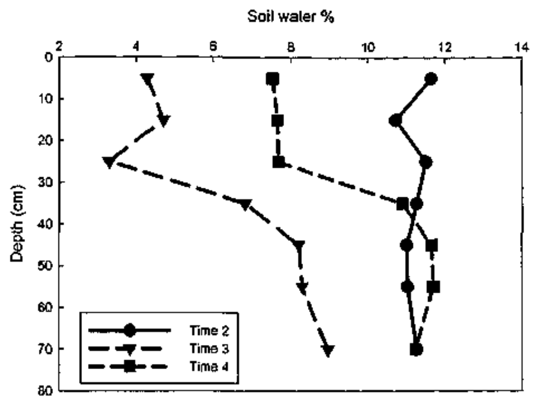
Location	**Crop**	**Variety**	**Yield (t/ha)**	**Protein (%)**	**Screenings {%)**	**Plans for 2005**
Forbes	Field peas	Excell	0.25	-	-	Barley
Condobolin	Barley	Unicorn	not harvested			
Parkes Tank	Wheat	Babbler	1.82	11.7	**2.9**	Lucerne
Parkes Mine	Pasture	grasses & clover				
Parkes Silo	Pasture	grasses & clover				
Tottenham Back	Wheat	Strzelecki	**2.9**	13.9	**1.8**	-
Tottenham Spring	**Wheat**	Babbler	**?**			

Figure 1 (a-g): Soil moisture at 3 times through the growing season for the seven paddocks sampled in 2004.

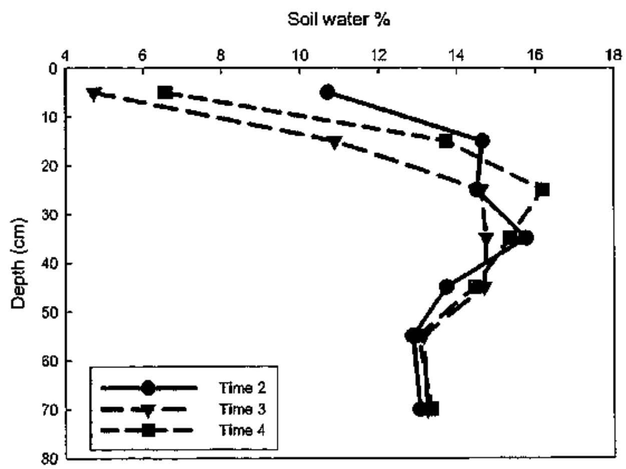




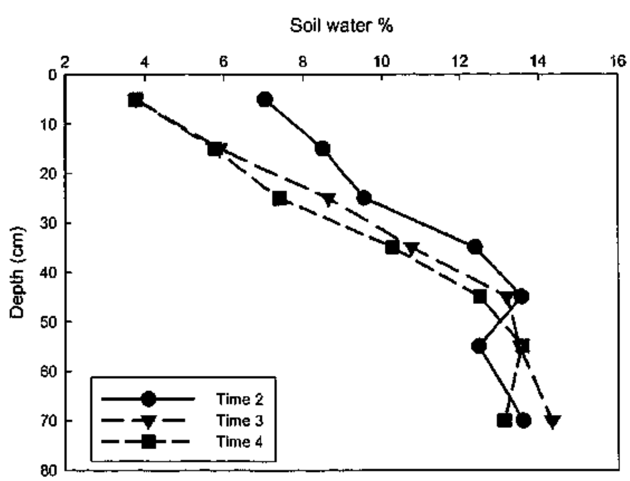




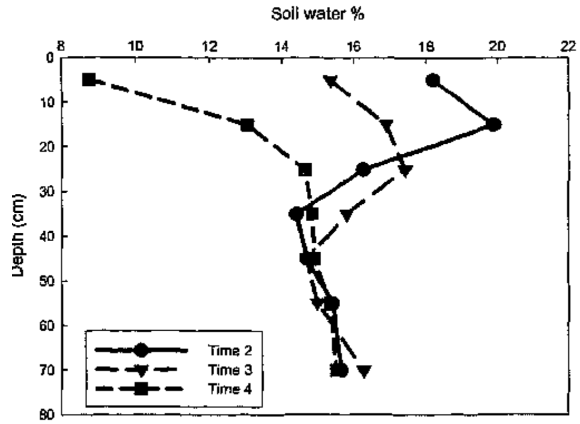
d) Parkes - Tank



e) Parkes - Mine



f) Condobolin



g) Forbes

In Figure 1 a - g) there is evidence of water loss from the soil throughout the season (shown by the movement of the 3 lines). Rainfall did occur throughout the year and plants grew, so this water loss is assumed to be plant uptake. At some sites it is obvious that there was little moisture uptake below a particular depth (usually below 45 cm), which is often where the soil texture changes to a clay in these duplex soils. This lack of soil water uptake may because plant roots do not extend into this depth, water below this depth may be unavailable for plant uptake (soil water can be attached to the soil too tightly for plant roots to draw the water out) or plants were unable to use this water for some other reason.

If we look at each figure and see how water is used through the season we may have a better understanding of water use and soil issues.

Figure 1 a) Water is used throughout the whole profile. The circle symbols indicate the start of the season and water is at about 8% in the surface and 17% at depth. The triangles pointing downwards indicate the second soil sampling period at mid-late tillering (September-October) and there is less water in the soil (5-14%) throughout the whole profile (the line has moved to the left for the entire depth sampled). Just before harvest, there is more soil water than at the previous sampling (the squares have moved to the right of the triangles). This indicates recharge of the soil profile (usually rainfall) and the rainfall in Table 1 shows that Tottenham had 92 mm rainfall in October and November. So this is the likely cause of the recharge. Plant uptake of this rainfall would have been minimal as the wheat had largely finished growing by this time.

Figure 1 b) Once again water is used from the entire profile through season. There is less recharge in this paddock than in the previous paddock (the squares sit over the triangles; Fig. 1 b). This may be because this paddock received less rainfall than the previous paddock, or the plants were still growing when the rain fell and so used some of the rainfall, or there was more runoff on this paddock and less went into the soil profile, or some other reason.

These two Tottenham soils (Fig. 1 a and b) indicate that in the 2004 season, the plants growing on these paddocks had little problem extracting soil water to a depth of 80 cm. (It's nice that we called these soils benign at the start!)

Figure 1 c) The Parkes Silo paddock had some water used at depths below 45 cm but water is not extracted as easily as the previous paddocks. This may be because this paddock was a pasture paddock and so there may have been fewer plants with deep rooting ability to extract water to depth, compared with a cereal crop (as at Tottenham). There is some recharge of soil water before harvest but the pastures would have still been using water, unlike a crop which would have been harvested. I would not like to say that there is a problem with this soil as the soil water is low to begin with and it may just be the texture, and pasture, that is limiting any water extraction and not a soil problem. A wetter year would give a better indication.

Figure 1 d) The Parkes Tank paddock had water at an almost equal soil water percentage through the soil profile at sowing. This soil water was used, more from the surface than from at depth, throughout the season. Plant roots are more dense at the soil surface and so this is not unexpected. There is water used at depth, so the roots are getting down into the soil profile and extracting water. There is recharge before harvest and this is reflected in the 95 mm rainfall seen in Table 1. There more recharge in this paddock than either of the other Parkes paddocks.

Figure 1 e) The Parkes Mine paddock was also a pasture paddock. There was little water extracted below 30 cm, which may be due to lack of plant roots below this depth. It may also be due to the heavier clay soil and more sodicity at depth in this paddock than the other Parkes paddocks. There was also little recharge of the profile with the rainfall in October and November, probably because plants were growing and using the soil water. Once again, a wetter season and deeper rooted plants, would give a better indication of whether this lack of water uptake below 30 cm is a sodic subsoil constraint or a soil problem.

Figure 1 J) There was not much soil water in this profile and after 5 very dry seasons this is not surprising. There was not much soil water extracted probably because of the lack of water in the soil. Plant roots, and growth, would have been affected by the dry soil and the dry conditions (crop not harvested). The minimal water uptake below 40 cm may be a feature of the dry conditions and not a soil problem itself. A wetter year would give a better indication of this.

Figure 1 g) Throughout the season water was extracted from the surface 35 cm. There was little soil water used below this depth. This paddock was chosen to be included in this project because the soil is saline and sodic and the paddock uses raised beds to overcome these soil problems. The soil is a heavy clay prone to water logging. Some years ago the fanner developed raised beds to improve his crop yields. It appears that the plants are utilising the beds for much of their soil water uptake as there is little soil water extracted from below 35 cm.

Conclusion

The dry year in 2003 meant that there was little subsoil water available for plant uptake. This meant that little could be determined about the effect of sodic subsoils on plant growth.

Ackowledgements

We would like to thank the 5 co-operators who allowed us access to their properties throughout the year. We would also like to acknowledge the contribution of the late Greg Webb to this work. Greg was an active member of CWFS who died suddenly in 2004. *We would like to dedicate this paper to the memory of Greg Webb.*