How do Lachlan Valley cotton soils compare to cotton soils in northern NSW?

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Recently, a soil survey project was carried out in the lower Lachlan Valley around the township of Hillston with the aim of identifying current and potential soil limitations to cotton production in this region. Within the lower Lachlan cotton-growing area, three main soil classes were identified, each with distinct features which influence cotton production. Soil features were also compared with other cotton-growing valleys in northern NSW, and it was found that subsoil sodicity and structural instability pose the greatest potential threat to cotton production in the lower Lachlan. Other potential soil limitations which will require consideration in regard to cotton production in the lower Lachlan include subsoil alkalinity and deficiencies in organic carbon and subsoil phosphorus.

Cotton production in eastern Australia occurs on the numerous river plains of the Murray-Darling river system. In recent years, the cotton industry has expanded from the more traditional cotton-growing regions of northern NSW and southern Qld into new river plain areas such as the lower Lachlan Valley in southern NSW. Some distinct differences exist, however, between southern and northern growing regions of NSW, particularly with regard to climatic conditions. It is important for the success of cotton production in southern NSW, that management techniques that have been developed in established cotton-growing regions of northern NSW are modified and adapted to southern NSW cotton-growing regions.

This article specifically examines features of the soil resource in the lower Lachlan River Valley, particularly around the township of Hillston, with a view to identifying current and potential soil limitations to cotton production in this region. We also compare the soil properties of the lower Lachlan cotton-growing area with those of the established cotton-growing areas of the lower Namoi and Gwydir Valleys in northern NSW.

Soil survey of the lower Lachlan River Valley

Over the last 12 months, a soil survey has been conducted within the lower Lachlan Valley, based around the township of Hillston. The study area encompassed the majority of cotton-growing properties within the region (Fig. 1), and involved the sampling of one hundred and fourteen soil cores to a depth of 1.5 m. Sampling focused on the alluvial plains where cotton production is based, but also included areas of sandy soil (wind-blown origin) which exist in locations adjacent to the Lachlan River and its associated streams. Soil was sub-sampled from the topsoil (0-20 cm depth) and the subsoil (80-90 cm depth) and analysed for various physical and chemical attributes.

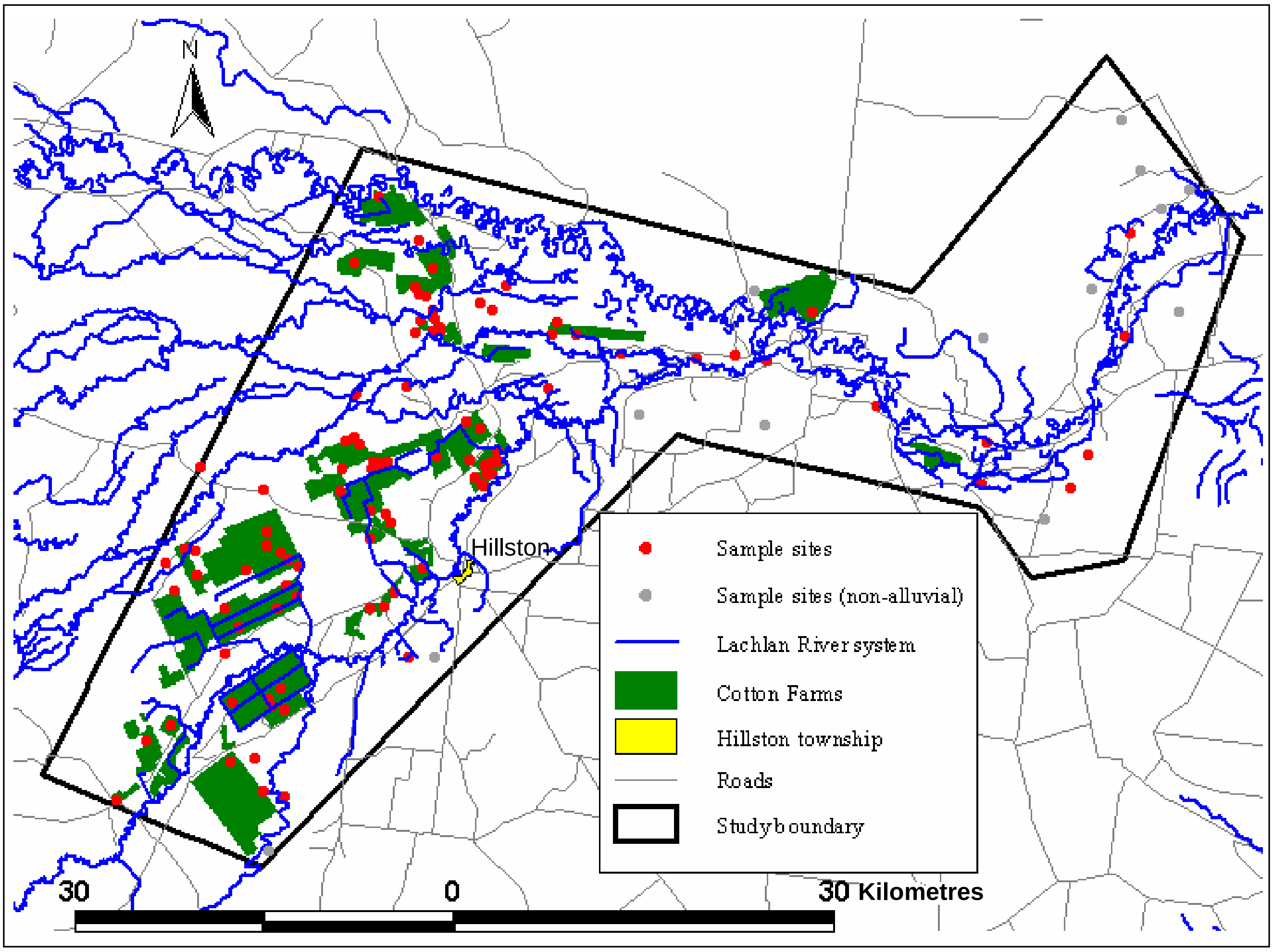

Figure 1: The lower Lachlan Valley soil survey area.

As discussed in the recent article by Cay and Cattle (2003), within the alluvial plains of the lower Lachlan Valley, three main soil types can be distinguished. These soil types can be differentiated primarily on colour and their proximity to active streams and waterways. Soil profiles closest to active streams and waterways are the most recently deposited in the landscape and are generally uniform in characteristics with depth. These soils are generally darker in colour and are classified under the Australian Soil Classification system (ASC) as Grey Vertosols. Secondly, a group of soil profiles can be identified as slightly more removed from active streams, but still within the alluvial floodplain. These soils are less grey and more brown in colour, and are classified as Brown Vertosols. The third and most dominant soil group in terms of area covered, also falls within the alluvial landscape, but is more remote to the active waterways. This soil group exhibits increased redness with a lighter (sandier) textured topsoil layer in undisturbed areas. Most of these soils are classified as Red Vertosols, although those with lighter textured topsoil may be classified as Red Chromosols / Sodosols. Outside of these alluvial riverine plains there also exists another class of soils which are of wind-blown origin. Generally, these soils display a significantly lighter texture throughout the profile and are predominantly red in colour.

Table 1: Physico-chemical attributes of three soil classes of cotton-growing soils within the lower Lachlan Valley. Mean topsoil (0-20 cm) and subsoil (80-90 cm) results are shown, with topsoil results displayed for cotton and natural sites. Data indicating a potential limitation to cotton production are highlighted.

	Grey Vertosol			Brown Vertosol			Red Vertosol		
	Topsoil		Subsoil	Topsoil		Subsoil	Topsoil		Subsoil
	Cotton	Natural		Cotton	Natural		Cotton	Natural	
pH	7.7	7.2	8.8	8.2	7.3	9.0	8.0	7.9	9.2
Clay (%)	56	50	53	52	46	49	52	43	53
CEC (cmol/kg)	34	24	31	31	24	28	30	22	28
ESP	3.0	1	11	2	2	11	3	4	15
ESI	0.18	0.17	0.04	0.11	0.07	0.02	0.09	0.09	0.04
Ca/Mg	1.8	1.6	1.6	2.1	1.9	1.7	1.7	1.9	1.3
P (mg/kg)	32	25	11	24	28	12	26	20	8
OC (%)	0.7	0.8		0.6	0.9		0.7	0.8	

Soil samples were analysed from both cotton-growing and uncleared (natural) sites, however the subsoil results presented here are a combination of those from both landuse types due to the small variation in physico-chemical attributes at depth in the profile. Table 1 illustrates that although there are many similar characteristics between these three soil types, there are also subtle differences which are important in relation to cotton production.

The pH values measured throughout the topsoil and subsoil of all soil classes are higher (more alkaline) than the optimum range preferred by cotton. It is also evident that pH increases significantly from the topsoil to the subsoil. This trend is most pronounced in the Red Vertosols. For all soil classes, the natural sites display a reduced pH in the topsoil compared to the cotton production sites. This is thought to be largely due to the homogenisation of the top soil layers within cotton sites by landforming and cultivation, which serve to mix higher pH soil from the subsoil in with the topsoil.

The Grey Vertosols contain slightly larger clay contents throughout the profile than the other two soil classes. This may be related to this unit’s position in the landscape and its proximity to recent alluvial deposits. It is apparent that the undisturbed (natural) Red Vertosols have a distinctly lower clay content in the topsoil than the Red Vertosols used for cotton production. Again this may be attributed to the practise of cultivation homogenising the upper layers of the profile, and mixing the heavier clay lower layers with the lighter-textured topsoil. It is also apparent that the cation exchange capacity (CEC) variation between the soil classes closely mirrors the trends observed in the clay content.

Soil structural instability is usually correlated with comparatively large amounts of sodium associated with clay particles. A sodic soil is often dispersive upon wetting, leading to the breakdown of soil aggregates and an undesirable massive structure, which also increases erosion risk. The two structural instability indicators examined here, exchangeable sodium percentage (ESP) and electro-chemical stability index (ESI), are especially relevant when considering current and potential limitations to cotton production in the lower Lachlan Valley. As indicated in Table 2, all three soil classes exhibit ESP values in the topsoil below the critical value of 5 (as defined by SOILpak), with the Brown Vertosols having the lowest ESP values. The subsoils, however, display very high ESPs for all soil classes, most particularly the Red Vertosols, with mean ESP values of 15, indicating a very high sodicity risk. Figure 2 displays ESP values of natural sites for these three soil classes as a function of depth. It is evident that the Red Vertosols rise above the ESP critical value of 5 much closer to the soil surface than the other soil classes. This suggests that the Red Vertosols, with a significant sodicity risk high in the soil profile, require careful management for sustainable cotton production.

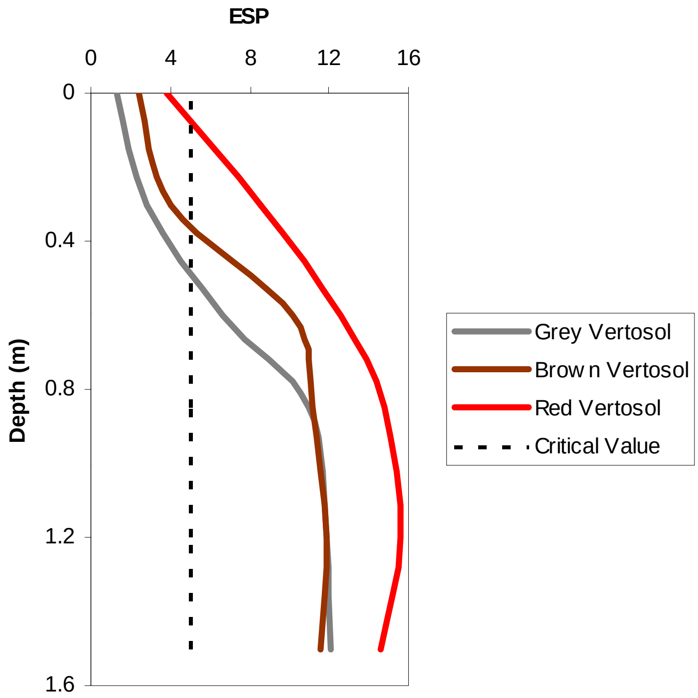

Figure 2: ESP values as a function of depth for natural sites of Grey, Brown and Red Vertosols within lower Lachlan Valley natural soils.

The electro-chemical stability index (ESI) incorporates ESP and electrical conductivity (EC), and indicates whether a high electrolyte concentration will suppress dispersive behaviour caused by large sodium contents. SOILpak suggests a critical value of 0.05 ESI, where any value below this cut-off indicates a potentially dispersive soil. Like the ESP results, the ESI values for the lower Lachlan soils suggest that the topsoils of all classes are structurally stable, but that all subsoils fall below the critical value of 0.05, indicating potential structural problems. Interestingly, it is the Brown Vertosols which are projected by the ESI to be at the greatest risk of structural instability, with a mean value of 0.02.

The exchangeable calcium : magnesium ratio (Ca/Mg) data also indicates a tendency in the soils of the lower Lachlan Valley toward dispersion and structural instability. SOILpak suggests that soil with a Ca/Mg less than 2 show an inclination toward clay dispersion. Only the topsoil of Brown Vertosols lie above this critical value. Concurrent with ESP and ESI trends, the Ca/Mg diminishes significantly from the topsoil to the subsoil for the three alluvial soil classes.

Topsoil phosphorus (P) levels are quite similar throughout the three soil classes, with no obvious trends between cotton and natural sites. A large reduction in P levels from topsoils to subsoils is evident in all three soil classes. A suggested critical value for Vertosol P content for cotton production is 10 mg/kg, with cotton likely to show a response to P fertiliser application if soil P levels are less than this value.

All three soil classes are well above this critical value in the topsoil, and hence P is unlikely to be a current limitation to cotton production. However, the subsoil P values are significantly less and are all close to this critical P value, especially the Red Vertosols. Although these subsoil samples were taken from beneath the root zone, these low values may become relevant in areas where the subsoil has been brought to the surface by land levelling for furrow irrigation. The other consideration regarding soil phosphorus content, is that there is a net deficit of phosphorus from the soil due to uptake and removal during cotton production. Therefore, phosphorus deficiency is a potential limitation to cotton production in the future and soil phosphorus testing should continue.

Soil organic carbon (OC) contents are uniformly small throughout the lower Lachlan cotton-growing region, which in turn may have a limiting influence on other soil properties such as soil stability and CEC. It is important to note that there is a general increase in organic carbon in natural sites compared to cotton sites, due to the presence of natural vegetation decomposing in these topsoils.

Comparison of the lower Lachlan Valley with northern cotton-growing regions

To better assess the attributes and limitations of the Lachlan Valley cotton-growing soils, soil data from two established cotton-growing regions in northern NSW have been examined. Data from recent soil surveys of the lower Namoi Valley cotton-growing region, located between Narrabri and Burren Junction, and the Gwydir Valley cotton-growing region, located around the township of Moree (Fig. 3), have been accessed from the Australian Cotton Cooperative Research Centre. Both of these soil surveys contain over one hundred soil sample sites, with topsoil (0-20 cm depth) and subsoil (80-90 cm depth) analyses carried out for a similar range of properties to those of the lower Lachlan Valley survey. A comparison of soil properties from cotton-growing sites (with the exception of organic carbon contents, which are from natural sites) within the three regions is displayed in Table 2.

Cotton-growing farms within all three regions lie in the alluvial plains of their associated river systems. However, the geological origin of this alluvial material differs in the northern and southern valleys. This in turn leads to different clay minerals in the soil, greatly contributing to the distinctive soil characteristics evident in the cotton-growing valleys examined in this study.

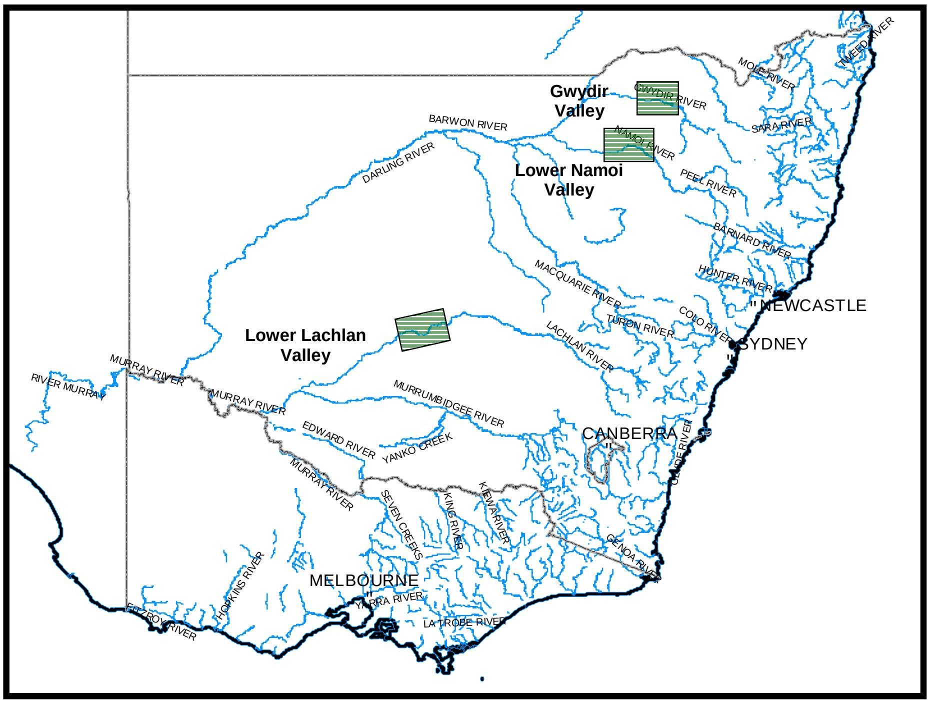

Figure 3: The location of the lower Lachlan, lower Namoi and Gwydir Valley study areas within NSW.

Table 2: Comparison of some physico-chemical soil attributes from cotton-sites (with the exception of OC% which is taken from natural sites) from the lower Lachlan Valley with the Lower Namoi and Gwydir Valleys. Data indicating a potential limitation to cotton production are highlighted.

	Lower Lachlan		**Lower Namoi**		**Gwydir**	
	Topsoil	**Subsoil**	**Topsoil**	**Subsoil**	**Topsoil**	**Subsoil**
pH	8.0	9.2	8.4	8.9	7.5	8.5
Clay (%)	53	53	56	57	55	56
CEC (cmol/kg)	31	30	39	44	35	40
ESP	3	15	4	8	1	10
ESI	0.12	0.04	0.06	0.07	0.2	0.04
Ca/Mg	1.8	1.3	1.8	1.7	2.4	1.7
P (mg/kg)	29		34		24	
OC (%)	0.8		1.5		1.3	

In the data presented (Table 2), information from all Vertosols has been averaged for each valley. The main differences between the soils of the different valleys are summarised in the following points.

- Evaluation of soil pH indicates that all three regions contain alkaline (pH > 8.5) subsoils, with the lower Lachlan Valley subsoils the most alkaline (mean subsoil pH of 9.2). This increased pH in the southern valley may be due to increased salt and carbonate accessions deposits blown in from the arid interior. Excessive alkalinity is related to reduced availability of certain plant nutrients such as nitrogen, calcium and magnesium, and micronutrients zinc, manganese and iron, and is a potential limitation to cotton production in this region.

- The average clay contents are high throughout the profile for all three valleys, with many sites containing >50% clay. However, cotton-growing soils within the lower Lachlan Valley exhibit significantly lower topsoil CECs compared to the lower Namoi and Gwydir Valley topsoil CECs. These differences are likely to relate to the mineralogical composition of the different valleys' soils. Practically, this relates to a slightly reduced ability of soils within the lower Lachlan Valley to supply cations that are used by plants as nutrients, but the "chemical fertility" can still be regarded as moderate to high.

- Reflecting the different climatic regimes of the three valleys are the ESP results. While all three cotton growing valleys have similar topsoil ESP values (less than the critical value of 5), the average subsoil ESPs increase to levels well above the critical value in all valleys, and in particular, the lower Lachlan Valley. The average subsoil ESP of 15 in this region is extremely high. Electro-chemical stability index (ESI) data also indicates reasonable topsoil structural stability throughout all three cotton-growing valleys, with all values above the critical value of 0.05. However, the average subsoil ESIs for both the lower Lachlan and Gwydir Valleys fall below this critical value.

- Exchangeable calcium magnesium ratio (Ca/Mg) results for the three cotton growing valleys are consistent with the ESP and ESI results. Exchangeable magnesium can aggravate the effects of sodium in the soil, and it is suggested that a Ca/Mg ratio of less than 2 indicates a tendency towards clay dispersion. Only the topsoil of the Gwydir Valley showed results within the optimum range. It is also important to note that for both the topsoil and subsoil, the Lachlan Valley samples expressed the lowest Ca/Mg ratios, indicating an increased tendency toward dispersion compared to the northern cotton-growing valleys.

- Phosphorus (P) levels throughout the three valleys are reasonably similar, with the Lower Namoi Valley showing the highest mean topsoil P (34 mg/kg) and the Gwydir Valley the smallest (24 mg/kg). All valleys, however, contain topsoil P well above the critical value of 10 mg/kg, indicating that cotton production in these valleys is generally not suffering from P deficiencies at present.

- Soil organic carbon (OC) contents in the topsoil of natural sites are also seen to be significantly less in the lower Lachlan Valley than in the northern cotton-growing valleys (Fig. 4). This is likely to be a function of the reduced rainfall received in the southern cotton-growing district. Hillston receives an annual average rainfall of 360 mm, compared to approximately 600 mm around the Moree and Narrabri districts, contributing to a reduced growth of biomass that can decompose into organic carbon. This in turn contributes to reduced organic carbon levels within cotton production systems in the lower Lachlan, a potential limit to current and future production. It is also evident that organic carbon levels fall within all valleys when landuse changes from natural vegetation to cotton production.

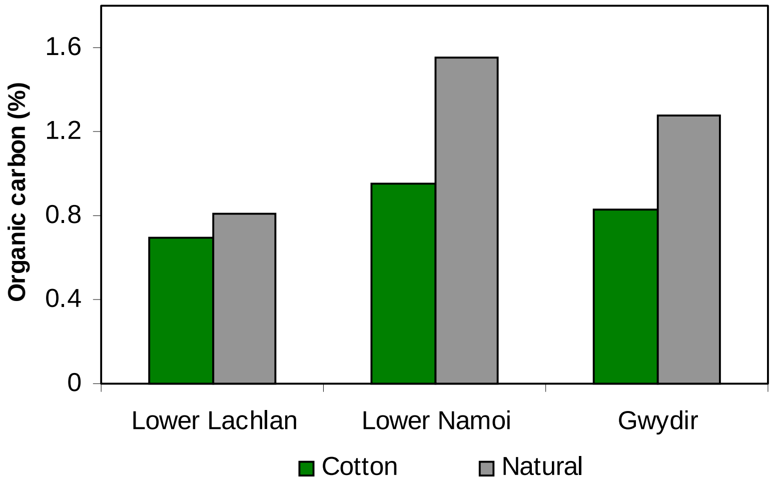

Figure 4: Comparison of organic carbon levels of cotton and natural sites between cotton-growing regions.

In summary, our detailed study of the lower Lachlan Valley cotton-growing region has revealed that there are some distinct differences between the soil resources of northern cotton-growing regions and the lower Lachlan Valley. It has been revealed that the greatest potential limitation to cotton production in the lower Lachlan is the threat of soil sodicity and structural instability, most particularly in the subsoils of this region. Other limitations which require further consideration in the lower Lachlan Valley in comparison to the northern valleys are the issues of increased soil alkalinity, low organic carbon levels and subsoil phosphorus deficiencies. Within the lower Lachlan Valley cotton-growing region three main soil classes have been defined, with their different attributes discussed. It is important that future production management decisions recognise this soil variation and the current and potential limitations that various soil attributes impose on cotton production.

Reference:

Cay, E. and Cattle, S. R. 2003. Unearthing problem soils in the Lachlan Valley. Australian Cotton Grower Magazine (Vol 24, No 1, Pg 32).

Figure 5: **A Red Vertosol landscape used for cotton production in the Hillston district.**