

## The important role of soil organic carbon in future mixed farming systems

K.Y. Chan

Industry & Investment NSW, Locked Bag 4, Richmond NSW 2753  
yin.chan@industry.nsw.gov.au

**Abstract:** Soil organic carbon (SOC), because of its influence on all aspect of soil fertility, is a useful indicator of the health and the performance of mixed farms, and increasing SOC can improve productivity, stability and resilience. With development and adoption of improved management practices in both of the cropping and pasture phases, there is scope for further SOC increases in mixed farming systems. In view of predicted climate change, SOC monitoring and management will play an important role in managing future farming systems.

### Introduction – historical perspective and looking into the future

Traditionally, mixed farming in the form of crop-leys has been very popular in southern Australia. This refers to cereal cropping in rotation with pasture in the same area, and the practice has increased productivity and stability of many farms. This practice is regarded internationally as a triumph in securing long-term stability of dryland farming. The pasture phase, as leguminous ley, helps to maintain soil organic matter level, which in turn helps to maintain soil nitrogen fertility and soil physical properties (Greenland 1971; Fig. 1). It has been estimated that the 31% increase in wheat yield

(0.87 t/ha to 1.14 t/ha) recorded between 1945 and 1955 has been due to the introduction of this mixed farming practice (Leeper 1970).

Under predicted climate change scenarios, farming in southern Australia will be confronted with a hotter and drier environment, with increasing prevalence of extreme climatic events such as drought, rainfall and floods (Garnault 2008). In this paper, it is proposed that farming systems that maintain or even increase the soil organic carbon level of agricultural soils will hold the key to adapting agriculture to such future environments, and that pasture will play an important role in this challenge.

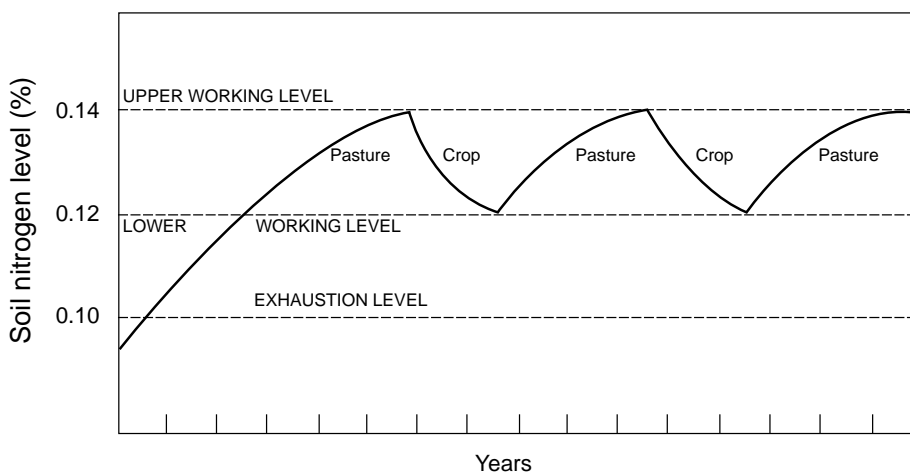


Figure 1. Change in soil organic nitrogen level (an indication of soil organic matter level) in a ley crop mixed farm system

### Soil Organic Carbon and its functions in agricultural systems

Soil organic carbon refers to the carbon associated with soil organic matter (SOM). Soil organic matter is the organic fraction of the soil and is made up of decomposed plant and animal materials as well as microbial organisms. Soil organic carbon is important for all aspects of soil fertility, namely chemical, physical and biological fertility.

Conveniently, SOC has been divided into a number of pools according to its stability, namely labile, slow and recalcitrant pools, in increasing order of stability. The labile pool includes partly decomposed organic matter and microbial biomass, the slow pool includes humus, while charcoal represents the recalcitrant pool. Different forms (pools) of SOC serve different functions (Table 1) and are found in different proportions in soils of different fertility levels. Therefore, SOC is a good indicator of soil health. The size and the proportion of the different pools indicate how healthy the soil is.

### SOC and farming system performance

SOC, because of its profound influence on soil fertility and soil functioning, also affects farming system performance in term of productivity,

stability and resilience. There are many examples of increasing crop yield resulting from increased SOC levels. For instance, an increase of 1 ton of SOC increased wheat grain yield by 40 kg/ha in semi-arid pampas of Argentina (Lal 2004). In a long-term trial at Wagga Wagga, NSW, SOC in extreme management treatments (traditional tilled, stubble burnt under continuous wheat vs no-till, stubble retained under wheat and lupin) was 1.5 and 2.5% in the top 0–5 cm of soil and the average wheat yield was 1.5 and 2.9 t/ha respectively (Chan *et al.* 2010). This difference in crop yield will have important implications regarding future food security. A more stable soil, found under well-managed crop-ley systems, should be more resistant to predicted more extreme drought and rainfall events, and have lower erosion hazards.

Performance of the farming system will be closely related to its water use efficiency. SOC plays a role in improving water use efficiency via its effect on soil structure and associated soil physical properties, thus improving and maintaining yield in the face of changing climate. Attributes like increased water holding capacity, higher infiltration rate and higher nitrogen availability arising from increased

**Table 1. Soil Organic Carbon affects all aspects of soil fertility**

Soil fertility	Effects of Soil Organic Carbon	C pools
<i>Chemical fertility</i> Provides nutrients available to plants	Microbial decomposition of SOC releases nitrogen, phosphorus and a range of other nutrients for use by plant roots	Labile, slow
<i>Physical fertility</i> Improves soil structure and water holding capacity	In the process of decomposition, microbes produce resins and gums that help bind soil particles together into stable aggregates. The improved soil structure holds more water available to plants, allows water, air and plant roots to move easily through the soil, and makes it easier to cultivate	Labile, slow
<i>Biological fertility</i> Provides food for soil organisms	Organic carbon is a food source for soil organisms and micro-organisms. Its availability controls the number and types of soil inhabitants and their activities, which include recycling nutrients, improving soil structure and even suppressing crop diseases	Labile
<i>Buffers toxic and harmful substances</i>	SOC can lessen the effect of harmful substances such as toxins and heavy metals by sorption, and assist degradation of harmful pesticides	Slow and recalcitrant

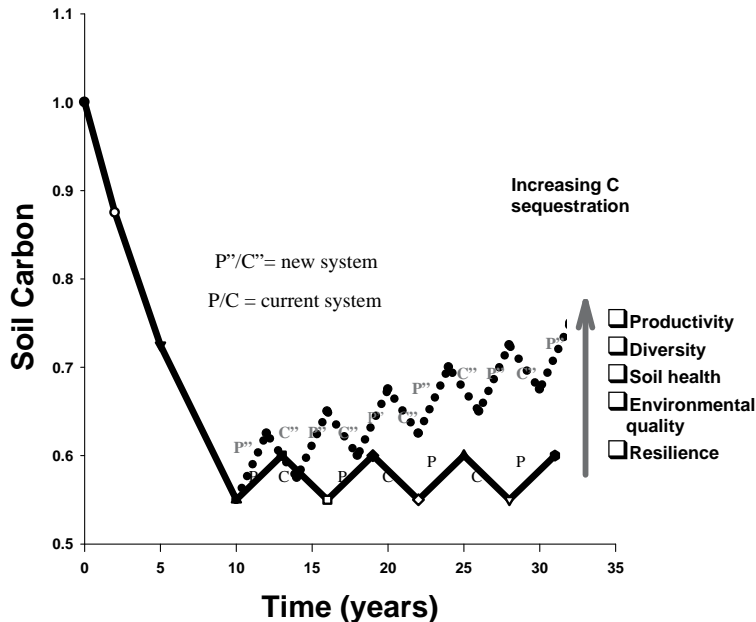


Figure 2. New mixed farming systems to increase soil carbon and other benefits

SOC, make farming systems more resilient to climate change.

### Scope for increasing SOC in future mixed farms

In contrast to the past, when SOC usually declined under cropping, new conservation farming techniques can increase or at least maintain SOC. For pasture, there are also management practices that have the potential of further raising SOC. Significant increases in SOC (0.5 t C/ha/yr) under improved pasture (P fertilised and use of leguminous pasture) have been achieved, and improved management practices such as grazing management and pasture cropping can potentially also increase SOC. Use of deeper rooting perennial pastures instead of shallow rooting annuals may also change soil carbon cycling and distribution in the soil profile. Combining cropping and pasture phases in a mixed farming system may offer additional potential for further SOC increases (Fig. 2).

### Conclusions

Soil Organic Carbon monitoring and management should play an important role

in running future mixed farms. Because of its influence on all aspects of soil fertility, SOC is a useful indicator of the health of mixed farms, and increasing SOC can improve productivity, stability and resilience of the farming systems. With the development and adoption of improved management practices in both of the cropping and pasture phases, there is scope for further SOC increases in future mixed farming systems

### References

- Chan, KY, Oates, A, Lui, DL, Li, G, Prangnell, R, Poile, G & Conyers, MK (2010) A farmer's guide to increasing soil organic carbon under pastures, Industry & Investment NSW, Australia. ISBN 978 1 74256 010 6. <http://www.dpi.nsw.gov.au/pubs/increasing-soil-organic-carbon-under-pastures>
- Garnault, R (2008) The Garnault Climate Change Review. (Cambridge University Press, Port Melbourne, Australia).
- Greenland, DJ (1971) Changes in the nitrogen status and physical condition of soils under pastures, with special reference to the maintenance of the fertility of Australian soils used for growing wheat. *Soils and Fertilizers* 34, 237–51.
- Lal, R (2004) Soil carbon sequestration impacts on global climate change and food security. *Science* 304, 1623–1626.
- Leeper, GW (1970) The Australian Environment. (CSIRO: Melbourne University Press).