Redesigning european cropping systems by developing Intercropping

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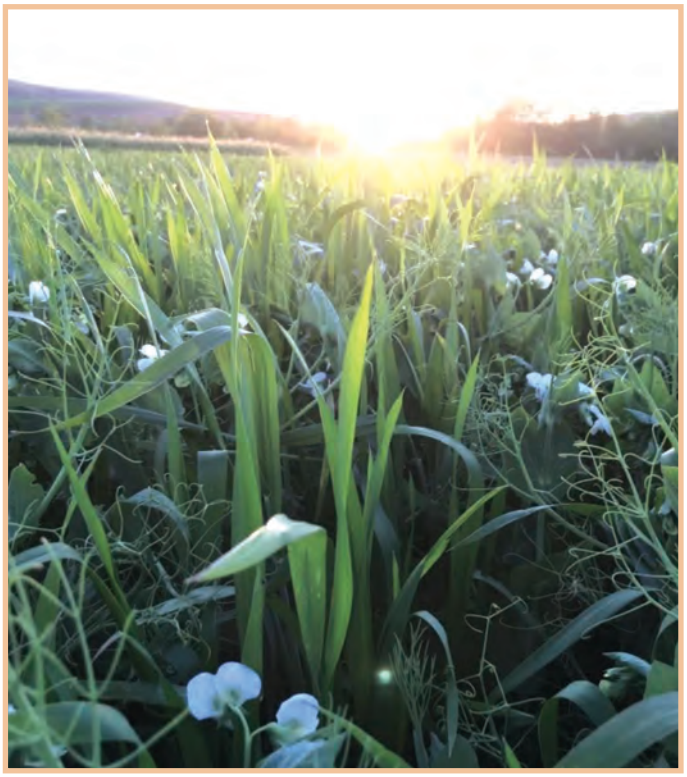
REDESIGNING EUROPEAN **CROPPING SYSTEMS** by developing Intercropping

ReMIX
Species mixtures for redesigning European cropping systems

The EU is undergoing a fundamental change in the aims for its agriculture and food systems, with a significant emphasis on meeting sustainable goals and reducing reliance on imports from outside Europe. The Horizon 2020 ReMIX research project (N. 727217) collaborated with farmers and additional stakeholders such as agricultural advisors to analyse and optimize the performance of intercropping based on species mixtures, mainly cereals associated with grain legumes, to design productive, diversified, resilient and environmentally friendly cropping systems that are less dependent on external inputs, or more productive in organic farming.



Intercrops pea wheat flower. ***Photo by Johannes Timaeus***

Species mixtures, also known as intercrops, can enhance and improve the control of pests, diseases and weeds, while increasing crop productivity and robustness to biotic and abiotic stresses, including those exacerbated by climate change. In addition, intercrops can reduce the use of fossil energy and chemical inputs and enhance production of ecosystem services.

Although it is still a minor practice, areas cultivated with cereal-legumes mixtures have steadily increased in the last 10 years, particularly in organic farming where intercrops can increase yield and product quality, in particular increase protein content of cereals, satisfy the increasing consumer demand for organic products and contribute to the global transition towards sustainable cropping systems.

Three examples of intercrops: sunflower: sunflower-soybean (left), wheat-pea (middle), soybean sown in relay in a barley (right)

Within the ReMIX project, several knowledge syntheses, new experimental studies, and modelling work have been carried out to determine the effect of plant characteristics, cropping practices and the environment on the performance of intercrops compared to pure/sole crops.

Eleven multi-stakeholder platforms were set up in ten European countries to identify promising intercrops that are acceptable to the stakeholders concerned, thus guaranteeing the development of solutions adapted to local socio-economic contexts. ReMIX showed that intercropping is a promising solution to overcome many of the limitations and can work well in both organic and conventional arable cropping.

Intercropping can reduce the use and dependance of chemical inputs

Weeds, pathogens and insect pests all need to be taken care of simultaneously by farmers. Herbicides, fungicides, and insecticides each only aim at one of the three constraints and often are only specific to a certain class of weeds, pathogens and insects. This results in the need for multiple pesticide applications. ReMIX provided strong support for the effectiveness of intercropping for weed, disease and insect pest control in both low and high input agriculture.

Results showed that intercrops where one crop was added to the other rather than replacing it had stronger weed suppression than intercrops replacing each other, in particular for grain legume crops.

Weed control by pea and wheat grown as sole crops and in mixture. ***Photo by N. Moutier***

In organic farming, weed, pest and insect control cannot be based on synthetic molecules. Therefore, organic farmers need to make the best use of naturally available biological regulation. Intercropping makes more efficient use of natural resources and covers the soil more effectively than sole crops. As a result, there is limited water, nutrients or light available to weeds.

Furthermore, by increasing the cultivated biodiversity at landscape, farm and field levels, intercrops support biological control of pests and diseases. For example, one crop can prevent the pest from reaching the sensitive crop via a "barrier effect" or "dilution effect". While in other cases, a partner crop may have attractant or repelling properties that keep a certain pest away from the sensitive crop.

Finally, intercropping of cereals and legumes allows improved production of legumes that are very sensitive to pests and diseases and that usually produce low and unstable yields in organic farming: it is a promising way to produce larger types of species and increase the production of grain legumes in Europe.

Harvest of a wheat-lupin mixture in Denmark with a Laverda M410 combine harvester from AGCO Group. ***Photo by Hans Henrik Pedersen***

Intercropping makes efficient use of resources and improves protein autonomy of the farm

Nitrogen is one of the main limiting factors in organic farming, particularly in systems without livestock. Stockless organic farmers are faced with the challenge of maintaining soil fertility while keeping inputs of external nutrients to the minimum. When wheat is intercropped with a legume, the seeding densities of both species are generally halved. In this system, the legume fixes atmospheric nitrogen and it does not compete with the wheat for soil nitrogen.

Each wheat plant has a higher quantity of nitrogen available than in a sole crop, which leads to improved nitrogen nutrition status and yield stability. Also, the additional nitrogen available allows increased protein content of the wheat/cereal grains, making them suitable for baking. So, intercropping of cereals and legumes enhances the productivity of the farm and improves nitrogen autonomy and income.

Solutions for harvest and separation of intercrops

Intercrops of grain legumes and cereals can be successfully managed with standard farm machinery for sowing and application of inputs. If species and varieties with equal maturity times are chosen, they can be harvested with classical combine harvesters. However, the difficulty in harvesting and separating the products is still one of the main obstacles in intercropping. Because it is not usually possible to sell the harvest as a grain mixture for human consumption, farmers often have difficulties in finding a trader that accepts their grain mixture of legumes and cereals. In the case of minor or new crops, there may simply not be a supply chain in the region. If the crop cannot be valorized directly on the farm or in local supply chains, it is often difficult to find a buyer who will want to bother with small quantities. ReMIX has tested harvesting settings using an AGCO classical combine harvester to evaluate the efficacy for various species mixtures on-farm. Results show that with the right settings of the combine harvester, even with a delay of a few days in the grain maturity of the intercrop, the losses as well as amounts of impurities and broken grains can be limited and the gross product improved.

Saving worktime while increasing and stabilising yields for organic

While organic farming protects the environment and biodiversity, yields are always largely lower when compared to conventional farming, affected by weather conditions and pest/disease pressure. Organic farmers spend more time on monitoring weeds, diseases and pests than farmers in conventional farming. Weeding must be done mechanically and may need to be repeated several times during the growing season. As a result, working time and fuel consumption can be higher than in conventional agriculture. With intercropping, mechanical weeding is either not necessary or only occasionally needed very early in the growing season. Furthermore, no (or very limited amounts) of external nitrogen or plant protection products are needed to obtain correct yields and gross products. So besides sowing and harvesting, no cultivation operations are needed.

Growing intercrops can increase yields and yield stability in organic farming because the cumulative yield of crops in intercrop is higher than the average yield of the two sole crops. Intercrops allow compensation between crops to occur, low yields in unfavourable environmental conditions or strong pests and diseases attacks to be avoided and/or limits the risk of no harvest.

The Toolbox on Agricultural Diversification

Practical information has been gathered and made available from ReMIX and from past and present projects. The Toolbox on Agricultural Diversification is an interactive user-fed knowledge source of regionally relevant information about complementary means to diversify agricultural systems. Among the information accessible on the toolbox, the project produced:

- Workshops and trainings
- 2 conferences and a virtual training school
- 29 practical sheets
- 52 technical sheets based on farmers' experiences
- 5 policy briefs
- A tool for the evaluation of ecosystem services: Ecosystemix
- A serious game: Interplay

Wider adoption of intercrops to support the transition towards more sustainable cropping systems

The European Union pictures Europe as the first climate-neutral continent by 2050. It supports the global transition towards sustainable cropping systems that have a positive environmental impact, reverse the loss of biodiversity, produces sufficient, safe, nutritious and sustainable products whilst ensuring fair economic returns for farmers.

Over the past 4 years, using a multi-stakeholder approach, ReMIX has initiated close collaborations with stakeholders in the sectors. Bringing in unique ideas, perspectives and opinions, this dynamic approach has stimulated innovation activities that have led to the design of locally relevant species mixtures and should allow for further development of intercrops beyond the project.

However, it will still take time for a wider adoption of intercropping in European agricultural systems as most stakeholders are still used to pure crops. Thus, to develop intercrops in Europe, institutional and regulatory changes are needed, with the possible introduction of innovation arenas with more direct interactions between the actors of the value chain. This will allow the development of new products and processes to add value and improve the range of products available to consumers.

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