CHARACTERISING SOIL STRUCTURAL STABILITY AND FORM OF SODIC SOIL USED FOR COTTON PRODUCTION

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ABSTRACT

In eastern Australia, Vertosols are widely utilised for the production of irrigated cotton (*Gossypium hirsutum*) due to their inherent fertility and large water–holding capacity. However, irrigated agriculture in eastern Australia is faced with a decline in the availability of good quality irrigation water sources *i.e.* waters with low electrolyte concentrations and small Na^+ contributions. Consequently, alternative water resources that contain larger contributions of Na^+ are becoming increasingly relevant as potential irrigation sources. It is known that the application of Na^+ rich waters as irrigation has the potential to increase the Na^+ content of the soil, and that this will affect the structural condition of Vertosols. However, the extent to which these poor quality water resources will influence the structural characteristics of different Vertosols is unknown. In addition to this knowledge gap, there is currently no suitable predictor of dispersive behaviour for this soil type, particularly where Vertosols are irrigated with different water quality solutions.

The research conducted in this study aimed to characterise the impact of different increments of water quality on the structural stability of different Vertosols. Once this was concluded, the study looked to assess the impact of irrigation water quality on the structural stability, structural form and soil water retention properties of intact soil columns. Knowledge of the structural stability of the soils investigated was then used to derive a model describing the impact of water quality on the structural stability of different cotton producing soils.

To achieve the aims nine different soil profiles were sampled from the Bourke, lower Gwydir, Hillston and lower Namoi cotton–producing regions. Eight of these soils are Grey and Black Vertosols with clay phyllosilicate suites dominated to different extents by 2:1 expanding clays, and the ninth soil is an illitic Red Vertosol containing small contributions of 2:1 expanding clays. The soils investigated have ESPs that range between 1 and 10, ECs of 0.1 to 1.2 dS m^{-1} and CEC_{eff} values that are largest for those soils that contain more 2:1 expanding clays.

This study shows that the clay phyllosilicate suite of different Vertosols is the primary determinant of structural stability, structural form and soil water retention properties. For example, the Gwydir and Namoi soils contain more 2:1 expanding lattice phyllosilicate clays, have the largest CEC_{eff} values of all nine soils and are the most dispersive after all applied immersion treatments. The Bourke and Hillston soils contain less 2:1 expanding lattice clay, have smaller CEC_{eff} values and are generally more stable.

Irrigation of structurally–intact soils with solutions of larger SAR_w resulted in larger exchangeable Na^+ contents for each soil (and larger ESPs) and smaller contributions of exchangeable Ca^{2+} and

Mg^{2+}. For each soil, larger ESPs are reflected by decreased stability, but generally the soils dominated by 2:1 expansive clays are much less stable than the soils containing smaller contributions of these clay mineral types.

Irrigating the structurally–intact Vertosols dominated by 2:1 expansive clays generally resulted in structural form attributes that do not indicate any impact of the applied water treatments, but the Vertosols with less of these mineral types tend to have less desirable structural form attributes after irrigation with solutions of larger Na^+ content. Similarly, where the water retention properties of two soils were assessed, the illitic Red Vertosol has less structural pore space after treatment using the large SAR_w solutions, while the other soil (a Black Vertosol dominated by 2:1 expansive clays) does not show any differences between water retention properties that can be linked to irrigation water quality. These results were clarified for the water retention properties by the assessment of pore–solid space relations, which show both these soils to contain less solid space after irrigation with clean water or solutions of large SAR_w. This is attributed to increased swelling of clays in the presence of larger Na^+ contributions, but both soils have different structural arrangements as shown by the water retention properties and structural form assessment. The red illitic Vertosol shows signs of structural collapse, while the black Vertosol maintains its structural arrangement.

Finally, a model describing the structural stability of different Vertosols was developed from the stability assessment of soils, both in different water quality treatments and after the irrigation of structurally–intact columns. The model presented uses a surface response function to describe the impact of increased EC_w and SAR_w of irrigation solutions on soil stability after immersion according to specific soil physico–chemical attributes. In this model increased exchangeable Na^+, SAR and a larger CEC_{eff} (and consequently, an increased proportion of 2:1 swelling clays) are associated with increases in clay dispersion, while a smaller Ca^{2+}:Mg^{2+} ratio, EC and less total clay are associated with decreases in clay dispersion.