Analysis of crops as a productive system from a regenerative perspective

Crops comply with the principles of the regenerative model and maintain their productivity when: **(1) there is a high diversity of species** due to the rotation of crops in terms of time or space; **(2) the return of green or dry plant materials to the soil** is maintained; **(3) there are no interventions that alter the soil** such as ploughing or the use of insecticides, herbicides or chemical fertilisers; **(4) there is a balance between carbon extraction and inputs into the soil;** and **(5) the organic matter in the soil maintains its water retention capacity** and this is complemented by adequate irrigation.

Applying the principles of the regenerative model to crops

The regenerative production model is defined by **5 basic principles** that can be applied to crops. The analysis of these principles in the case of crops allows us to assess how the system is working and which interventions could help to improve it most efficiently

1) The diversity and quantity of plants

In regenerative agriculture, **maximum crop production is achieved with maximum diversity**. This is based on the need to have **plants covering** the ground and growing for **most of the year**. Furthermore, if these plants have different characteristics (greater tolerance to environmental conditions, deeper roots, etc.) it is easier for them to make better use of all the available resources. The maximum diversity of plants is achieved by **combining different crops and even animals in terms of time and space**.

There are different production models that allow **crops to be combined over time**. All are based on crop rotations throughout the year or between years. In the **Fukuoka method**, rotations are carried out in the same year. Along with rice, which is the base crop, other cereals are grown in winter such as rye and barley in the same field and they are even compatible with the planting of white clover, which is a legume that enriches the soil with nitrogen. In the **pasture cropping system**, winter cereal crops are combined with warm season grasses throughout the year and their periods practically do not overlap. In other cases, such as the **legume alternation method** proposed by **Pinheiro**, the rotations are carried out in different years: one year a legume species is sown and a second year a non-legume species (cereal or oilseed) is sown, in order to maintain nitrogen fertilisation every two years.

Other models **combine crops in space**, thereby increasing biodiversity and its advantages in the production of the system. The clearest case is **agroforestry**, which **combines trees and crops on the same land**. These different elements complement each other and a greater biodiversity and a greater quantity and variety of products is obtained. But any **orchard without tillage** has a high biological variety, since **crops and wild plants grow simultaneously**, which gives rise to a significant heterogeneity of species and available resources (**Figure 1**).

Figure 1. Garden without tillage showing the great variety of plants growing in it. Photo: MJ Broncano.

2) The return of plant materials to the soil

The regenerative production system requires the return of plant materials to the soil. **The most important incorporation occurs through the roots**, but the one we can manage is the incorporation of the aerial part on the surface that, in addition to providing nutrients, plays an important role in covering the soil surface.

The **balance between mineralisation and humification is key in this return**. If the process is driven by bacteria, the materials are quickly consumed and represent an immediate nutritional supply. On the other hand, if the decomposition is caused by **fung**i, the plant matter remains in the soil longer and **creates a stable humus**. Thus, if the return is green remains of crops or adventitious plants at their peak production, the decomposition process is faster. But if the remains are from these plants when they have already been **lignified or even dried**, **decomposition is much slower** and an intermediate decomposition phase can be obtained, which is the **more stable humus**.

In the different types of crops there are certain peculiarities. Thus, in **pasture cropping**, the return of plant material to the ground is combined with the return that occurs with **animal excrement**. In cases of intensive vegetable production, as is usually the case in the orchard, the contribution of **external transformed materials** (such as BRF or compost) is necessary to compensate for the outputs produced with the harvests.

Figure 2. In the regenerative model, not very heavy agricultural machinery can be used to avoid soil compaction. Photo: CC0

Figure 3. BRF covering the irrigation ditches in the Planeses farm. Photo: Marc Gràcia.

3) Interventions that block the functioning of soil biological processes

Unlike conventional agriculture, in regenerative agriculture **there are no interventions that block the biological processes of the soil**: the land is not tilled, the soil is not compacted, insecticides or herbicides are not used and chemical fertilisers are not added. The way the regenerative model works allows these interventions to be compensated with the use of the resources of the area and the enhancement of the functioning of natural processes.

However, **regenerative agriculture also uses machinery**. A tractor is used for different activities on the crops; in extensive vegetable production (and also in pasture cropping) **direct sowing is used to protect the seed and increase production**; and if the harvest is large it is also done with a combine harvester. In all these cases, it must be borne in mind that this machinery can cause soil compaction and therefore an alteration of the soil structure. This risk of compaction is reduced by u**sing machinery that is not too heavy** (**Figure 2**) and avoiding intervening when conditions are not suitable, for example, when the ground is very wet, in order to achieve the least possible impact.

4) Soil functioning and the carbon cycle

Soil function and the carbon cycle **depend on the global balance of stocks**: when products obtained from the system's crops are extracted, it causes a global loss of carbon stocks. When this **export is small**, **the system can recover naturally**. With the return of green remains and straw from both crops and adventitious plants, and considering the high diversity of plants, in most cases the system allows the production of grain or fruits without the need for external inputs.

However, if **a lot of carbon is removed from the system, mechanisms must be found to return it**. This often happens in gardens, which have a high production and from which a large quantity of products is extracted. In this case, the outputs affect the total stock and the biological activity of the soil and cause a **progressive impoverishment of the system**. Therefore, in the garden it is necessary to add BRF or compost, which are external to the garden and have high amounts of organic matter and nutrients, to restore balance to the system (**Figure 3**).

5) Water as a limiting factor for system productivity

The basis of the regenerative model is to **increase the amount of organic matter** and, with it, substantially **increases the water holding capacity** of the soil. Despite this, at certain times of the year, such as summer in the Mediterranean, water can become limiting for crops. For this reason, in the regenerative model, **weeds are cut before the summer** to reduce water consumption for crops. In any case, if there is water available for irrigation, it greatly improves the potential of the site for crops, since in any land-based system, the more water, the more production. In the case of the garden, this need for irrigation is especially relevant and, in fact, for many garden crops it is necessary to have irrigation water to achieve acceptable productions.