



How can SOIL be healthy?

It makes sense for producers to seek and maintain soil health. Let's explore how. By Pieter Raath (CRI) and Larne Auerswald (Labserve)



Pieter Raath



Larne Auerswald



The UN Agency's Intergovernmental Technical Group on Soils (ITPS) defined healthy soil as "the ability to sustain productivity, diversity, and environmental services of terrestrial ecosystems" (Isonio, 2021). If, in an orchard context, soil health constitutes the ability of soil to ensure the sustained successful production of a crop, then it is something that producers must seek and maintain.

A populist view is that soil health is associated with the preservation and enhancement of so-called useful microbes in the soil and that conditions must be created to promote the proliferation of these microbes. However, the chemical and physical characteristics of the soil (rather than its organic matter and biology per se) mostly determine its ability to ensure successful production of a crop.

In pursuit of soil health as defined above, the focus should firstly be on proper soil preparation that focuses on ensuring and maintaining a balanced soil chemical status and good physical attributes, i.e., a chemically homogenous, well aerated soil that is free from physical restrictions. Any soil characteristic that reduces aeration, e.g., compaction or wetness, will reduce the soil biological activity, and more so, the plant root activity. Healthy, adequately fertilised, properly managed trees in well-aerated (not over-irrigated) soil will have healthy roots that create and maintain their own rhizosphere microbial populations. Active growing roots exude organic compounds (exudates) into the soil. These compounds are a food source for micro-organisms, raising their number up to 500 times higher than in the rest of the soil (McLaughlin *et al.*, 2000). The characteristics

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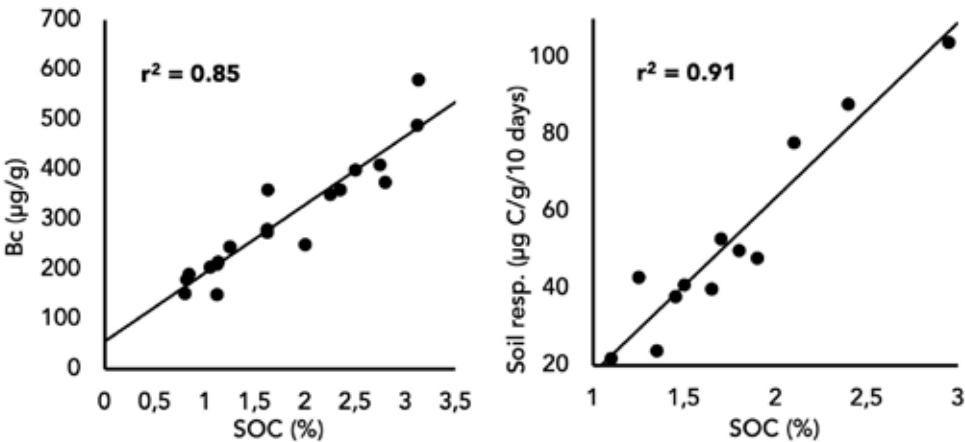


Figure 1. Correlation between (a) soil microbial biomass (Bc) and soil organic C (SOC) (adapted from Leita *et al.*, 1999) as well as (b) biological activity and SOC (adapted from Witter *et al.*, 1993)

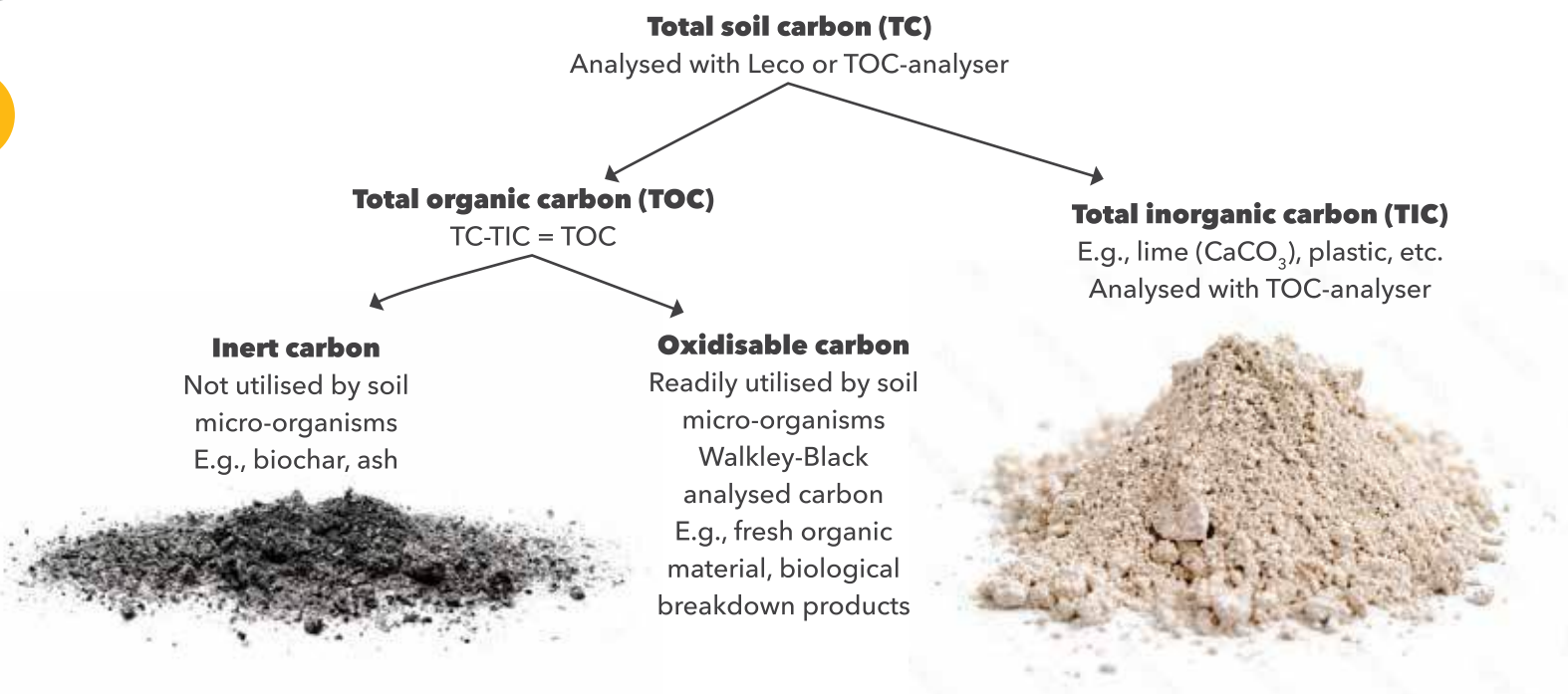


Figure 2. Different types of carbon found in soil

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of the exudates changes according to the age of the tree, season, chemical inputs, water availability and tree nutritional status. Therefore, the rhizosphere is a constantly changing environment in which the relative number of each member group adjusts according to the nature of the exudates and the environmental conditions. For example, when a plant wilts due to water stress, more amino acids are released by the roots to the rhizosphere. Likewise, more organic acids are released into the rhizosphere in response to iron (Fe) or P deficiency, which then solubilise Fe, P, Zn and other metals, thereby enhancing their bioavailability (McLaughlin et al., 2000). Thus, the addition of external soil microbiological systems has little direct effect on root and plant health or plant nutrition. We can then, instead of referring to “healthy soil”, rather pursue healthy roots through well-managed soil.

In established orchards, maintenance of an adequate amount of organic carbon (C) in the soil, ensures that microbial activity and diversity in the soil outside the rhizosphere is sustained. The simplest and most logical way to increase the soil biological activity and diversity beyond the root zone is therefore simply to increase the soil organic C (preferably Walkley-Black analysed) – it was proven that there is a direct correlation between soil C content and microbial biomass and activity (Witter et al., 1993; Leita et al., 1999; Bhogal et al., 2009), as shown in Figure 1. In addition, soil organic material also increases the water holding capacity and nutrient retention ability of soil. An increase in soil C from a very low level, and subsequent increase in soil biological activity, will also enhance overall soil physical conditions, i.e., reduce susceptibility to compaction and increase

soil aeration. This benefits root health and growth, and consequently the rhizosphere microbial population, which fosters tree health. The maintenance of an appropriate (not necessarily high) soil organic C level is, therefore, good common sense.

Soils that are higher in clay content generally retain more organic C than sandy soils. As a result, well-managed clayey soils have higher biological activity than sandy soils. But structure, water holding capacity, nutrient retention and biological activity of sandy soils can be increased when inputs of organic material are greater than losses, but the converse is also true. In situ plant biomass production is a viable input, whereas amendments added to soils are more costly. And since losses occur when organic matter decomposes, the cost and effort to retain a certain level of soil organic C needs to be weighed up against the benefits. It often does not justify the cost and effort.

Producers who want to establish the soil C levels must note that laboratory analysis must be interpreted correctly. Total soil carbon (TC) cannot be equated

Table 1. Appropriate oxidisable organic carbon levels, analysed with the Walkley-Black method, of topsoil (0-30 cm) for orchards in South African conditions, as affected by soil texture (as deduced from Schütte et al., 2019)

Soil texture	Appropriate soil organic C levels (%)		
	Low	Optimal	*High to excessive
Sandy	<0.4	0.5-1.0	>1.5
Loamy	<0.7	0.7-1.5	>2.0
Clayey	<0.8	0.8-2.0	>3.0

*Costly to maintain, can also result in excessive and untimely N mineralisation

Figure 3. Properly prepared and ameliorated orchard soil before the trees are established. The soil is not over-irrigated and sustains healthy roots and trees irrespective of a pursuit of improved soil biology.



with soil organic carbon that is oxidisable and therefore, utilised by the soil micro-organisms (i.e., Walkley-Black analysed carbon). Any TC analysis also includes other carbon sources, like the carbon in lime (CaCO₃), biochar and even plastic or coal (ash) residues. All last-mentioned forms of C are inert and do not originate from biological organisms. Therefore, total carbon is not a certain indicator of the soil’s microbiologically available carbon. It is suggested that producers who want to monitor and manage their soil carbon, distinguish between the different types of carbon found in the soil, as illustrated in Figure 2. Many soils contain free lime, and sometimes residues of biochar or wood ash. Hence, a Leco analysed carbon value (total combustion) is not always helpful. Rather, it’s advisable that either the total C (TC) as well as the inorganic C (TIC) are analysed to obtain the total organic C (i.e., TC-TIC = TOC), or that the Walkley-Black carbon (i.e., oxidisable C) is quantified. For reference, appropriate soil oxidisable organic carbon levels (as analysed by the Walkley-Black method) for South African conditions are indicated in Table 1.

Producers who are concerned about soil health, should focus on responsible soil management practices, i.e., correcting and maintaining the soil chemical and nutritional status, limit soil compaction and avoid over-irrigation. Where physical and chemical conditions are optimal for the intended

crop, balanced and beneficial soil biology is established. Maintenance of soil C is usually also a given in well-managed orchards where the soil is not cultivated regularly, and the produced plant biomass (e.g., dropped leaves, prunings and inter-row vegetation) is not removed. A well-managed soil is a “healthy soil”.

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