The impact of cotton production and fluctuating rainfall patterns on Hillston soils

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IN 2002, an extensive soil survey was conducted in the Hillston district by The University of Sydney. The aim of the survey was to evaluate the soil condition in this southern NSW region, where the cotton industry was then a relatively new player. Rather than analysing only the topsoil, soil cores were analysed to 1.5 metres depth, as subsoil constraints are often the most limiting to production.

Since 2002, Hillston has undergone some fluctuating rainfall patterns, as well as some significant land use changes. From 2002 to 2009, Hillston experienced the worst drought on record, which meant that only growers who had access to groundwater could continue to irrigate. In 2010, rainfall patterns changed abruptly and Hillston received 70 per cent above-average rainfall in the three consecutive years until the end of 2012, making irrigation water more available again. Despite the lengthy drought, the land area under irrigated cotton production expanded at Hillston, but significant areas were also converted to irrigated almond production. These observed climatic and land use changes prompted a second soil survey to be conducted to analyse how these factors may have influenced the soil condition.

The soil surveys

In the 2002 soil survey, 115 cores to 1.5 metres depth were extracted and sub-sampled at six depth increments (Figure 1). In the 2015 survey, 160 soil cores were extracted to the same 1.5 metres depth, with many of the same sites returned to and re-sampled, as the original sites were georeferenced. In both surveys, soil cores were taken from areas under four broad land use types; irrigated cotton, dryland cereal cropping, irrigated horticulture, and natural (primarily extensive grazing). A suite of soil properties were analysed in the extracted samples, including soil pH, electrical conductivity (EC), exchangeable sodium percentage (ESP) and carbon content (both organic and inorganic).

FIGURE 1: The locations of soil cores extracted in the 2002 and 2015 soil surveys

Soil property maps

Digital soil maps (DSM) were produced for the different soil properties. A collection of predictor variables was used in this mapping approach, including terrain attributes, gamma radiometric data, soil type and land use. Maps for both time points, and change maps (2015–2002) were produced. When showing maps of the change in soil properties over time, it is important to take into account the uncertainties of the predictions. Because of this, only statistically significant changes in soil properties are shown in this article to avoid misrepresenting the magnitude of soil change.

Soil pH

The pH of soil at Hillston is neutral to alkaline in the topsoil, and alkaline to highly alkaline in the subsoil (Figure 2), suggesting that this may be a limitation to crop growth in some cases. Overall, little statistically significant change occurred in the topsoil over time, except for some decreases in pH in the northeast of the study area. In the subsoil, there were more widespread trends of acidification between the 2002 and 2015 surveys, with this process occurring under several different land uses. This acidification is likely to have been caused partly by management practices associated with irrigated cotton production (e.g. use of N fertilisers and constant irrigation), and partly by the dissolution

FIGURE 2: Soil pH status in 2002 and 2015, and statistically significant change (2015-2002) at the 0–0.1 and 0.5–0.8 metre sampling depths

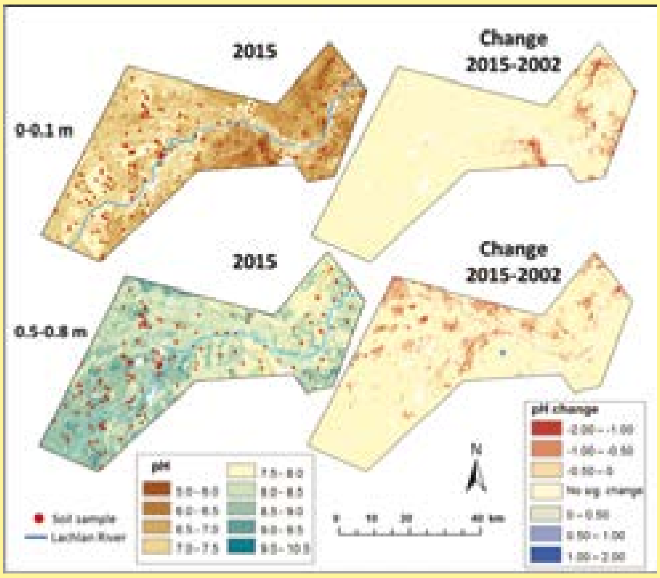


FIGURE 3: Soil EC status in 2002 and 2015, and statistically significant change (2015–2002) at the 0–0.1 and 0.5–0.8 metre sampling depths

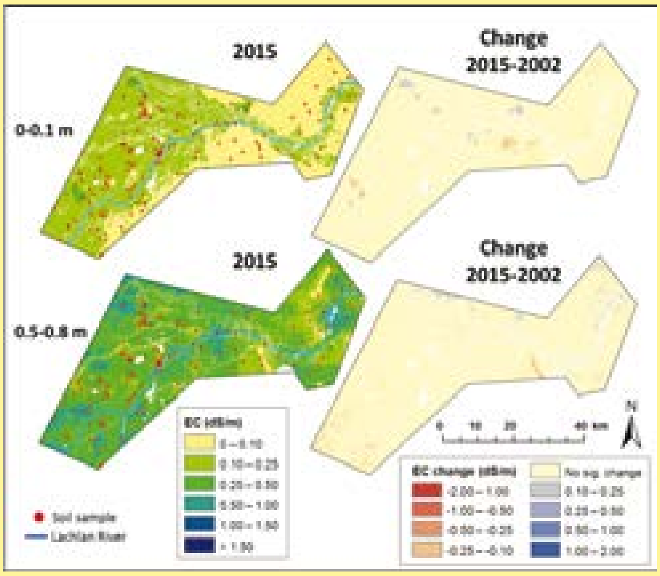
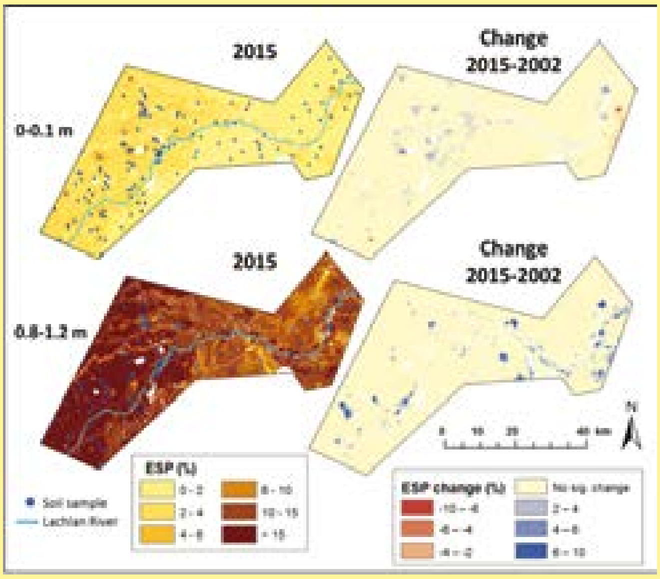


FIGURE 4: Soil ESP status in 2002 and 2015, and statistically significant change (2015–2002) at the 0–0.1 and 0.8–1.2 metre sampling depths



of naturally occurring carbonates as a result of the heavy rainfall in the 2010 to 2012 period. While acidification of soil (lower pH values) is generally considered to be a degradation issue, this is not necessarily the case in the highly alkaline subsoils of the Hillston district.

Soil salinity – electrical conductivity (EC)

Soil salinity is not an important limitation for cotton production at Hillston as the soils are generally non-saline, except for a few isolated areas deep in the subsoil (Figure 3). An EC value above 1.00 dS/m in the rootzone would start to have an impact on cotton crops. Some changes in salinity over time were detected, and these seem to be largely driven by land use. In some areas under irrigated cotton production, there was a small decrease in topsoil salinity, while in some areas under irrigated perennial horticulture small increases in soil salinity were observed.

Similar decreases in topsoil salinity were found in soils under irrigated cotton in southern Queensland by Allice Melland and others in 2016, with the authors attributing this trend to a shift to using higher quality river water for irrigation, rather than groundwater.

The increase in topsoil salinity under horticulture is attributed to the application of large amounts of irrigation (drip), the use of typically poorer quality irrigation water, and the use of fertilisers that contain salts. It must be noted that while increases in salinity were observed under irrigated horticulture, the magnitude of this change is quite small, meaning that there is no major concern for soil salinisation in the near future.

Soil sodicity – exchangeable sodium percentage (ESP)

Sodicity is generally the biggest soil constraint to cotton production at Hillston. Sodicity levels at Hillston are generally low in the topsoil, but high to very high in the subsoil, leading to potentially undesirable impacts on soil structure (Figure 4). Soil layers with an ESP of six per cent or more are generally prone to waterlogging and permeability issues. Although the soils in the study area are considered to be naturally sodic, a trend of increasing soil sodicity through time was observed in isolated parts of the study area in both the topsoil and subsoil.

Most of the statistically significant increases occurred in areas under irrigated cotton and horticultural production, suggesting that this may be a function of management. This could be due to the ongoing addition of sodium to the soil system through irrigation water and salt-containing fertilisers. In the short-term, using more saline irrigation water will offset the negative impacts of moderate to high ESP on soil structure, but there is the danger that continuously using saline water could gradually increase ESP levels in the soil, leading to more severe structural degradation. It is essential that growers are aware of both the sodicity levels of their soil, as well as the quality of their irrigation water, to reduce the negative impacts on cotton crops.

Conclusions

Overall, there have been some minor changes in different soil properties in the Hillston district between 2002 and 2015. These changes have not necessarily all been negative, but more monitoring in the future should be done to track this. Some of the key points from this research are:

- Soil pH is very high in the subsoil, and may be a limitation for crop growth.
- In some areas, subsoil pH is decreasing due to the dissolution of carbonates following periods of very high rainfall.
- Most of the soil in Hillston is considered to be non-saline, with very little impact on crops.
- Soil salinity is unchanged or decreasing under irrigated cotton, but increasing under some areas of irrigated horticulture.
- These salinity trends were linked to the quality and quantity of irrigation water used during the 2002 to 2015 period and the use of salt-containing fertilisers in perennial horticulture.
- Soil ESP is only limiting in isolated locations in the topsoil at Hillston, but most of the subsoil is highly sodic (over six per cent ESP).
- Some isolated areas under irrigated cotton and horticultural production experienced an increase in sodicity over time.
- These increases could be due to addition of sodium to the system through irrigation water and fertiliser.
- Topsoil organic carbon levels are naturally low at Hillston, and most areas experienced no change from 2002 to 2015, but SOC was found to increase in some areas, with this attributed to heavy rainfall received from 2010 to 2012 (data not shown).
- The high rainfall experienced from 2010 to 2012 appears to have had a discernible impact on soil condition.
- While irrigated cotton production appears to have changed the soil to some degree, some of these impacts can be considered positive.

During the late 1990s to early 2000s several baseline soil surveys were also conducted in the northern cotton-growing valleys. The soils and growing environment of the northern valleys are often distinctly different from that of the southern valleys, and it would be interesting to re-survey these areas to evaluate if any similar trends in the change of soil properties have occurred.

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