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Harvesting rainfall in dense clay subsoils to increase yields of rain-fed crops

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Yields of managed agricultural crops relate directly to the soil water taken up by their roots and transpired through their leaves. The availability of this water for rain-fed crops depends on the rainfall and the soil's ability to capture and store the rain for use by the crop. Unfortunately, there are many soils with dense impermeable clay subsoils that have limited capacity to capture and store rainfall. Past attempts to ameliorate these subsoils have failed. Field experiments were therefore carried out across the high rainfall zone (>500 mm annual rainfall) of Victoria, Australia with the aim of ameliorating the constraints posed by these subsoils. The key finding was that deep-banding of high rates of nutrient-rich organic amendment, into the dense, dispersive clay subsoil, a practice known as subsoil manuring, transformed the subsoil into a friable, aggregated soil. Pore-space and permeability increased after one crop and large, consistent and profitable increases in the yield of wheat and canola crops, were measured over four consecutive crops. The improved yields were associated with enhanced nutrient uptake and the increased use of subsoil water by the crops. Crop responses resulted when preceding rainfall was sufficient to replenish subsoil water and when one or more rainfall events occurred during the spring months, as crops filled their grain. The improvement in crop productivity is attributed to the increased capture and storage of rainfall in the subsoil, and its use by crops during their critical pre-flowering, flowering and grain-fill periods. Increased nutrient supply from the mineralizing organic amendment during these periods also contributed to the crop response. Soils with dense clay subsoils occur in many countries. They may well respond to this practice and grow more resilient and productive rain-fed crops, as rainfall becomes more variable.

Recent Publications

1. Clark G J, Sale P W G and Tang C (2009) Organic amendments initiate the formation and stabilisation of macro-aggregates in a high clay sodic soil. Australian Journal of Soil Research 47(8):770-780.
2. Gill J S, Sale P W G and Tang C (2008) Amelioration of dense sodic subsoil using organic amendments increases wheat yield more than using gypsum in a high rainfall zone of southern Australia. Field Crops Research 107:265-275.
3. Gill J S, Sale P W G, Peries R R and Tang C (2009) Changes in physical properties and crop root growth in dense sodic subsoil following incorporation of organic amendments. Field Crops Research 114: 137-146.
4. Gill J S, Clark G J, Sale P W, Peries R R and Tang C (2012) Deep placement of organic amendments in dense sodic subsoil increases summer fallow efficiency and the use of deep soil water by crops. Plant and Soil 359:57-69.
5. Sale P W G and Malcolm B (2015) Amending sodic soils using sub-soil manure: an economic analysis of crop trials in western Victoria. Australian Farm Business Management Journal 12: 22-31.

Figure 1. Transformation of the physical structure of a dense, dispersive clay subsoil, four years after deep-banding 20 t/ha of nutrient-rich organic amendment, at a depth of 30-40 cm. Photos show untreated subsoil (left) and treated subsoil (right).

Biography

Peter W Sale has carried out his research for over 30 years to address constraints that limit the productivity of farming systems in eastern and southern Australia. His initial work investigated slow-release P fertilizers for legume-based pastures and he became Lead Investigator in the National Reactive Phosphate Rock Project during the 1990s. Work on the form of applied P changed to the impact of P supply under abiotic stress, focusing on how pasture legumes under water deficit stress respond to P availability. Research then began on how to ameliorate subsoil constraints in cropping land in the Victorian high rainfall zone. This followed requests from grain producers who grew disappointing, low-yielding crops when dry periods occurred during the spring. Dense, dispersive clay subsoils, that restricted root growth and stored little plant-available water, were implicated. Research projects since 2005, on ameliorating these constraints, led to the development of the practice known as subsoil manuring.

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