Combining crops in terms of time and space for greater production and the biological activity of the system

The increase in plant biodiversity leads to an increase in production and biological activity in production systems. One of the bases to achieve maximum crop production is to **combine the elements of the system in space and time**. Among the production models that are based on combining crops over time, we highlight the Fukuoka method, the legume rotation method and pasture cropping. Of those that are based on **combining crops in space**, agroforestry and intensive farming systems without tillage should be highlighted.

Biodiversity is a key aspect of how ecosystems function and are maintained. An increase in plant biodiversity **leads to an increase in the production of the system and its biological activity**. Biodiversity is associated with greater complexity in the production system, which is the basis for mitigating environmental fluctuations, less vulnerability to diseases and pests, preventing soil erosion and stable system performance. **Combining the main elements of the system** (trees, pasture plants, extensive crops, garden crops, fruit trees and even animals) in terms of **time and space** is one of the bases to achieve maximum crop production.

Combining crops over time

There are different production models that are based on combining crops over time. Among them we highlight the following:

• **Fukuoka method.** In this type of agriculture, a set of techniques described by **Masanobu Fukuoka**, a Japanese biologist, farmer and philosopher, are carried out which tend to reproduce natural conditions as closely as possible. The basis of the Fukuoka method is **crop rotation**, which means waiting for the **right moment to carry out the different actions** to the crop and the soil. If the natural cycles and physiology of plants are respected, their development is enhanced. In a rice crop, in early autumn Fukuoka sows seeds of white clover, which is a legume that enriches the soil with nitrogen. Then he sows rye and barley seeds among the rice. When the time comes, he harvests the rice, mows it, threshes it, and returns straw to the field. Then the white clover has already grown and allows a reduction of adventitious plants and fixes nitrogen in the soil. At that point, the rye and barley grow between the clover and the straw. Just before harvesting, the rice is replanted and the cycle starts again. In this way, **other winter cereals, together with rice, can be grown in the same field for many years, without reducing the fertility of the soil.**

• **Legume alternation method**. The method proposed by Luis Carlos Pinheiro, a Brazilian agronomist, is also based on crop **rotation over time**. In his case, he proposes alternating a legume species one year and a non-legume species (cereal or oilseed) in the second year, in order to maintain nitrogen fertilisation every two years. Rotation allows the environment to not always be the same and this **reduces the presence of pests and adventitious plants**. In the first few years it is important to sow the legume in a high density and not to harvest it so it can be used as green manure for the system. Legumes can be combined with some rye, which eliminates adventitious plants and favours soil. In successive years, **legumes and non-legumes alternate**, and soil fertility and crops progressively improve.

• **Pasture cropping**. This method is an agricultural practice originally developed in New South Wales (Australia). It involves **sowing winter cereals directly onto perennial pastures that are active in summer**, allowing cattle to graze until sowing time**. The growing periods of cereal crops and pastures are separated** (**Figure 1**): winter crops grow from November to May and warm season grasses grow from March to November. After the cereal harvest, the field is ready for grazing again as soon as the summer grasses respond to the removal of the cover. **The procedure to sow the cereal on the grass in this system requires a series of steps**: (i) before sowing, high intensity grazing is used to reduce the biomass of the grass and suppress the adventitious plants; (**ii**) the sowing method seeks to minimise damage to the pasture while achieving good soil-seed contact; (**iii**) finally, the spacing between cereal rows cannot be excessively wide (since the crop yield is reduced) or excessively close (since it causes too much damage to the pasture). This system has a positive environmental impact because it improves erosion management and the salinity of drylands, an increase in organic carbon and soil cover and the promotion of agrobiodiversity, including native species, although it results in a lower total soil water content.

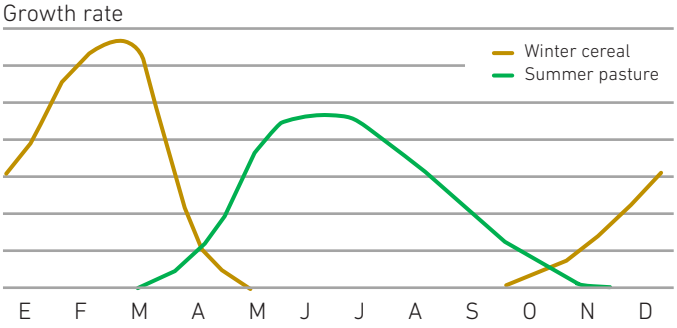

Figure 1. Growth of the winter cereal crop and the summer grass throughout the year in the pasture cropping method.

Figure 2. Agroforestry system where trees are combined with herbaceous crops. Photo: National Agroforestry Center, CC-BY.

Figure 3. Detail of an orchard without tillage with the simultaneous presence of cabbages and wild plants. Photo: MJ Broncano.

Combining crops in space

There are also various models that allow crops to be combined in space, thereby increasing biodiversity and the advantages it has in the production of the system.

• **Agroforestry.** Agroforestry is a farming system that **combines trees and agriculture (crops or livestock) on the same land** (**Figure 2**). These different elements complement each other. This leads to greater resilience, greater biodiversity and more productive use, compared to a monoculture system. The joint result is very positive because the system allows the production of vegetables, grains, fodder and other raw materials from crops, together with wood and fruit from trees. **This multiplicity of products** allows farmers to access different markets, ensuring a sustainable yield. Among others, **the benefits of combining** trees and crops are: (**i**) the trees serve to fix the soils, and their remains (dead leaves, branches, bark) to fertilise them naturally; (**ii**) the association of agricultural and forest species makes the system more resistant to attacks by pests and diseases; (**iii**) nitrogen-fixing trees and crops can increase the amount of nitrogen available to the entire system; (**iv**) trees can provide protection for crops and shade and shelter for livestock.

• **Intensive crops without tillage.** These systems show a **high biological variety** because diverse crops and diverse wild plants grow in them simultaneously (**Figure 3**). This plant heterogeneity by itself constitutes a form of **preventive protection**, for the following reasons, among others: first, it generates a **great availability of small habitats** and a multiplicity of food sources, which makes it possible to maintain **permanent populations of predators and parasites of pests**; on the other hand, the variety of species allows **continuous production of organic matter** that helps to improve the structure of the soil and maintain cover for most of the year, which controls erosion.

Why is high plant diversity better in agricultural systems?

The **high diversity of plants** in **regenerative agricultural** systems, as opposed to the homogenisation and simplification of intensive agroecosystems, has **several excellent advantages**:

• **Greater differentiation of habitats.** The high diversity of plants usually entails a greater differentiation of habitats and diverse microclimates. Specifically, the shelter that trees provide when combined with other plants **improves the yield of nearby crops and livestock**.

• **Soil erosion control.** The almost continuous presence of a high diversity of plants makes it possible to **control runoff and soil erosion** by means of plant cover.

• **Combination with legumes.** The presence of nitrogen-fixing trees and plants can substantially **increase the nitrogen supply** to the soil and, therefore, improve the fertility of agroecosystems as a whole.

• **Better use of resources.** Greater plant diversity allows **light and nutrients to be used more efficiently** than systems with one or few crops. Plants of different heights, leaf shapes and root depths contribute to this better use of resources.

• **Pest and disease control.** Systems with lots of crops are **less vulnerable to diseases and pests** than monocultures because given that there are lots of plants, flowers are guaranteed for the maximum period possible, and sources of food and shelter are assured for beneficial or predatory species.

• **Resistance to climate change.** Agroecosystems with high species diversity have been shown to have a greater resistance to climate change than single crop species that predominate in conventional agricultural industry.

• **Conservation of the biodiversity of the environment**. Farms with a high crop diversity provide safer and more **stable habitats for the natural biodiversity** of the areas where they are located.

• **Fewer risks for the farmer.** These multi-crop systems provide **a more diverse and stable agricultural economy**. Economic risks are reduced when systems produce multiple products.