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Super Soils

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Introduction

Australian horticultural industries face an ongoing requirement of increasing their productivity to remain world competitive. Productivity is a complex topic involving numerous components, but a key area is the efficient use of our natural resources leading to high yields per ML of irrigation water or kg of fertiliser at reduced costs. Uncertainties in the cost and availability of water and fertiliser are also providing further impetus to their efficient and productive use.

Dr Bruce Cockroft and others from the soils science fraternity declare one of the major causes of low productivity is Australia's comparatively poor soils, in particular our poor organic matter content, biological activity and soil structural properties.

For more than 50 years Bruce has researched the most productive soils of the world and highlighting the challenges of soil and irrigation management with Australian soils. This has led to the development of practical management strategies to essentially build the ideal soil type, maximise the rooting volume, in particular the very fine roots and root hairs of irrigated crops, and facilitate the most efficient use of the inputs used in modern agriculture.

These strategies are largely based on the growing of rye grass as a cover crop and its creation and maintenance of good soil structure and structural stability (no coalescence), and soil of a low resistance (non-compact). Bruce's work has developed the concept of a "Super Soil" that exhibits loose, soft and porous soil to depth, mimicking the most productive soils of the world. This has led to improved productivity and previously unrealised yield potential.

Physical properties of productive soils

An understanding of the key physical properties of productive soils is important when trying to develop strategies to "build" and alleviate the soil of any physical impediments. Bruce's research indicates the ideal physical properties can be created, stabilised and maintained.

Soil structure

Soil structure is defined by the way individual particles of sand, silt and clay are aggregated. Ideal aggregation results in soils with a varying pore size distribution enabling good transportation, storage and supply of air, water and nutrients. Pores are classified into three main categories based on pore size: macropores (>75µm), mesopores (75-30µm) or micropores (<30µm), with the ideal soil having macroporosity of >15%.

Soil structural stability

To remain functional pore systems must remain stable over time. Stability is commonly assessed in terms of water stable aggregation or the ability of soil aggregates to resist disintegration when subjected to disruptive forces associated with water. However, Bruce's work indicates stability should be measured when aggregates resist disintegration under stresses from subsequent wetting and drying cycles. His work found that loose, water-stable, zero-tilled soils not subject to traffic, hardened between three and six months following the preparation of soil beds for orchards and this phenomenon differed to the problems of slaking, dispersion and compaction. This phenomenon was termed soil coalescence. Coalescence was not restricted to certain clay minerals or texture groups (Cockroft and Olsson, 2000).

Soils that are unstable and coalescent become more resistant and less porous. The advantages of maintaining adequate porosity and low resistance have been discussed previously and below, respectively.

Soil resistance

Most soils chosen for irrigated development should provide enough depth and volume of soil for suitable readily available water (RAW) holding capacities and rootzone depth. These soils may not be soft. High soil strength or soil resistance, can occur naturally from hard pans or be induced as a result of traffic compaction from previous farming practices.

Soil strength or soil resistance is measured by a penetrometers and should ideally remain below 0.5Mpa as the soil dries or <1.0Mpa at field capacity. Soil resistance below these levels will allow roots to proliferate across a range of soil moisture contents.

The role of a quality and functioning root system

When soil physical properties are not limiting improvements in surface infiltration rates, availability and storage of water and nutrients, aeration, drainage, and temperature will arise. This will create an environment where rooting volume and functioning is optimised. When functioning correctly, roots will

Figure 1: The fibrous root system of ryegrass

Figure 2: Sandy soil aggregates held together and stabilised by the ryegrass roots

communicate important messages to the above ground components of the plant influencing stomatal conductance, shoot growth, fruit growth and ultimately fruit yield.

The checklist to building a Super Soil

If the building blocks to a Super Soil are loose soft porous soil, is there anything that can be done on-farm to "replicate" a Super Soil? Whilst some soil characteristics can't be changed such as soil texture, others can be influenced. The following is a list of practices Bruce recommended to apple and pear growers in the Goulburn Valley:

- avoid traffic compaction (in the tree line)
- no point in trying to improve the traffic lane – it will always be compacted
- avoid clay contamination (mixing subsoil with topsoil)
- avoid former cropping soil
- avoid former pasture soil
- if ex-cropped or ex-pasture, fix the soil with rye grass
- avoid sites with poor drainage
- avoid excessive subsoil clay (drainage risk)
- avoid soil that is too wet (tillage or ripping)
- avoid powdering the soil during tillage
- cultivate with soil slightly moist
- re-aggresize (break down large clods into smaller aggregates)
- elevate nitrogen fertiliser
- pre-plant rye grass and grow for one to two years
- cultivate and re-sow at six to 12 months
- install slow capillary irrigation
- maintain rye grass over the whole area two years or more, except immediately near young trees
- cultivate, incorporate rye grass, build up bank every six months
- use the topsoil into tree bed line and build in stages
- incorporate the rye grass during these operations (top and roots)
- regrow rye grass immediately following incorporation
- repeat every three to six months until all the soil surface is in the bed – say 3m x 0.6m (for apples)
- plant trees
- grow rye grass soon after all tillage
- in young trees keep areas surrounding the trees bare
- as trees mature grow rye grass in autumn-winter only

The aims of the checklist are to both prepare the soil before planting and to maintain soil health throughout the orchard life.

The checklist can be consolidated into four categories listed below.

1. Avoid former cropping and pasture land as it will most likely be compacted

If soil is compacted, rip at the correct soil moisture content and plant rye grass. Land used for cropping is likely to have plough-pans or hard-pans that will impede root growth and water infiltration. The same applies for land used for pasture and livestock grazing as the surface layers are most likely sealed and compacted from trampling.

2. Avoid poorly drained sites with clay subsoils

If drainage is a problem, mound the tree line to improve drainage. The idea of mounding is to take good topsoil from the mid-row and move it to the tree-line. This increases the available depth of topsoil for root growth and reduces the drainage risk within the rootzone.

***CAUTION**: The extreme rainfall events of 2010-11 showed poorly drained soils with mounds can cause localised flooding and tree deaths. Tree mounts impede the natural flow of surface water during heavy rainfall events causing localised intra-row flooding. Mounding will not solve drainage problems due to soil texture and/or structure*

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but will aid root growth. Drainage concerns and extreme weather events and/or over-irrigation need to be addressed separately.

3. Add organic matter at every opportunity

Numerous sources of organic matter (e.g. mulch, compost, manure) can be purchased or sourced on-farm (green manure crops, mulched prunings). Whilst they all provide improved soil health benefits, some may require further investigation and confirmation from your marketers regarding their implications on food safety. The current ground harvesting regime also means it's difficult to add large quantities of organic matter once the orchard is established.

4. Grow rye grass to maintain or improve soil structure

Research on improving soil structure quality has made substantial progress over recent times, but more importantly progress has been made on maintaining coalescence-stable, "Super Soils". The planting of rye grass as a cover crop, in combination with other soil management practices, has led to this development and maintenance of a loose, soft soil porous to depth. These benefits are a result of both the tops (green foliage), but particularly the bottoms (roots) of the rye grass.

The tops benefit the soil by providing a source of mulch and organic matter once incorporated into the soil or sprayed-off.

The roots of rye grass benefit the soil by developing preferred pathways for root growth, rapid water infiltration, rapid water and nutrient uptake and exchange of respiratory gases, and importantly the creation of rhizosheaths (rhizo = roots) of soil particles (Figure 1).

Rhizosheath soil develops particularly well around the roots of rye grass and is soil very high in biological activity and organic matter, and is very stable and porous (Figure 2). Rhizosheath soil is also very efficient at conducting water and nutrients to the roots. It is the cycling of new and dying rye grass roots and rhizosheaths that will create aggregation needed for super soils.

Use of rye grass in orchard establishment

Bruce's work has illustrated the benefit of growing rye grass in soils prior to planting fruit trees. Whilst it may not always be possible, Bruce recommends we grow rye grass for up to two years and across the whole orchard floor. The rye grass should be cultivated to depth and re-sown every six months. If mounding is employed, build the mound every six months with the freshly cultivated soil. This process builds the organic matter which is then protected by the next germination of rye grass. The cultivation is said to re-aggregate the soil and ensure the new rye grass roots build the ideal soft, porous stable aggregates that become the structural building particles of the new soil.

Use of rye grass in ongoing maintenance

After the trees are planted grow rye grass in autumn and winter, avoiding grass in spring and summer and thereby minimising frost risk and the competition with trees for water and nutrients.

Rye grass varieties

A mix of three to six rye grass varieties consisting of annual and perennial species is recommended. The mixture allows for adequate germination, growth rates and maturation under a range of climatic conditions. Varieties include Matilda, Kingston, Victorian, Crusader, Nutecia, Bronson, Feast, Kangaroo Valley, Ellet and more. A local seed supply merchant should be consulted to help determine the most appropriate species of rye grass.

Sowing rates

Heavy sowing rates of rye grass are recommended to ensure a heavy cover and the choking out of weed competition. Rates of 50kg/ha may work in certain situations, but a rate of 100kg/ha is recommended.

Remember, sowing in established orchards needs to occur above the root system. The focus is not stabilising the surface of the midrows following harvest and x-blade activities. Therefore, sowing needs to cover the wetted area of the irrigation system, which will be particularly challenging in drip irrigated orchards. However, anything is possible if your mind is put to work.

Irrigation

In a dry autumn, or more generally a dry climate, germination of rye grass from natural rainfall can be challenging. Orchards with sprinkler or micro-jet systems will have successful germination with supplementary applications of water. Orchards with drip irrigation will rely more heavily on rainfall but would also benefit from supplementary irrigations, particularly if you have a soil type and irrigation system that facilitates pulsing and wider wetting patterns.

Soil nutrition

Annual fertiliser applications to an existing orchard are normally adequate for basic levels of rye grass germination and growth. However, to facilitate vigorous growth, or in the absence of annual fertiliser applications during orchard development, additional fertiliser is recommended.

Weed spraying and frost

Allowing rye grass to grow during the spring and summer will result in competition with the trees for water and nutrients and possibly yield decline. Almonds also bloom in a frost sensitive period and if rye grass was allowed to grow at this time, it may present an increased risk of frost damage. Spraying the rye grass prior to bloom is essential to eliminate competition and reduce frost risk.

Concluding remarks

While it may be difficult to implement all the practices on Bruce's shortlist there are benefits to suggest they should at least be given a go. Almond yields may not double with the Super Soil principles but changes to soil management practices may lead to increased efficiencies for some of our largest input costs; fertiliser, water and electricity. The bigger picture of the Australian almond industry undertaking new, innovative steps to improve soil health and our orchard environment is surely worthy of marketing to our consumers also.

References

Cockroft, B. 2012. Soil management for Australian irrigated horticulture, National Program for Sustainable Irrigation Project No. SRP005026.

Moore, G. (1998). Soilguide. *A handbook for understanding and managing agricultural soils.* Agriculture Western Australia Bulletin No. 4343

Murray, R.S. 2007. A review of Dr Bruce Cockroft's work for Australian irrigated horticulture, milestone report 2.

Olsson, K.A. 2006. Development of structure quality for high yields from irrigated orchard soils - a review of the research of Dr Bruce Cockroft's from 1997-2006. Horticulture Australia Limited, Project No. FR05019.

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ACKNOWLEDGEMENTS

This project has been facilitated by HAL in partnership with the Almond Board of Australia and has been funded by the Research & Development levy. The Australian Government provides matched funding for all HAL's R&D activities.