Factsheet **CARBON FROM AIR TO SOIL - Pasture** vs 5 – July 22

By Trevor Galletly [i], Peter Van Beek [i]

The basic question

How does Carbon[1]) get from a gas in the air (where too much is bad) into solid forms in the soil where it does a lot of good? The secret lies in sunlight, green plants and the countless micro-organisms in the soil. The energy from the sun drives the process.

Green plants are the only realistic way to extract carbon from the air.[2]

Plant leaves produce sugars by using the energy of sunlight to combine water from the soil with carbon-dioxide (CO_2) from the air. Some of these sugars are used by the plant itself.

The remainder of the sugars are transported down to the roots. These use some to function and grow and exude some which feeds the soil microbiota. This consists of billions of organisms, from microscopically small ones to earthworms, that improve soil structure. Microbiota has been found to be crucial for the health, growth and optimal functioning of the plant[3]). Roots can create compounds from the sugars that get desirable responses from the microbiota, a form of 'communication' between plants and microbiota. The amount of root exudate varies during a plant's life – the blue sections below.[4]

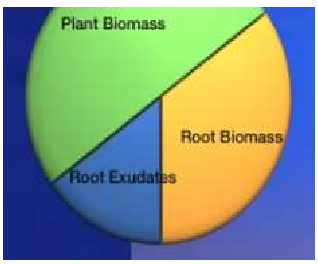


Fig 1-Seedling stage

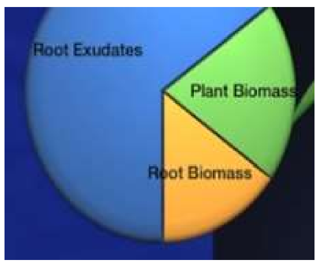


Fig 2-Near full growth

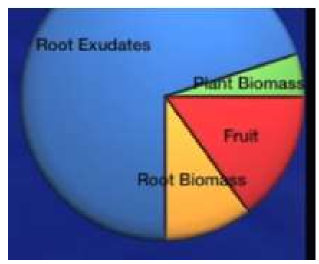


Fig 3-Early flowering

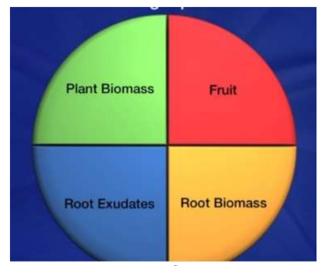


Fig 4-Full life cycle

Microbiota

Much of the soil microbiota depends on plants. Root exudate from plants feeds bacteria and other life forms that recycle dead plant material back into food for the next generation of plants. They make that food available in forms that plants can take up easily e.g. as chelated forms[5]. Some also fix nitrogen from the air which will become available to plants. Part of the exudate is taken up by a wide range fungi which form carbon structures. Some carbon structures are quickly used by the next plant, others can last longer.

A group of specific fungi grow in direct association with the root: mycorrhizal fungi. These spread their hyphae, the thin structures that are their main body, over long distances. They can free-up minerals locked in the soil and dissolve minerals out of rocks. The minerals can be transported back to the roots to be exchanged for exudates.

Many other fungi convert dead plant material and form complex long-term carbon-based molecules. These can last for centuries when left un-disturbed by cultivation. They are part of humus, the lasting part of soil organic matter. Much of this has been lost due to human activity. Humus molecules can absorb and hold large quantities of water which plant roots can extract easily when needed. All forms of humus add to the water holding capacity.

---

[1] Carbon can take many forms:

- Carbon in the air is mainly in the form of a gas: Carbon dioxide (CO_2).
- Carbon can combine with many other elements and then form the organic matter, the myriad of complex molecules that are the basis of all life on earth (including us).

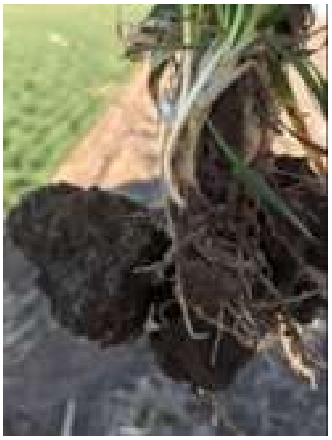
[2] Carbon Capture and Storage at coal fired power-stations requires huge investments in machinery, storage tanks, transport and energy. Green plants run on free solar energy and reproduce themselves.

[3] Wikipedia - https://en.wikipedia.org/wiki/Microbiota

[4] https://www.youtube.com/watch?v=o55RGuELgII

[5] https://en.wikipedia.org/wiki/Chelation: bonding mineral ions to organic compounds that plants can take up.

Carbon in soils



More carbon indicates more microbiota and more organic matter and humus in a soil. Photo 1 shows a hard, compacted soil with low carbon, low aeration and reduced soil biological activity.

Photo 2 shows a high carbon soil, well aerated and with soil biology sticking soil to roots. Photo 2 is for illustration but the principles equally apply to grazing land. (Even if the effects may be less dramatic.)

Photo 1

Photo 2

The better the soil structure, the better the water infiltration and the more water soil can store. An increase of 1% humus can add an extra 10-15 mm being held in the soil and leads to better retention of minerals and a more diverse microbiota.

Getting optimal benefits from rain on grazing land

Grazing management effects the carbon content of soils and thus the retention of rain water, the rate of regrowth after grazing and ultimately the long-term financial returns.

Fig 5 - Stages of growth

Figure 5 shows a rough balance between leaves and roots throughout the plant's lifecycle. The amount of sugars produced at seedling stage is small because there are few leaves, see figure 1. Of this small amount, only a small part is available as exudate. Larger plants produce larger amounts of sugar and a larger proportion of that is exuded as shown in figures 2 and 3. Also, it takes much longer for a plant to re-grow from very small to mid-size than from mid-size to fully grown.

Fig 6 - Less green parts = less roots

Figure 6 shows that a reduction of green leaves leads to a more or less corresponding reduction of active roots. Combining this with figures 2 and 3 shows why it pays to keep the plants at least at mid-sized, if at all possible, and not graze them into the ground or burn the pasture. More roots are left to supply water to leaves and more leaves to produce more sugars. That means quicker regrowth after rain and more exudates available to feed the microbiota.

Management

Key management practices to build up the microbiota - <u>a form of invisible capital</u> - are:

- Manage grazing pressure by rotational grazing in some form.
- Avoid chemicals and some fertilizers that kill or reduce the microbiota.
- Maintain groundcover where possible to help water infiltration and prevent erosion.
- Avoid exposing the microbiota to direct air and sunlight.
- Avoid burning pastures: it sets plants back to the seedling stage and leaves soil bare.

---

[i] Trevor Galletly, *QDA, B AgSC - 40 years in biological farming* Peter van Beek, *Dip Agr, B Ec, M Ag studies*