Sustainable soil health for intensive production

Horticulture Australia

What is soil health?
In agriculture, the term soil health defines a soil's capacity to sustain productivity and its ability to promote plant health with little farm input. In a broader definition, soil health also describes a soil's capacity to function as a living filter in breaking down and recycling organic wastes, chemicals and pollutants, hence, protecting our environment and ensuring clean food production.

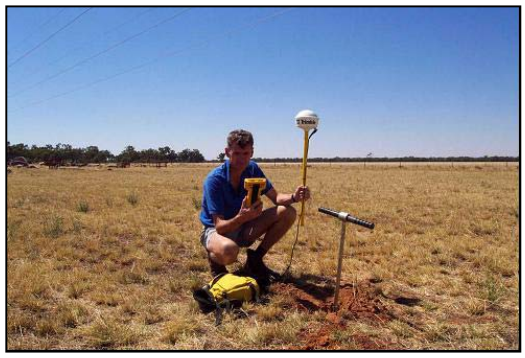
Poor soil structure leads to hard setting soil surfaces and crusting in a paddock in north-west Tasmania.

Potential soil health indicators can be broadly divided into two categories, in accordance with their functions. "The first category is akin to a building structure (measurements such as soil structure, aggregate stability, penetration resistance, soil structure score) and the other is akin to building materials that will influence the quality of the building (such as soil type, organic carbon, total microbial activities, fungi, bacteria, nematodes)", says Dr. Hoong Pung from Serve-Ag Research in Devonport, Tasmania.

Decline in soil health will lead to soil structural problems, with reduced aggregate stability, infiltration, porosity, aeration, water and nutrient storage. It also results in increased erosion, runoff, cloddiness, and penetration resistance. The resilience of soil structural integrity to stock and machinery will largely be influenced by the quality of the soil materials.

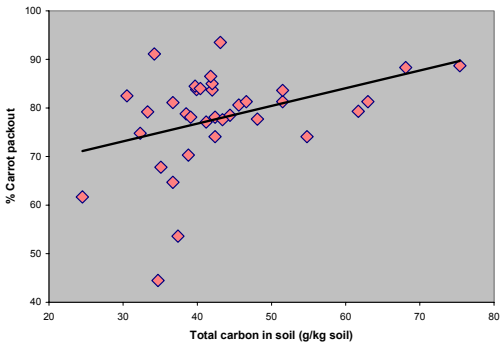
Root crops like carrots are sensitive to soil structural properties.

Studying soil health
Do you know how healthy your soils are, and what are the implications of crop management practices on the health of your soils, plant roots and crop yields?



Global positioning system used to record sampling site locations for future reference in NSW.

To answer these questions, a two-year survey study was conducted in a national project (VG99057) with a broad and multidisciplinary approach to investigate soils from approximately 100 sites in major production areas in Queensland, New South Wales, Victoria and Tasmania.



Soil organic carbon levels were closely associated with increase in diseased and misshapen carrots, and decrease in carrot packout rate.

The study aimed to determine what intensive vegetable production does to soil health and to identify potential soil health indicators. This project was funded by Horticulture Australia and levies from Australian vegetable growers, and was carried out by researchers from State Departments of Agriculture and Natural Resources from Queensland, New South Wales, Victoria and Tasmania, as well as CSIRO and the private research

organisations, Serve-Ag Research and Biological Crop Protection Pty Ltd. Capsicum and carrot crops were used as benchmark crops for this study.

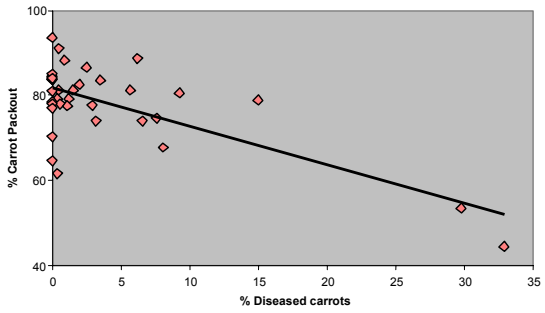
Soil carbon critical for soil health

Soil carbon was identified as the basic and most important building component for a healthy soil, irrespective of soil type, region, or climatic conditions. Some cropped sites in Tasmania and Queensland showed similar or higher soil carbon values than their comparable reference sites. This indicates that with good farm management practices, even with intensive land use for vegetable production, soil integrity and soil health can be sustainable.

Increased carbon levels in soils were generally associated with reduced disease, misshapen and forked carrots.

According to Mark Hickey, Horticulturist at Yanco Agricultural Institute, NSW Agriculture, "Not many of us realise the important role carbon plays in soil health. A recently completed study of carrot soils in southern Australia has revealed carbon credits are just as important for our soils as for our air quality."

Whereas, with our air we are striving to reduce carbon emissions, increasing carbon levels are actually good for our soils. Project Leader, Dr Hoong Pung has concluded that in a study of 35 carrot sites in Tasmania, 4 in Victoria and 8 in NSW, increasing carbon levels in the soil were generally associated with reduced disease and misshapen carrots, and increased packouts for fresh market carrots.

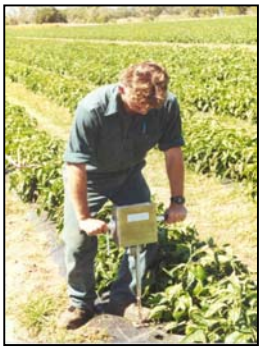


Diseased carrots were the most important cause of reduced packout rate for fresh market carrots.

In the project study, soil carbon was closely linked to soil aggregate stability and many other soil properties that contribute to the health of a soil. Elevated carbon levels in the soil occur as a result of incorporation of plant residues or manure, and higher total carbon levels were present on properties where soils are routinely in rotation with pasture, grass, barley or poppy. Carbon decline is symptomatic of decline in soil health.

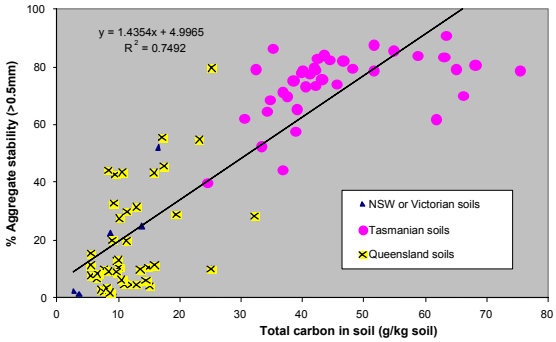
Managing soil carbon

Maintenance of high carbon levels in the soil, however, is not straightforward. For instance, the rate of organic matter decomposition and carbon loss into the atmosphere is higher under a warm climate than under a cool temperate climate. Soil type and management practices, such as use of green manure crops, also have an influence. As a result, average total carbon levels in Queensland, NSW and Victoria (1.1, 0.9 and 0.3% respectively) were much lower than those in Tasmania (4.4%).



A mechanical soil penetrometer used to measure soil strength in Queensland.

Research showed that the optimum or desirable carbon levels in each major production regions could be determined by examining typical regional soils from non-cropped sites. For example, the average carbon levels from non-cropped sites were 6.3% in Tasmania, 1.9% in Queensland, and 1.6% in NSW. When compared to crop soils, this represents an average carbon decline of 31% in Tasmania, 42% in Queensland, and 44% in NSW.

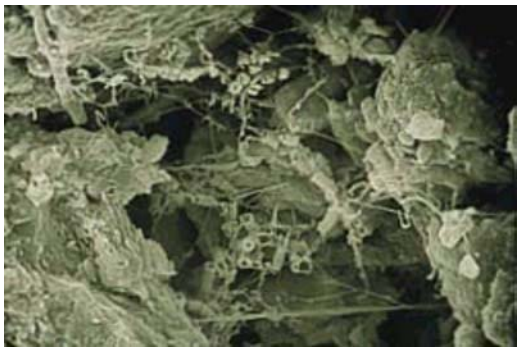


Irrespective of soil types and locations, an increase in soil carbon levels soils was closely associated with an increase in the percentage of small and stable soil aggregates of soils in the study. The small and stable soil aggregates are essential for well structured soils that can resist erosion by water and wind.

Total carbon is closely related to labile carbon (considered to be the most active form of carbon in soils) and microbial biomass (or "bugs") in the soil. This relationship suggests that total carbon, which can be measured in routine soil analysis, could be used as a soil health indicator. If monitored over a 5 to 10 year period, it could become a useful tool for farmers to identify management practices that may either prevent or accelerate soil degradation.

Increased carbon levels in soils were generally associated with reduced disease, misshapen and forked carrots.

Living soil important for soil resilience
Soil is alive with billions of bacteria, fungi, microscopic animals, and larger animals like ants and earthworms. Without these organisms, the soil is dead and unable to sustain plant growth. Changes in soil organisms could be used to detect short-term soil quality changes.

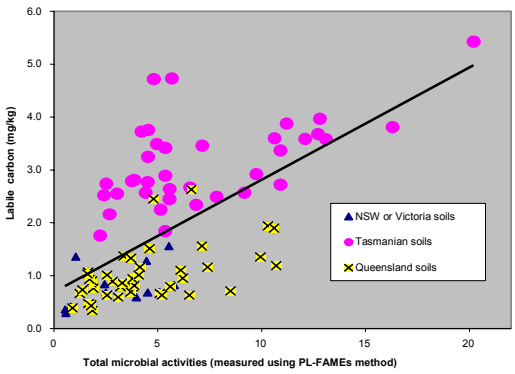


Highly magnified photo of soil particles held together by fungal hyphae and organic 'glue' produced by soil microbes to form stable soil aggregates.

Unlike soil carbon, which changes slowly over many years, soil organisms (consisting of many beneficial organisms that are essential for re-cycling nutrients and suppressing root disease) are particularly sensitive to organic matter, soil disturbance and management practices. "Soil organisms such as bacteria and fungi could serve as an early warning system for practices that can affect soil resilience," says Dr Pung.

Research showed that there were several different methods for determining the types of useful soil bugs present in a cropping soil. However, further studies are needed to determine how they could be used and their role in root disease suppression.

"When determining the impact of soil health on crop production, we sometimes need to look beyond crop yield alone," Dr Pung says. "In some types of crops, high yield could still be obtained in poor soil with increased use of pesticides, fertilisers and irrigation. However, these high yields are obtained with high pesticide costs, increased risk of salinity, and decline in soil health." Capsicum crops studied in Queensland are a good example of high maintenance required to counter poor soil quality. According to Dr. Jason Olsen of Queensland's Department of Primary Industries, "The capsicum crops studied in this work were grown from transplants, which were then nurtured with trickle irrigation, extensive fertiliser applications, plastic mulch, and grown in soil which had been fumigated to reduce the risks of root disease".



The close relationship between labile carbon and total microbial activities of soils in Queensland, Tasmania, NSW and Victoria. Soil microbe populations were closely linked to labile carbon levels in soils.

Dr Phil Moody, Principal Soil Scientist with Queensland's Department of Natural Resources says that this phenomenon is like having an oil leak in your car – if you keep topping up the oil every day it will perform acceptably in the short term, but in the longer term it will have negative impacts on both your finances and the environment. He likens the introduction of practices to improve soil structure and diversity of soil microbes (creating a disease suppressing soil) with fixing the cause of the oil leak in the car.

The project team. From left to right are:
Hoong Pung (Serve-Ag), Steve Jackson (QDPI), Pam Cox (Serve-Ag), Marcelle Stirling (Biological Crop Protection), Phil Moody (DNR), Clive Pankhurst (CSIRO), Mark Hickey (NSW Agriculture), Bill Ashcroft (Vic Natural Resources and Environment), Jason Olsen (QDPI), Leigh Sparrow (HRDC), and Bill Cotching (Tas Dept Primary Industry and Fisheries).

This newsletter highlights the major findings of project VG99057. We would like to thank all growers and processors involved with this study.

For more information on the project outcomes, contact Dr. Hoong Pung, Serve-Ag Research, on Ph (03) 6423 2044; Email: hpung@serve-ag.com.au

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