Soil carbon study

By Jackie Bedford

A Plant & Food Research-led team has shown the potential of promoting deep root growth by kiwifruit plants.

Higher levels of carbon in soil – as the basic constituent of organic matter – provide many benefits, team leader Markus Deurer reported to the Soil Carbon Conference, held in Wellington in August.

Organic matter in soil improves soil structure, reducing run-off of nutrients and limiting erosion, filters excessive nutrients and contaminants, and acts as a net sink for greenhouse gases. To gain these benefits, land users think about promoting accumulation of soil carbon and organic matter in soils.

"Regional Councils already monitor soil carbon contents as an indicator of soil health to assess environmental benefits," Markus notes.

But the question of where in the soil carbon could most effectively be accumulated has been "seldom addressed".

Water repellency issue

A recent survey, conducted as part of a post-doctoral project funded by Agmardt, assessed how prone 10 main types of North Island pastoral soils are to water repellency and showed "a significant and positive correlation between the tendency of a soil to repel water and the accumulation of soil carbon in the top 4cm of soil".

This correlation makes sense because soil water repellency is understood to result from a lack of biologically driven decomposition of organic matter. The "burning" of organic matter provides an energy source for a range of soil microbes, bacteria and fungi, that help keep the soil structure open and receptive to water. If organic matter is accumulating and not being broken down, organic compounds are formed that coat the soil aggregate and mineral surfaces and these have a strong water-repelling effect.

It is a serious matter for land users because water repellency prevents the infiltration and storage of water in topsoils. With water repellency, there is more run-off, reduced plant growth and reduced ability for the soil to filter excessive nutrients and contaminants. A high level of biological activity in the topsoil is therefore used as an indicator of soil health.

Organic growers

Soil biology is particularly important for organic growers, Markus says. "If you don't want to use synthetic N fertilisers and you need nitrogen, the only thing you can do is use your soil biology to carry out nitrogen mineralisation."

New Zealand research has shown a strong correlation between easily available (hot-water extractable), high-turnover soil carbon and the rate of nitrogen mineralisation under both organic and integrated apple growing systems. "So if you want to substitute for fertiliser, you need to burn your carbon."

Researchers Markus Deurer (left) and Hasinur Rahman.

Soil carbon dilemma

The water repellency effect presents a challenge for carbon storage, if this is an aim, because it means there is this need to keep organic matter in the upper layers decomposing – and giving off carbon – in order to avoid water repellency and feed micro-organisms.

It is what Canadian researcher H Janzen called the "soil carbon dilemma": the recognition of benefits from hoarding carbon in soil as well as benefits from burning it.

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A comparison of soil carbon in soils under two neighbouring kiwifruit blocks: one 10 years old (top 2 images) and the other 25 years old (bottom 2 images).

Deeper carbon storage

The potential for sequestering carbon deeper in soil was shown by a large survey of 1500 soils worldwide conducted by United States researchers Jobbagy and Jackson and reported in 2000. It was found that under a wide range of land uses, about one-third of the carbon in the soil depth from the top to three metres down is stored below one metre depth.

"So that's a huge reserve there that we haven't thought much about and we might be able to tap into that. Usually for some reason we just think about the top 30cm.

"Or to put it another way, in the one to three-metre depth, we store 50 percent of the amount we store in the zero to one-metre depth."

Bay of Plenty research

The Plant and Food Research-led research team investigated the profiles of soils in two neighbouring Bay of Plenty kiwifruit blocks, one established 10 years ago and the other 25 years ago, to assess the levels of long-term storage, or "sequestration", of soil carbon.

This work was funded by the Sustainable Farming Fund and the main contributors were kiwifruit consultancy firm PlusGroup and Zespri, with some input from several regional councils with kiwifruit growers in their catchments.

Kiwifruit is a perennial crop with quite different characteristics to cropping – which has had a lot more attention worldwide, Markus points out. Under kiwifruit there is less mixing of soil because it's not worked every year and roots have longer to become established and leave behind organic residues at depth.

Soil samples from both the vine row and the alley ways between with grass growing in them were assessed for carbon concentration (using the loss-on-ignition method after doing some work to show the accuracy of this approach) and soil bulk density.

The researchers found 139 tonnes of carbon per ha in the younger orchard soil and the older 145.

From measuring the top one-metre of the profile of the Te Puke sandy loam-type soil, the researchers found more carbon sequestered in the older block, "but only in the subsoil below a soil depth of 0.5 metres".

"We hypothesise that the source of this subsoil carbon sequestration is via the fine roots and possibly aided by deep-burrowing worms, associated with the deep roots.

"Other studies have shown that root residues are the more important source of stored soil carbon than organic residues applied to the soil surface."

This means land users need to be "strategic" about where they sequester carbon, says Markus. "We conclude that the best location to store soil carbon is in the subsoil, and management practices need to enhance deep root growth as a promising mechanism of soil carbon sequestration."

Or, in other words to sequester carbon: burn it in the topsoil and hoard it in the subsoil.