NATIONAL PROGRAM FOR Sustainable Irrigation

Fact Sheet

WAYS TO IMPROVE SOIL STRUCTURE AND IMPROVE THE PRODUCTIVITY OF IRRIGATED AGRICULTURE

Extensive work on soil structure by researcher Dr Bruce Cockroft from Northern Victoria has brought the maintenance of soil structure into the spotlight as a promising area for irrigators to work on to improve their yields. An overview of Cockroft's research has been prepared by Dr Rob Murray at the University of Adelaide for the National Program for Sustainable Irrigation.

Australia's most important irrigated soil group

Quoting Cockroft's work, Murray (2006) summarises the concerns about one of the major soils: 'While the Red Brown Earths are Australia's most important irrigated soil group, their generally hostile B horizon and fragile A horizon underlies a history of structural collapse under irrigation. The clay B horizon is usually poorly drained so that the soil remains wet longer, accelerating structural collapse and leading to disease and loss of nitrogen. The A horizon is usually high in fine sand and silt, has low organic matter and biological activity so that it slakes easily leading to crusts and high strengths. Cultivation to break up this poor structure just makes the soil more unstable.'

Soil Improvement – Lessons from around the world

- Low soil quality that leads to low farm productivity can be improved to equal the best worldwide.
- The very best soils overseas yield more than five times those in Victoria, and will produce consistently into perpetuity. These can be seen in older civilizations in China, the Nile, Rhine and Euphrates deltas and in other areas such as California.
- After visiting some of the most productive soils in the world, Bruce identified elements that these soils had in common. He then returned to the Goulburn Valley in Victoria and attempted to improve the structure of the local soils to match these global 'super soils'. The characteristics of these 'super soils' have been replicated (through careful attention to soil structure management) in a normal Goulburn Valley orchard soil. Several fruit growers and fodder crop farmers are setting up small commercial areas of this 'super soil'.

Strategies for improving soil

Cockroft's work focuses on:

- Increasing soil depth via mounding
- Excluding tillage and soil compaction through 'no traffic zones'

- Increasing root depth and the amount of roots by reducing the soil's hardness and re-forming the soil into aggregates of various sizes
- Increasing the porosity of the soil through the incorporation of organic matter
- Using mulches and rye grass in between tree rows to increase the volume of roots in the soil
- Avoiding rapid wetting or drying of the soil and ideally, keeping the soil constantly moist to avoid the phenomenon of 'coalescing', where soil aggregates (peds) gradually adhere to each other and the soil hardens and loses the variety of sizes that give it porosity and structure.

The 'super soil' identified by Bruce Cockroft requires the following practices to be developed and maintained. The most important are listed first. These are then further explained below.

Practices to avoid
Traffic compaction
Clay contamination from the subsoil
Powdering (caused by cultivation when too dry)
Ex-cropping soil
Ex-pasture soil
Poor drainage

Traffic compaction
It is crucial that growers avoid any traffic on the beds.

Clay contamination
Deep ripping techniques to fracture the subsoil must be carefully employed to avoid lifting heavy clays up into the A horizon.

Powdering
Excessive cultivation or cultivation when too dry can destroy the most valuable physical characteristic of the soil – the aggregation of the soil particles into 'peds' of various sizes.

Ex-cropping soil
Many conventional cropping practices deplete organic matter to less than 1%. Desirable organic matter levels might be as high as 6-7% to achieve 'super soils'. Accumulation of organic matter is an important precursor to achieving re-aggregation of the soil, through the action of root growth, fungal growth and colonisation by bacteria, worms and insects.

Ex-pasture soil
Compaction by grazing animals makes these soils difficult to work with. Compaction primarily occurs when soils are moist, but one brief compaction event can take years to undo. Cockroft recommends that areas that have been grazed should be cropped with grasses and left unstocked for at least 2 years to initiate the processes of restoring the porosity of the soil.

Poor drainage
Poor drainage leads to low oxygen levels in the soil which leads to low biological activity.

Practices to use
Rye grass
Capillary irrigation
Organic matter
Reaggresizing
Lime

Rye grass
Rye grass has prolific root growth and can assist in re-instating organic matter in the soil and promoting biological activity that will assist in improving the soil's physical structure.

Capillary irrigation
Flood and furrow irrigation have the effect of causing compaction and coalescence of the soil. Capillary irrigation, where the water is drawn up to the roots from sub-surface drip systems, helps to protect the soil.

Organic matter
In order for soil biota to thrive they need a food source, which organic matter provides. Soil organic matter also helps to retain moisture in the root zone and make it available to the plant for longer.

Re-aggresizing
This process refers to a cultivation process which causes soil clusters, or peds, to re-form in the soil, through a combination of root growth, increased organic matter and increased biological activity.

Lime
For the red-brown earths there is a common requirement to reduce the acidity of the soils, which makes plant nutrients more available and creates the chemical environment for increased biological activity.

Conclusion

With progress towards this improved soil, where the plant has ready access to available soil water and nutrients, Cockroft has estimated that the productivity of Australian horticulture could be improved 2-3 times its current levels. While his focus has been on perennial horticultural plantings, there are many aspects of this work that are more widely applicable to agricultural soils in general.

Further reading

Cockroft, B. and Martin, F. M. (1981). Irrigation. In *Red-Brown Earths of Australia*. Edited by Oades, J. M., Lewis, D. G. and Norrish, K. Adelaide, Waite Agricultural Research Institute, University of Adelaide and CSIRO Division of Soils, S.A. **p.** 133-147.

Cockroft, B. and Olsson, K. A. (2000). Degradation of soil structure due to coalescence of aggregates in no-till, no-traffic beds in irrigated crops. Australian Journal of Soil Research **38**(1): 61-70. http://www.publish.csiro.au/paper/SR99079.htm

Murray, R.S. (2006) A review of Dr Bruce Cockroft's work for Australian irrigated horticulture (in prep.). National Program for Sustainable Irrigation.