ABOVE: Jones contends that the plant bridge provided by perennials in pasture cropping is what allows for large increases in soil carbon in a relatively short time.

INSET: Despite providing organic matter and protection to soil, chemical fallow stubbles maintained without perennials will achieve only slow increases in carbon content.

tion systems, as are the year-round green leaves required to fuel the photosynthetic process and provide carbon in liquid form.

These factors have been overlooked in models of soil carbon sequestration such as Roth C.

Roth C model

The Roth C model was developed by scientists to mathematically predict movement of carbon in and out of soils. It is based on the assumption that most carbon enters soil as 'biomass inputs', that is, from decomposition of plant leaves, plant roots and crop stubbles.

The model provides useful estimations of soil carbon fluxes in conventionally managed agricultural soils but fails to account for carbon sequestration in soils actively fuelled by soluble carbon.

Data from the Australian Soil Carbon Accreditation Scheme (ASCAS), which measures soil carbon under regenerative agricultural regimes, will enable models such as Roth C to be recalibrated.

When carbon enters the soil ecosystem as plant material (such as crop stubble), it decomposes and returns to the atmosphere as CO_2. Hence the lamentation "my soil eats mulch", familiar to home gardeners and broadacre croppers alike.

While plant residues are important for soil food-web function, reduced evaporative demand and buffering of soil temperatures, they do not necessarily lead to increased levels of stable soil carbon.

Conversely, soluble carbon streaming into the soil ecosystem via the cytoplasm of mycorrhizal fungi can be rapidly stabilised by humification and permanently retained in soil, provided appropriate land management systems are in place.

Mycorrhizal soluble C

The types of fungi that survive in conventionally managed agricultural soils are mostly decomposers, that is, they obtain energy from decaying organic matter such as crop stubbles, dead leaves or dead roots. As a general rule, these kinds of fungi have relatively small hyphal networks. They are important for soil fertility and soil structure but play only a minor role in carbon storage.

Mycorrhizal fungi differ quite significantly from decomposer fungi in that they acquire their energy in a liquid form, as soluble carbon directly from actively growing plant roots.

There are many different types of mycorrhizal fungi. The species important to agriculture are often referred to as arbuscular mycorrhizae (AM) or vesicular arbuscular mycorrhizae (VAM) belonging to the phylum Glomeromycota.

It is well-known that mycorrhizal fungi access and transport nutrients such as phosphorus and zinc in exchange for carbon from their living host. They also have the capacity to connect individual plants and can facilitate the transfer of carbon and nitrogen between species.

Plant growth is usually higher in the presence of mycorrhizal fungi than in their absence. What is less well-known is that in seasonally dry, variable or unpredictable environments (that is, in most of Australia), mycorrhizal fungi can play an extremely important role in plant-water dynamics, humification and soil building processes. Under appropriate conditions, the major portion of soluble carbon siphoned into short-lived mycorrhizal hyphae undergoes humification, a process in which simple forms of carbon are resynthesised into highly complex polymers.

Humification

These large, high-molecular-weight molecules are made up of carbon, nitrogen, soil minerals and soil aggregates. The resultant humus is a stable, inseparable part of the soil matrix that can remain intact for hundreds of years.

Humified carbon differs physically, chemically and biologically from the labile pool of organic carbon that typically forms in agricultural soils. Labile organic carbon arises principally from biomass inputs (such as crop residues) which are readily decomposed.

Conversely, most humified carbon derives from direct exudation or transfer of soluble carbon from plant roots to mycorrhizal fungi and other symbiotic or associative microflora. Once atmospheric CO2 is sequestered as humus, it has high resistance to microbial and oxidative decomposition.

The soil conditions required for humification are diminished in the presence of herbicides, fungicides, pesticides, phosphatic and nitrogenous fertilisers — and enhanced in the presence of humic substances such as humic and fulvic acids and compost teas — particularly when combined with microbial inoculants.

The biological soil environment required for humus formation is commonly found in association with year-long green farming practices such as pasture cropping.

It is also possible for humification to occur in annual cropping systems, provided long fallows are avoided, soil is kept covered at all