Changing soil organic carbon

Strategies for cropped soils in the Woomargama area of southern NSW

Key messages

- Understanding soil bulk density is essential for understanding how much carbon is in soil.
- Stubble retention is most beneficial where soil organic carbon stocks are low.
- Consistently high stubble loads (over 5 t/ha) allow stubble management to be flexible whilst maintaining soil organic carbon.

Importance of soil organic carbon

Increasing the amount of organic matter in soil through retaining stubble is a means of improving long-term soil fertility and crop productivity (see 'Nitrogen management for wheat' fact sheet by DEPI). The organic carbon (OC) in organic matter helps bind soil together, reduces erosion and improves water retention. Most OC is in the topsoil of cropped paddocks.

In the short-term, retaining stubble can cause challenges in the following crop including reducing crop emergence and causing nitrogen in the soil to be immobilised thus increasing the need for nitrogen fertiliser (see 'Canola stubble retention' fact sheet by DEPI).

Stubble management

Cereal stubble is commonly mulched, grazed, baled or burnt. Each management practice has its own advantages and disadvantages for whole-farm management. The choice to mulch, graze, bale or burn stubble affects how much carbon is retained in the soil. The impact of these practices are explored here using the Roth C model, soil data from a farm at Woomargama and climate data from Holbrook as sourced from Bureau of Meteorology.

How much organic carbon is in soil?

When soil tests come back from the lab organic carbon is presented as %OC. However, this is only half the story when it comes to knowing how much organic carbon is in a soil. To convert %OC into t/ha we need to know the bulk density of the soil; that is how much soil is present in a soil layer. Bulk density in cropped topsoils tends to be range from 1 g/cm^3 to 1.6 g/cm^3.

Whilst soil tests are usually conducted on the top 10 cm layer of soil, the total amount of soil OC stock is often reported for the top 30 cm layer of soil. The amount of soil OC in the top 30 cm layer of soil at Woodstock is converted from OC% in the top 10 cm layer of soil in Table 1.

OC% in top 10 cm	OC stock in top 30cm
Bulk density = 1.5 g/cm^3	
0.5%	15 t/ha
1.0%	30 t/ha
1.5%	45 t/ha
2.0%	60 t/ha
2.5%	75 t/ha
3.0%	90 t/ha
3.5%	105 t/ha
4.0%	120 t/ha

Table 1: Conversion from % OC in the top 10 cm of soil to OC stock (t/ha) in the top 30 cm of soil at the bulk density measured on a farm at Woomargama (1.5 g/cm^3) Conversion factor sourced from Valzano et al 2005.

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Increasing soil organic carbon

Stocks of soil OC increase as more stubble is retained in the paddock. More stubble is retained by choosing a stubble management practice, such as mulching instead of burning. In addition, more stubble is retained by choosing cropping practices that produce more stubble, such as high yielding cereals instead of fallowing.

Thus the highest increase in soil OC occurs when all the stubble from high yielding cereals is retained in the paddock (Table 2).

This may not always be possible due to other issues such as using stubble for feed, lower yielding seasons, or burning stubble occasionally as a weed control strategy. Less OC accumulates under these condition and modelling suggests that at Woomargama, soil OC stocks will decrease unless stubble loads are consistently over 5 t/ha. When stubble load is very low (less than 1 t/ha) OC will decline regardless of management practice in the Woomargama area (Table 2).

Annual Stubble Load	1 t/ha	3 t/ha	5 t/ha	7 t/ha
	tonnes soil OC/ha			
Burn stubble	-9	-4	0	5
Bale stubble	-8	-3	3	8
Graze stubble	-7	2	11	19
Mulch stubble	-6	4	15	25

Table 2: Change in soil OC (t/ha) at the Woomargama site after using the same stubble management practice for 25 years with 1 to 7 t stubble/ha produced every year. BD=1.5 g/cm^3 in the top 10 cm, initial OC = 36 t/ha in the top 30 cm.

Further Reading:

GRDC (2011) Stubble management fact sheet. pp8.

Valzano F et al (2005). The impact of tillage on changes in carbon density with special emphasis on Australian conditions, Tech. Report No. 43. Dept Environment and Heritage. pp164.

Long-term stubble management

Increasing soil OC is a long-term goal. How long the goal takes to achieve depends on the starting level of soil OC, how much stubble is available and how stubble is managed. Consideration needs to be given to how the amount of stubble varies over the years with crop type and crop growth.

The figures below show that consistently retaining stubble by mulching builds soil OC in soils at Woomargama where there is less than 3% soil OC. Consistently removing stubble by burning at Woomargama depletes soil OC where there is more than 1.5% soil OC (Figure 1).

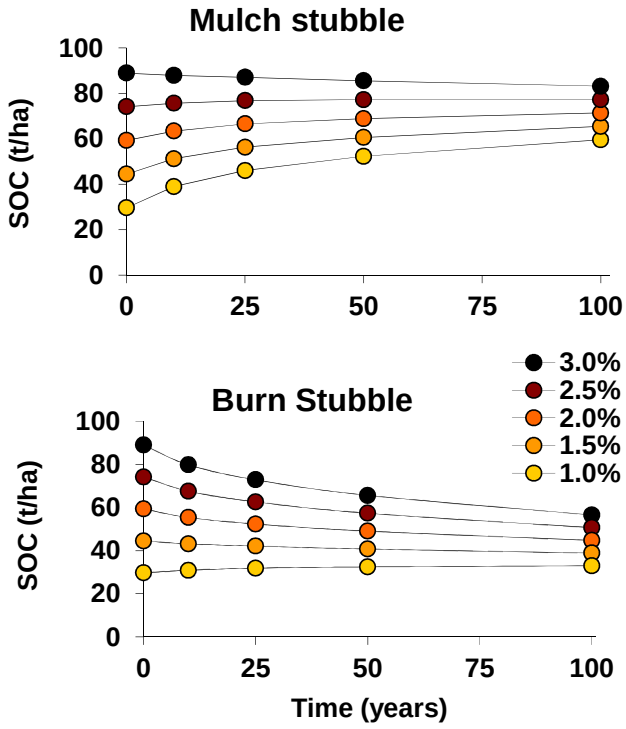

Figure 1: The long term effect of two stubble management practices (burning or mulching 5 t /ha of stubble every year) on soil organic carbon stocks (t SOC/ha) at Woomargama. Modelling starts with 5 different levels of soil OC%.

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