The return of plant materials to the soil: balance between mineralisation and humification

The organic matter incorporated in the surface provides nutrients and plays an important role in covering the soil surface. The way in which organic plant materials are incorporated into the soil can vary greatly in each ecosystem depending on environmental conditions. The main factors that regulate the **balance between mineralisation and humification** of these materials are the **C/N ratio of the organic material**, the **degree of lignification**, **the level of crushing** and the **microenvironmental conditions of the place**.

Incorporation of organic matter into the soil surface

A production system based on **feeding the soil food web** and maintaining the **habitat conditions** necessary for it to function is defined by the type, quantity, and way in which organic materials are incorporated into the soil. Although the most important incorporation occurs through the roots, the incorporation of the aerial part is the one that we can manage the easiest, therefore, it is what characterises our system. The **organic matter incorporated in the surface**, in addition to providing nutrients, plays an important role in covering the soil surface. The value of this organic matter depends on the speed at which it decomposes. **The way in which organic materials from the aerial part of plants are incorporated is a characteristic of different natural systems:**

• In the **forest**, incorporation occurs mainly by **leaves** falling, which accumulate on the ground (**Figure 1**). The interior microclimate of the forest makes it easier for these leaves to **decompose** and, in this way, they are the basis of organic matter for the functioning of the food web.

• In **grazed grasslands**, the incorporation of organic matter occurs mainly through **manure and urine** from animals that graze on the grassland. Manure is a partially decomposed organic material **rich in microorganisms.** For effective incorporation into the soil, especially at depth, manure requires the activity of its **own set of insects** such as dung beetles (**Figure 2**), among others.

• In **non-grazed plant systems**, the incorporation of plant material from the aerial part of the plants requires some type of intervention (such as cutting or trampling leaves and branches) that allows this material to be lowered to the ground. If the **material does not reach the soil** it degrades without being incorporated into the soil (**standing oxidation**), so that a significant part of the material is not used by the food web (**Figure 3**).

Balance between mineralisation and humification

When **bacteria very quickly consume the plant materials provided on the surface**, this produces a rapid supply of nutrients, in a process called **mineralisation**. If this happens, plant materials disappear quickly and cannot play any role in soil cover. On the contrary, **when decomposition is slow, plant materials create a soil cover that protects against direct attacks from the sun, rain and wind**, it encourages water infiltration, creates the necessary habitat for important elements of the food web, and is responsible for forming a stable surface humus. It is a process called **humification**.

Figure 1. Holm and cork oak forest with ground covered by a layer of leaves. Photo: MJ Broncano.

Figure 2. Dung beetle on cow excrement. Photo: MJ Broncano.

Figure 3. Tractor crushing the plant aerial part that remains on the ground and can be used by the soil food web. Photo: MJ Broncano.

To prioritise the process that is of most interest each time, it is necessary to know the factors that regulate the **balance** between mineralisation and humification. Modifying these factors can control the balance and therefore the role that the incorporated materials perform in the creation and function of the soil. **The main factors that regulate the balance** between mineralisation and humification of plant matter are:

• **C/N ratio**. To satisfy their needs, bacteria require an optimal **C/N ratio close to 24**, which is what they need to breathe and build up their organism. When the relationship moves away from this value, two different things happen:

- If the **C/N ratio of the organic materials is less than 24** (high nitrogen content), in relation to their needs, there is a lack of carbon, in order to consume all the nitrogen, they look for additional carbon in their environment. This leads to a rapid loss of organic matter, leading to a loss of soil structure and cover on the surface.

- If the organic material has a **C/N ratio greater than 24** (low nitrogen content), the bacteria look for more nitrogen to adjust this ratio to their needs, consuming a large part of the nitrogen available around them. In this case decomposition of the materials is slow and **can lead to a lack of available nitrogen for plants**.

Working with green manures, it must be considered that the nitrogen content varies throughout the life of the plant: in **young plants** the content is high for all species. When they **start flowering**, the C/N ratio is usually over 24. This is a good point to incorporate green manure superficially because microbes can quickly consume the material, but part of carbon remains, allowing slower decomposition. In the **plant's maturity** phase there is a drop in nitrogen content that can vary greatly depending on the species.

• **Degree of lignification**. There are several substances, such as lignin or suberin, that have a complex structure that makes it difficult for bacteria to break down. These complex substances must be broken down by actinomycetes and fungi. Therefore, materials with a **high lignin content**, such as forest debris from trunks and branches, decompose more slowly than other plant debris, and therefore **give rise to a more stable humus**.

• **Level of crushing of plant materials**. For the same material, **the more crushed it is, the more easily it is attacked by detritivore organisms** that make it more accessible to microorganisms, so that its decomposition is faster.

• **Micro-environmental conditions**. Environmental conditions largely determine the rate of decomposition of organic matter. **The activity of microorganisms and fungi increases with the right humidity conditions, temperature and the presence of oxygen**. Otherwise, in conditions of lack of water, low temperatures and anoxia (lack of oxygen) the decomposition rate of organic matter is reduced.

The regenerative production model is based on knowledge of natural processes

The proposal for a sustainable regenerative production model should not be confused with the return to a productive system of the past. The approach to a sustainable production model is possible thanks to **scientific advances in knowledge of natural processes, which allows us to know** how the natural nutrition of plants works and its technical application in a controlled way in the field. Efficiently controlling the return of organic materials to the soil and the mineralisation/humification balance allows improved production per unit area of fields. In this way, the environment's resources are used in a **real circular economy model**. This increase in production does not depend on external resources and makes it possible to recover the profitability of small farms in which the current model, strongly dependent on oil and agrochemicals, is not profitable. At the same time, **this new model is a scalable one**, i.e. it can adapt to any type of condition and offers a real alternative to the dependent and unsustainable system that we have at present.