Soil physical changes from rice to cotton

By Jonathon Moore

AT A GLANCE…

The diverse soil types of the Murrumbidgee Valley, have been shown to respond differently following a conversion from rice to cotton production. A grey clay soil, examined in the Murrumbidgee Irrigation Area showed increased structural repair compared to a red clay soil, examined in the Coleambally Irrigation Area. While these two soils have both been classed as 'Soils of the Plains', they responded somewhat differently to the change in landuse.

Why does a change from rice to cotton matter?

The physical condition of soil is a vital aspect of all sustainable agricultural systems. Soil structure, which describes the arrangement of soil solids into aggregates and the surrounding pore space, evolves through the interaction of management stresses (e.g. cultivation), climate and inherent soil physical, chemical and microbial properties.

The past decade has seen an expansion of the cotton industry into the Murrumbidgee region of southern New South Wales, with some growers shifting from rice to cotton production. As a consequence of this landuse change, and the changed management that follows, soil physical conditions of the region's highly variable soil types are also likely to be changing.

Two widespread properties of Murrumbidgee soils are coalescence and hardsetting. Both are examples of soil structural changes potentially exacerbated by wetting and drying cycles. Coalescence results from the welding of aggregates at contact points, gradually increasing rigidity through repeated wetting and drying cycles. Rather than a gradual change, hardsetting soils rapidly consolidate into a hard, structureless mass following drying. These soil physical processes, along with practices such as induced compaction, are factors behind the region's successful rice industry.

The development of soil with a hardened, structureless subsurface layer is well suited to rice production, where low water permeability is necessary during periods of flood irrigation. As a crop susceptible to waterlogging, cotton requires soils with higher permeability, meaning the optimal physical properties of cotton and rice soils are very different.

Changes in the soil physical condition are therefore required if cotton is to be successfully grown on soils with a history of rice production. Four treatments were used to examine these changes on two soils; a grey clay in the Murrumbidgee Irrigation Area and a red clay in the Coleambally Irrigation Area. Pits dug to 30 cm depth allowed for morphological observations and data collection to compare soils under native vegetation, rice, cotton (recent) and cotton (longer-term).

Observing soil structural change

The clearest indication of soil change due to landuse change was through observations of soil structural condition. Soil penetration resistance was the field method most correlated with these observations.

FIGURE 1: The red soil under native vegetation exhibiting an epipedal topsoil and strongly pedal structure, with biopore development, from 10 cm

FIGURE 2: The red rice soil exhibiting a massive, hardened structureless mass in the top 30 cm of the profile

FIGURE 3: The recently-converted-to-cotton red soil showing a softer, crumbly structure to depth

FIGURE 4: An example of interconnected macropores and strongly pedal structure on the longer-term red cotton soil

The native vegetation sites on both the red and grey soil showed strong structural development with interconnected biopores (Figure 1) despite high penetration resistance and bulk density measurements. This was expected given the frequent occurrence of coalescence in Murrumbidgee soils. But this structural development is known to be easily destroyed by cultivation, as was observed on both rice soils.

The red and grey soils under rice production exhibited massive, structureless subsurfaces (Figure 2). This supports the hypothesis of a loss of structure through management operations associated with rice production. Penetration resistance was representative of these soil morphological observations, with measurements of 12.9 and 7.7 MPa calculated at 30 cm depth on the grey and red rice soils, respectively. These levels are likely to severely impede cotton root growth. At 20 cm depth, similarly high penetration resistances of 8.7 MPa on the grey soil and 7.6 MPa on the red soil, were encountered.

The recently converted cotton soils showed a clear difference in soil physical condition, with improved pedality and a softer, crumbly structure to depth (Figure 3). This was consistent with lower penetration resistance measurements. The grey soil exhibited a decrease in penetration resistance to 4.8 and 4.6 MPa at 20 and 30 cm depths. A larger decrease was seen on the red soil, with penetration resistances of 2.4 and 2.9 MPa at 20 and 30 cm depths.

A clear variation was seen between the red and grey soils on the longer-term cotton soils. Where the grey soil continued a decreasing trend in penetration resistance, with measurements of 1.4 and 2.7 MPa at 20 and 30 cm depths, respectively, the red soil did not. Instead, penetration resistance increased at both 20 and 30 cm to 4.6 and 5.6 MPa respectively. These levels are still considerably lower than what was measured on the rice soil, and the structure showed a strongly pedal, not hardened structure, with clear interconnected macropores (Figure 4).

Moisture content is strongly correlated to penetration resistance, with a higher moisture content softening aggregate cementing agents and reducing penetration resistance. At the time of measurement, the gravimetric water content was similar on all sites on both the red and grey soils, allowing a fair comparison of soil strength across the various 'treatments'.

A tale of two soils

The red and grey soils studied have previously has been mapped as a Willbriggie clay loam and Jondaryan clay loam, respectively. The Murrumbidgee valley contains over 90 mapped soil types. To reduce complexity, previous work has classed these many Murrumbidgee valley soil types into five broad soil groups, with some subgroups. The Willbriggie and Jondaryan clay loams can be considered similar, with both placed within the subgroup 'Soils of the Plains'. Despite this, there were differences between corresponding treatments across the two soils. Based on decreasing penetration resistance readings and observed morphological features it was concluded that the structure of the grey soil responded more rapidly to the landuse change.

Chemical analysis of collected soil samples showed significant differences between the two soils (Table 1). The red soil is more clayey and has a higher exchangeable sodium percentage at both

TABLE 1: Inherent soil properties at depths of 0–10 and 30–50 cm averaged from all treatments on the grey and red soils

Depth (cm)	Soil	Clay (%)	pH	EC (μs/cm)	ASWAT (median)	Ca:Mg	ESP (%)	Total C(%)
0–10	Grey	42	6.7	475	0	1.99	0.7	2.97
	Red	54	6.7	222	1.5	0.99	1	1.29
30–50	Grey	55	7.9	349	0.5	1.31	2.6	0.66
	Red	61	7.7	339	2	0.83	3.4	0.7

depths. It also had higher Aggregate Stability in Water (ASWAT) test scores, showing it to be more prone to dispersion, and a lower Ca:Mg ratio, suggesting that the grey soil should exhibit greater aggregate stability. This data supports observations that the grey soil is inherently capable of faster structural improvement following a change to cotton production. It is likely that the red soil is more prone to coalescence when left uncultivated.

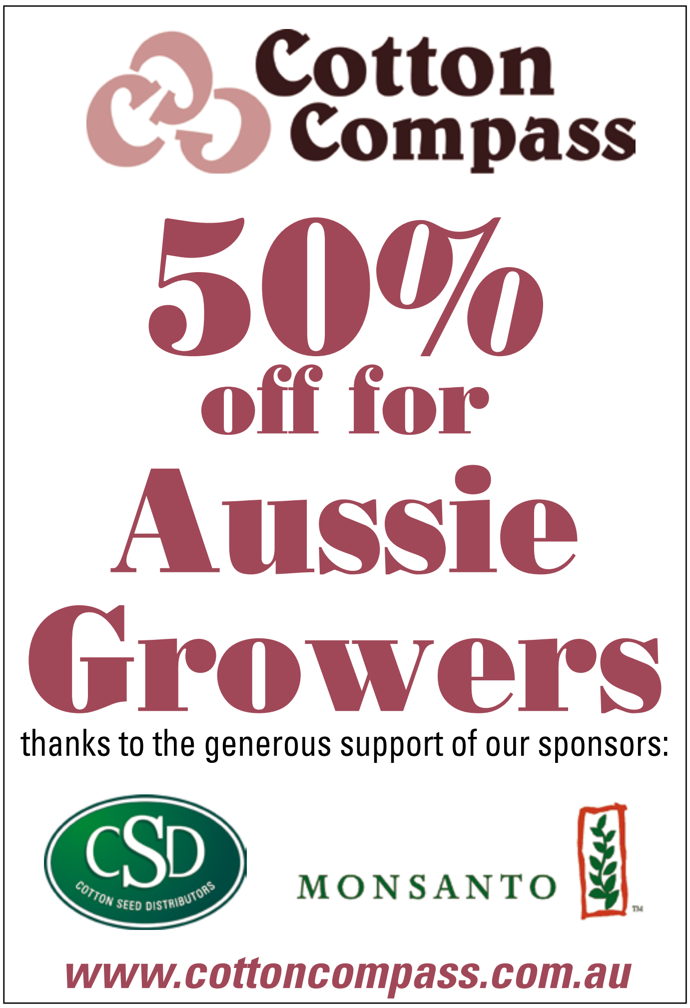
To wrap up

It is clear that the soils both underwent changes to physical condition following a conversion from rice to cotton, but it is also apparent that the two soils responded differently to changes in management systems.

These differences are dictated by variations in aggregate stability between the two soils; the lower structural stability of the red soil, especially at 30–50 cm depth, suggests that increased irrigation cycles may accelerate aggregate failure, a reason for the differences in structural repair on the recent and longer-term cotton soils. In contrast, the higher Ca:Mg ratio of the grey soil suggests it has a greater capacity to shrink and swell, while lower ASWAT scores show it to be more structurally stable when wet.

These factors allow the repeated irrigation cycles associated with cotton production to assist in structural improvement. This accounts for the grey soil exhibiting consistent improvement in physical condition under both the recent and longer-term cotton production systems.

This project was funded through the CRDC's Honours scholarship program. Thanks also to the relevant stakeholders in the region for their assistance in conducting this work.



New online biodiversity management guides

COTTONINFO, the cotton industry's joint extension program connecting growers with research, has launched new online biodiversity management guides for Australia's 36 cotton-growing shires.

For the first time, the innovative resources give cotton growers detailed biodiversity information and outline beneficial practices to support biodiversity on their farms.

Growers can select their LGA on CottonInfo's new clickable map to see a snapshot of the biodiversity in their shire, along with practical tips to improve conditions for the diversity of species in that specific cotton landscape.

The biodiversity data presented in the map was collated through Cotton Research and Development Corporation (CRDC) research projects to help the cotton community to understand and prioritise the conservation value of areas of native vegetation within cotton landscapes (cotton farms plus a 5 kilometre buffer).

The research looked at 315 threatened and iconic plant and animal species in the cotton landscapes of eastern Australia, from the NSW-Victorian border to the Fitzroy Basin in Queensland, and used that data to develop targeted biodiversity management profiles for each of Australia's 36 cotton-growing shires.

Building on previous research funded by CRDC, Forest & Wood Products Australia, CSIRO and the Australian Government's Rural R&D for Profit program, each management profile specifies the biodiversity assets, including vegetation types, wetlands, species, rivers and creek lines, and adjacent public land reserves, and recommends management actions to best suit the habitats of the species represented in each of the shires.

Stacey Vogel, CRDC R&D Manager, said the biodiversity management guides are based on comprehensive research that for the first time brings together valuable data to support 'boots on the ground' action to improve conditions for biodiversity in cotton landscapes.

"The cotton landscapes of eastern Australia contain an abundant diversity of native plant and animal species that occur in a mosaic of forest, woodland, wetland, grassland and cropland systems," she said.

"Research findings about these landscapes has been used to give all of our 36 cotton-growing regions practical and easily