LIFE AGRESTIC

Reduction of Agricultural GReenhouse gases EmiSsions Through Innovative Cropping systems

Il progetto LIFE AGRESTIC ha ricevuto finanziamenti dal Programma LIFE dell'Unione Europea

LAYMAN'S REPORT

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Summary

Introduction

Reduction of Agricultural GReenhouse gases EmiSsions Through Innovative Cropping systems

All sectors need to contribute to achieve the goals of reducing Green House Gases (GHGs) emissions. The most relevant GHG emitted from arable soils are N_2O and CO_2. N_2O emissions reduction can be achieved improving the nitrogen use efficiency in cropping systems, enhancing the exploitation of different N sources. CO_2 emissions can be mitigated from agriculture supporting practices able to increase the C storage in plant biomass and soil and to limit organic matter oxidation.

LIFE AGRESTIC aimed at fostering the adoption by EU farmers of innovative and efficient cropping systems with a high climate-change mitigation potential, and at spreading innovative views and tools for climate ready and resource efficient agriculture.

In particular, LIFE AGRESTIC designed innovative legume-based cropping systems managed through a Decision Support System (DSS) aiming to:

- increase N use efficiency in crop rotations exploiting biological N_2 fixation of legumes;
- enhance carbon storage in soil, promoting the cultivation of crops with high amount of residues and a developed root system (i.e. legumes) in the cropping systems.

Moreover, the techniques demonstrated in LIFE AGRESTIC can lead to other environmental benefits:

- reducing N losses from the agroecosystem, by introducing N-fixing crops in the rotation and applying a more efficient N management thanks to the use of the DSS;
- encouraging the soil coverage with the introduction of cover crops, thus preventing soil erosion;
- increase yield stability by the management through the DSS;
- improve soil structure, fertility and health, thus supporting soil functions as part of the wider ecosystem.

Catch crop (alfalfa) was intercropped in wheat, in order to advance the establishment and avoid period of bare soil.

Alfalfa catch crop developed after wheat harvest.

The LIFE AGRESTIC project: objectives and expected results

LIFE AGRESTIC had the specific objectives of:

1) Reduce agricultural Green House Gases (GHG) emissions and increase soil carbon sequestration by designing and implementing on three demonstration sites N- and C-Efficient Cropping Systems (ECSs) with higher potential of carbon storage and nitrogen efficiency and lower GHG emission rates compared to Conventional Cropping Systems (CCSs);

2) Develop, test and implement an innovative web-based Decision Support System (DSS) for supporting farmers in a resource-efficient management of ECSs, aiming at reducing GHG emissions and production costs, while maintaining or increasing yield, product quality and safety, and farmer's economic return;

3) Develop and use a prototype for automated and continuous monitoring of soil GHG fluxes, in order to measure the potential of ECSs in reducing soil emissions compared with CCSs, calibrate and validate a model for estimation of soil GHG emissions, and implement the model into a DSS;

4) Valorise GHG emissions and carbon storage mitigation potential of ECSs through market based and/or policy-based measures, and support national and local policies through the analyses of ECS-based simulation scenarios and providing dataset for more accurate Life-Cycle Assessment (LCA) analyses;

5) Involve national and EU stakeholders to ensure their real needs are met and proposed innovation is feasible and effective; increase the innovation acceptance rate and the future exploitation of the project results; create local agreements and regional collaborations about soil and ecosystem services; and, ensure replicability and transferability across EU.

Main project activities

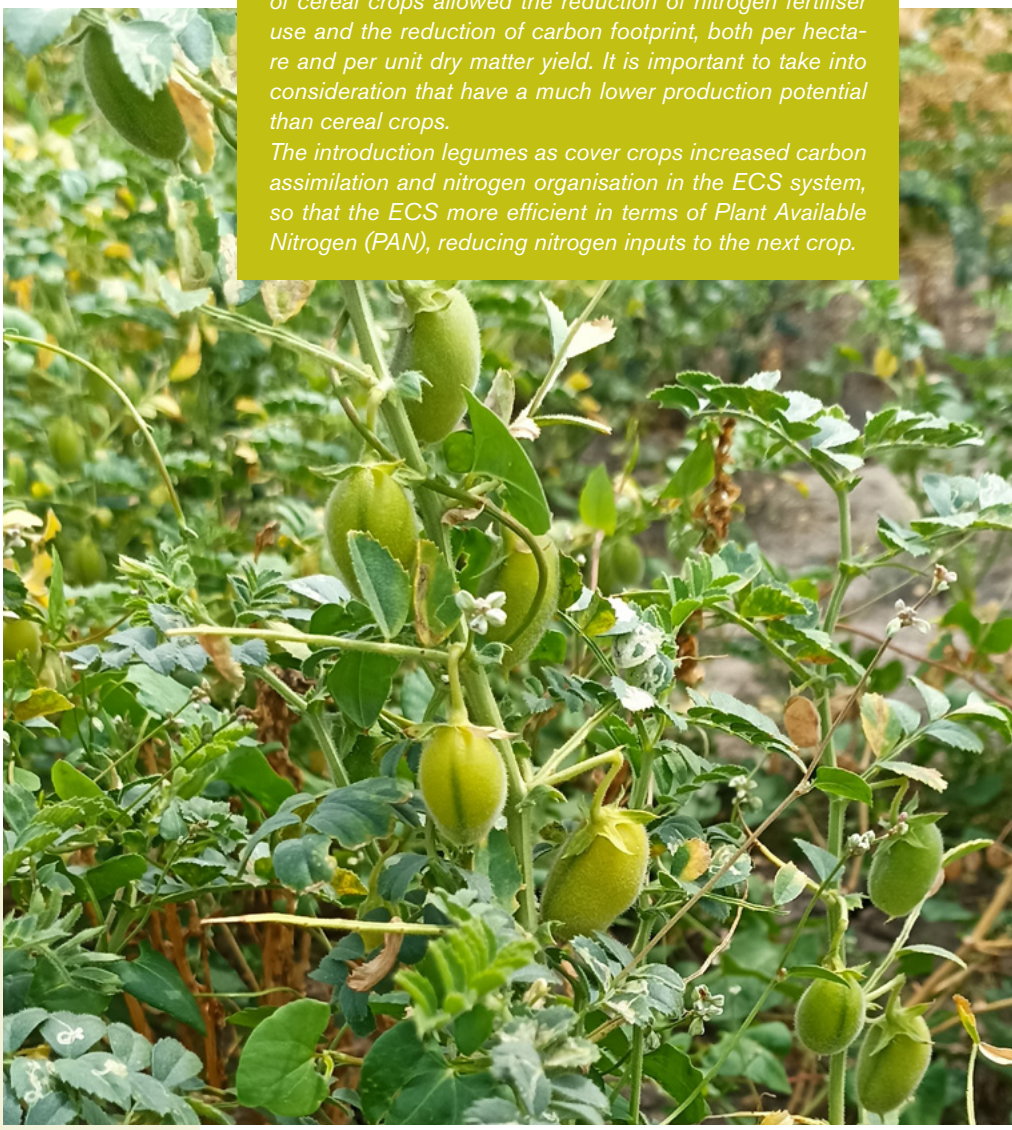
Efficient Cropping Systems tested in three demonstration sites

Innovative N- and C- efficient cropping systems were tested in 3 demonstration sites located in Emilia-Romagna, Tuscany and Apulia, representative of some main climate areas of Europe respectively of nearly continental climate, transitional/intermediate climat and mediterranean climate. ECSs are introducing leguminous crops in rotation, both as main and catch crops, and are managed with the use of DSSs, helping in the optimization of the crop management and the use of technical inputs, leading to a decrease in the environmental impact of the cultivation. The ECS were compared with Conventional Cropping Systems (CCS), cropped in the same locations, in terms of GHG emissions, carbon sequestration and sustainability (economic, environmental and social). The selected demonstration sites were equipped with the prototype soil GHG monitoring station, the weather stations and sensors to monitor weather, as well as porous capsules to catch the excess of water.

Improvements in ECS

In the ECS, the inclusion of the grain legume crops instead of cereal crops allowed the reduction of nitrogen fertiliser use and the reduction of carbon footprint, both per hectare and per unit dry matter yield. It is important to take into consideration that have a much lower production potential than cereal crops.

The introduction legumes as cover crops increased carbon assimilation and nitrogen organisation in the ECS system, so that the ECS more efficient in terms of Plant Available Nitrogen (PAN), reducing nitrogen inputs to the next crop.



Chickpea was introduced in the ECS in the Pisa demonstration site. In Ravenna pea was used, while in Foggia lentil was the selected grain legume.

PROJECT LOCATION

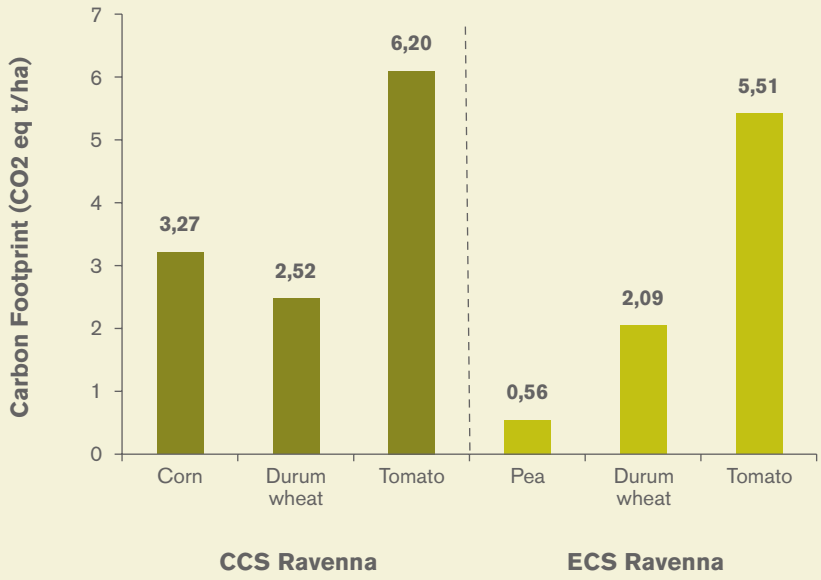
DEMONSTRATION SITES

Ravenna
Pisa
Foggia

Average results of three years 2019/2020, 2020/2021, 2021/2022
RAVENNA (Az. Agr. Cà Bosco)

Effects of improved cropping systems on Carbon Footprint per hectare, considering the cropped species.

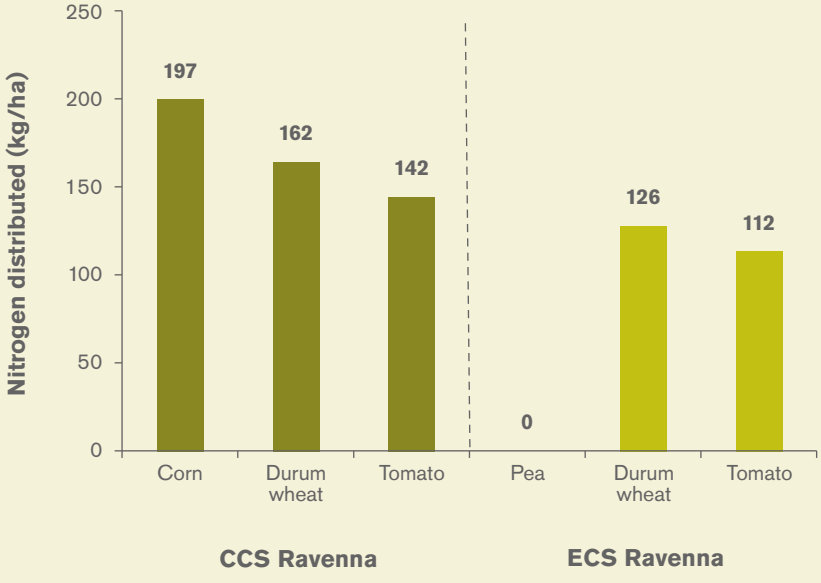
Carbon Footprint includes all the emissions generated from the production.



Average results of three years 2019/2020, 2020/2021, 2021/2022
RAVENNA (Az. Agr. Cà Bosco)

Effects of improved cropping systems on Nitrogen quantity applied per hectare, considering the cropped species.

The values include all the nitrogen forms applied.



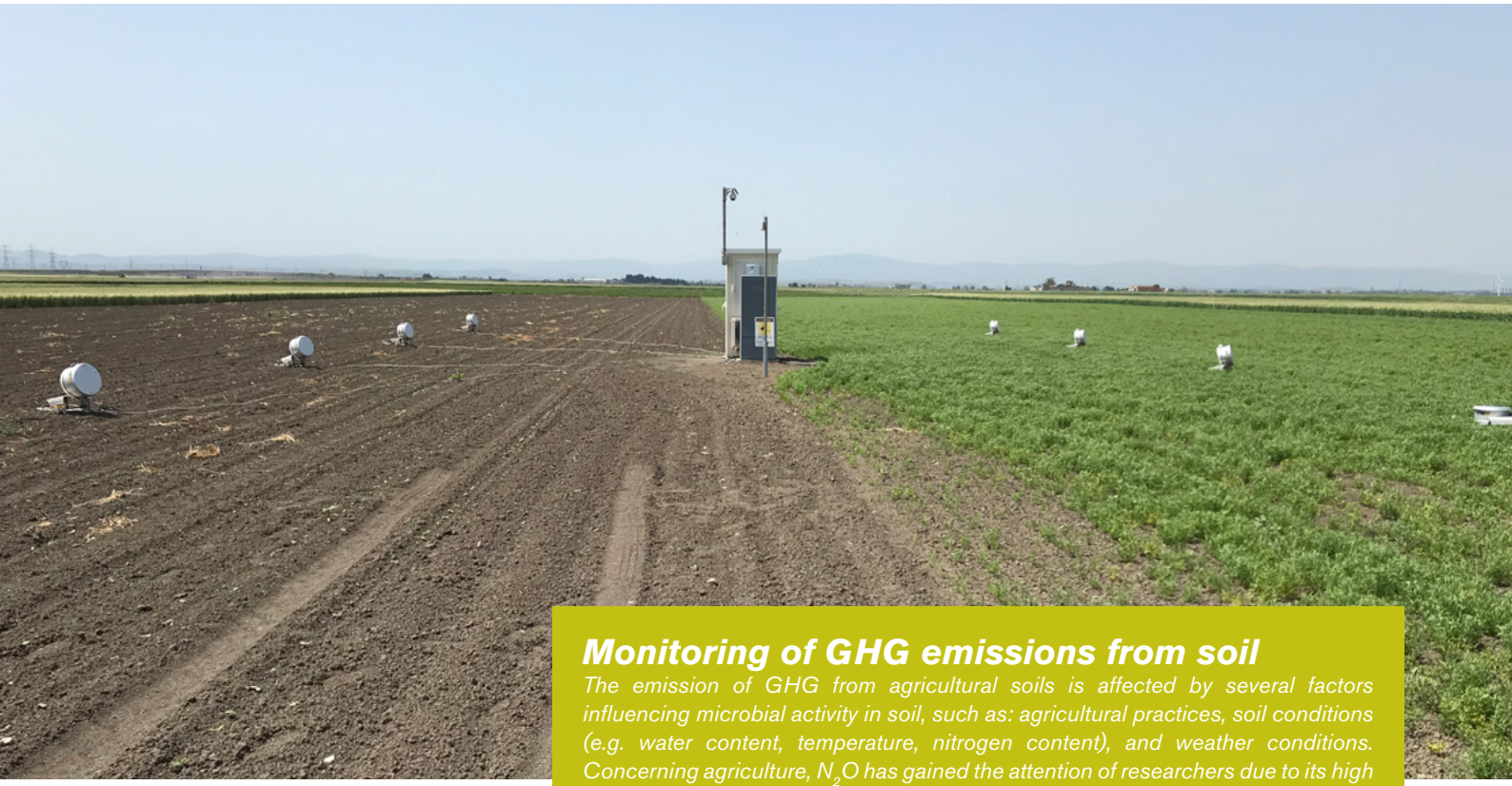
Selection of legume and catch crop varieties for their suitability to use in N- and C-Efficient Cropping Systems

LIFE AGRESTIC collected local and rare genotypes of legumes and catch crops which were selected to identify the most suitable to be used in ECSs and to make them available to farmers.
Field network for phenotyping of legumes, catch crops and the seed multiplication activities were carried out for three cropping seasons, the most suitable varieties for ECS have been identified and seed multiplication activities were performed.
For both grain legume and catch crops, the key traits considered in the selection were those impacting on agronomical and environmental performances of the varieties, such as yield and quality of the legume production biomass production; growth of the root system under normal and drought conditions; competitiveness against weeds; climate resilience and suitability of varieties in different climate zones; resistance to cold conditions.

Progresses on genotype selection

Some of the tested grain legumes genotypes started the process for inscription in the National Variety Register: one line for pea, three lines for chickpea and two lines for lentil. One genotypes of alfafa, tested among the catch crops, showed an interesing biomass production. Other species were selected to be tested and the best were: a mixture of Sinapis arvensis and Brassica juncea, Sinapis alba, Raphanus sativus var. oleifera.

A catch crop mixture was sown in the Foggia demonstration site.



Monitoring of GHG emissions from soil

The emission of GHG from agricultural soils is affected by several factors influencing microbial activity in soil, such as: agricultural practices, soil conditions (e.g. water content, temperature, nitrogen content), and weather conditions. Concerning agriculture, N_2O has gained the attention of researchers due to its high global warming potential and because agricultural soils are its main anthropogenic sources. The design of efficient cropping systems in which the nitrogen (N) use is optimized, is the main strategy for N_2O mitigation. Furthermore, the inclusion of legumes into crop rotations may be a valuable strategy to reduce the use of external N supply, since it allows the exploitation of biological N2-fixation. The estimation of cumulative GHG emissions allowed to evaluate the impact in terms of GHG emissions of the two cropping systems in the two sites and the decision support systems (DSS) may help farmers in the management of N fertilization (i.e. suggesting the dose of the N fertilizers and the most suited period for their application).

Development of a prototype for a real time GHG monitoring system

The project has developed a prototype system for continuously monitor GHG emissions from agricultural soils, which was used to measure GHG emissions in the ECSs and CCSs, for the comparison of the two rotations over a long period.

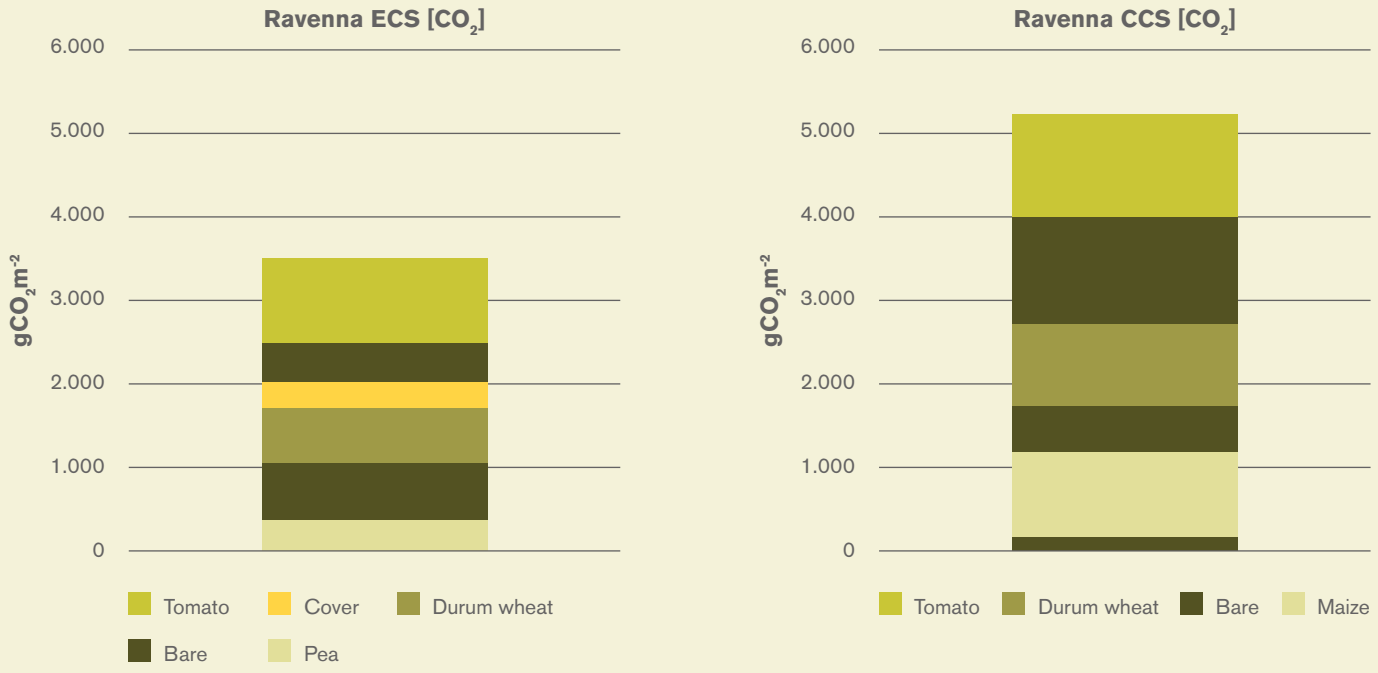
The prototype is constituted by two GHG monitoring stations, installed one in each pilot farm, and by an IT infrastructure for data management. Each GHG station is composed by a shelter, protecting the analysers, and eight automatic chambers which record and comunicate with the analysers. Each record containing the calculated CO_2 and N_2O fluxes, the soil temperature and water content.

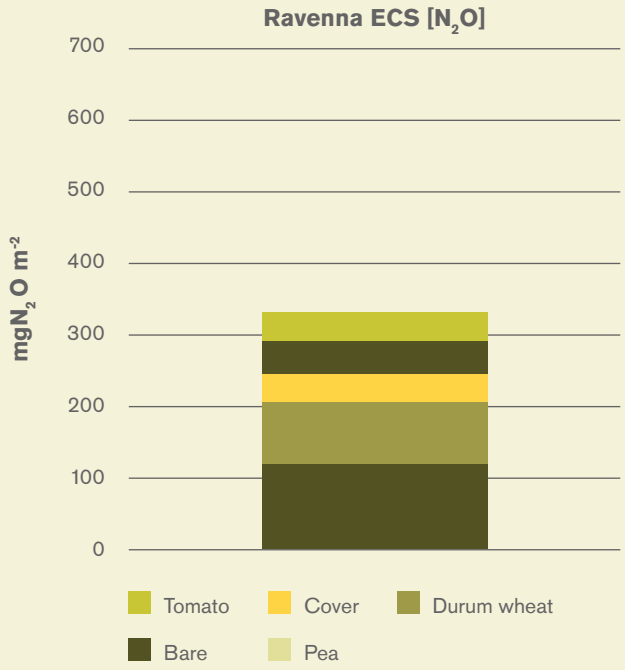
Data collected allowed to calibrate and validate a model estimating GHG emissions from agricultural soil at field scale, which was introduced into the DSS and up-scaled to provide estimates for different scenarios and several areas in the EU.

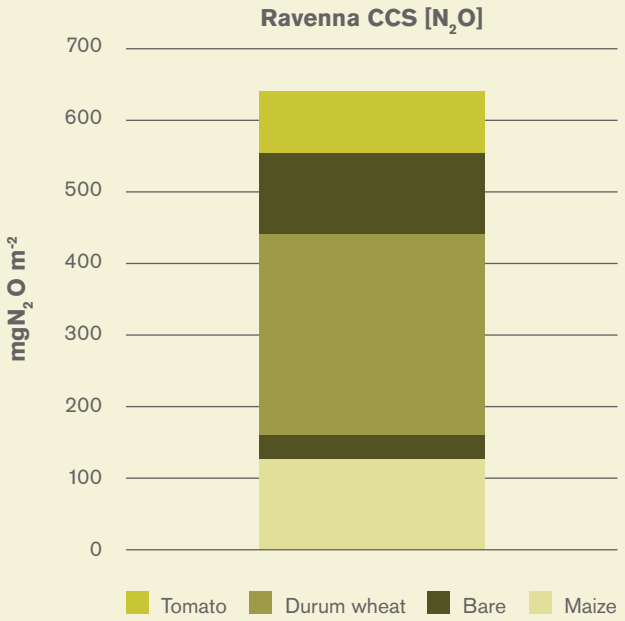
The prototype installed in the demonstration site (above) and detail of one of the chamber. The chanbers close at fixed intervals to do the measurements of GHG fluxes from soil.

Cumulated results of three years 2019/2020, 2020/2021, 2021/2022
RAVENNA (AZ. AGR. CÀ BOSCO)

Emissions of CO_2 and N_2O measured from the prototype installed in demonstration site.







Development of a new DSS for GHG emission reduction

Crop-specific GHG-focused DSSs and catch crops DSS have been integrated in a unique DSS platform for the optimized management of the legume-based ECSs. The integrated DSS support decision-making by farmers in the sustainable management of crop, increasing yield, product quality and on optimizing external inputs, and provides support to farmers on reducing GHG emission and increasing carbon storage in soils.

This new DSS come from the customization of traditional crop-specific DSSs for small-grain cereals, legumes, tomato and sunflower.

Improvements for the DSS include:

- a tool for soil management options able to reduce GHG emission and increase carbon storage;
- a tool for the managing of sowing and early growth enhancement to cover the soil as earliest as possible;
- a tool to support farmers in chosing catch crops;
- new models for specific crop diseases;
- a model which allows the user to quantify the GHG emissions related to the crop management, as well as the storage of carbon in soil.

Improved Decision Support Systems

The cropping system DSS was developed allowing the user to manage the crop rotation and to carry out an optimised management of the ECSs. The DSS was designed to be a tool used to manage the whole farm allowing the user to map the farm plots, which can be kept constant in the years, keeping track of the history of the plot during the rotation; including the crop operation registered in a digital field book, in a uniform way in the several crops.

The use of DSS actually in the demonstration sites made it possible to reduce:

- *fuel consumption;*
- *nitrogen fertilisers;*
- *the number of phytosanitary treatments;*
- *irrigation;*
- *sowing density;*
- *carbon footprint;*
- *cultivation costs.*

Sowing of crop in the demonstration site.

Valorization of GHG emission reduction through product labeling and Payments of ecosystem services

LIFE AGRESTIC wants to valorise climate and environmental performances reached by farmers and agro-food producers through the adoption of the project innovation. Externalities (both environmental and economic) were quantified in terms of carbon footprints (CFs) and ecosystem services (ESs) in order to develop a product label aiming at supporting new positive behaviours in land and soil management in agricultural sector.

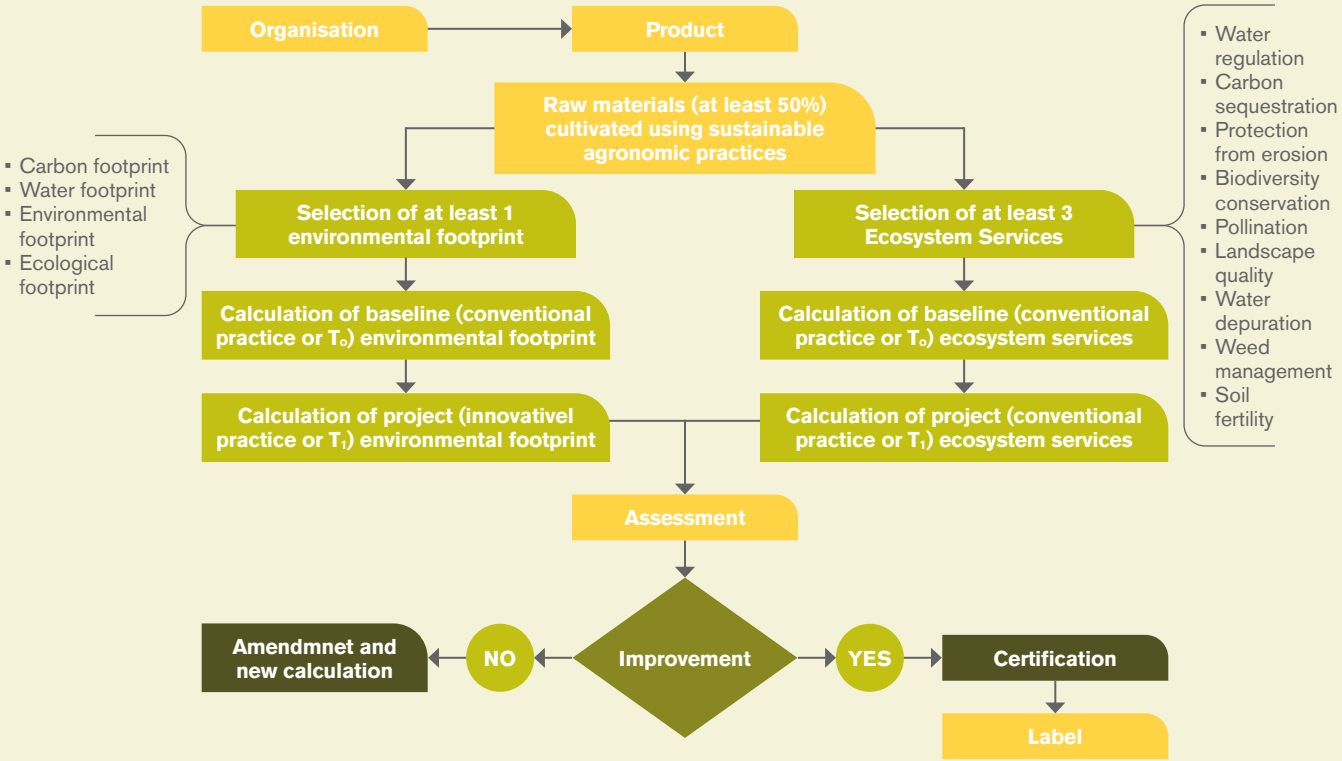
Moreover, the LIFE AGRESTIC practices could contribute to the achievement of the objectives of several European policies such as:

- Climate Strategy for 2050;
- New climate change adaptation strategy;
- Biodiversity strategy to 2030;
- Farm to fork strategy;
- Common Agricultural Policy 2023-2027.

Ecosystem Services

Ecosystem Services (such as pest management, pollination, carbon sequestration) of crop rotations and Payments for Ecosystem Services (PES) were elaborated to encourage the diffusion of ECSs. The principle is to pay the provider of the ES, so he can reinvest the income in activities that support the ecosystem service. Finally, a quality label, based on the assessment of environmental performances resulting from the application of sustainable agricultural practices was created. Environmental performances are expressed in terms of both 1) environmental footprints and 2) Ecosystem Services, which are applicable only to the agricultural phase, so the commodity production in field. The certification can be obtained by the product if: 1) at least 50% of the raw material was produced by sustainable agricultural techniques; 2) if at least one environmental footprint and three ecosystem services were improved thanks to the application of sustainable agricultural practices.

LIFE AGRESTIC quality product label

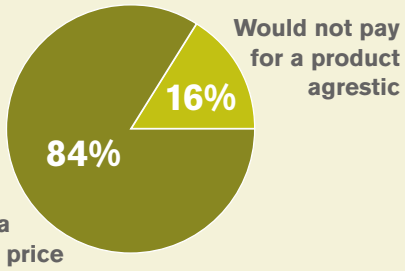


Replicability and transferability of the ECS in other food chains and countries

In order to establish a collaboration to transfer the developed ECS, a selection of four EU countries with the highest transferability potential was carried out. The selection was based on their similarity with the Italian project environment in terms of climate, agricultural practices (intensive agriculture, particularly for the growing of impoverishing crops) and production (cereals, dry pulses and proteins crops, oilseeds, leguminous plants harvested green, green maize and fresh pulses). As a result, the four countries for replicability and transferability were identified in: France, Greece, Hungary, Romania.

A market potential for the quality label analysis was carried out and the results are:

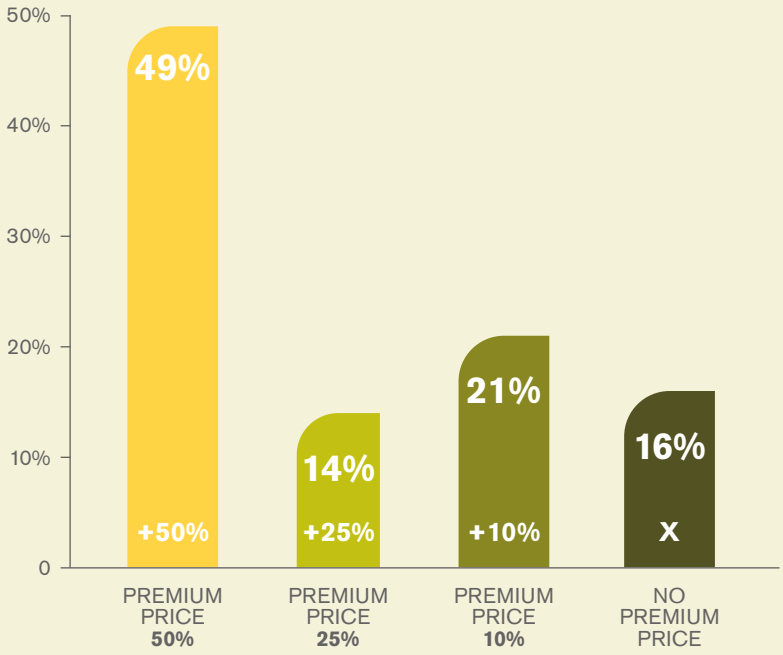
CONSUMER'S WILLINGNESS TO PAY



Would not pay for a product agrestic

Will pay a premium price for a product agrestic

30,4%
Average premium price for a product agrestic



FOOD INDUSTRY'S OPINION

Risk in purchasing agricultural products

1° Increase in the price of agricultural products

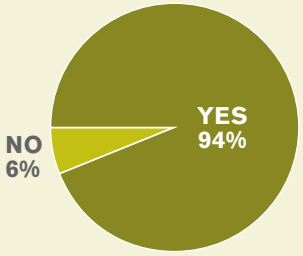
2° Environmental sustainability of agricultural products

3° Low quality of agricultural products

4° Lack of agricultural products

5° Lack of water

Would you give priority to suppliers who have adopted DSS?



FARMERS' OPINION

Most important issues for farmers

1 IMPROVING PRODUCT QUALITY

2 REDUCING PRODUCTION COSTS

3 REDUCING ENVIRONMENTAL IMPACTS

Perceived utility of DSS

1° Optimisation of weed control

2° Optimisation of water use

3° Selection of the most suitable crop varieties

4° Optimisation of pesticide use

5° Optimisation of fertiliser use

6° Planning crop rotation

Training course at University in Hungary.

Participation and dissemination activities

- Communication tools for the project activities and results were developed in order to target scientific, technical and general public:
  - the project website (**www.agrestic.eu**) contains all the information about the project;
  - social accounts (Facebook, X, Youtube, LinkedIn) with more than 31K users and 58K page views;
  - newsletters;
  - digital magazine;
  - technical and scientific articles published in Terra è Vita (**terraevita.edagricole.it**);
  - videos explaining the project;
  - posters, leaflets and gadgets.
- Stakeholders representing farmers, farmers associations, agri-food industries, authorities were involved in specific co-development meetings, and in the field visits of demonstration sites
- Field visits organized in each of the demonstration sites in order to see different cropping systems managed trhough the Decision Support Systems and the prototype GHG monitoring stations.
- Training course for stakeholders was organized in order to present them the innovation of the project, so they can appreciate the advantages of the proposed techniques and receive an appropriate training (in particular on the use of Decisions Support Systems) for their proper implementation.
- Seminars and training course were organized in different European Universities (Greece, France, Hungary, Romania), involving students, farmers, producers organisations and food industries, in order to present the project, to illustrate the Decision Support System and to present the Agrestic product label.

In the future

The innovative solutions demonstrated by the LIFE AGRESTIC project led to the reduction of the cropping systems environmental impact and contributed to climate change mitigation by agricultural activities. The innovative ECS and management options tested in the project proved to be efficient in decreasing GHG emission from agricultural soil, improve the utilisation of nitrogen and enhance carbon sequestration. Additional positive socio-economic effects:

1) Environmental-related benefits for farmers and local communities, identified and quantified as ecosystem services;
2) Social benefits from the technological transfer of innovation to farmers, by mena of technology adoption and improved agricultural knowledge;
3) Economic and financial stability of farmers, deriving from cost reduction of crop management and potential payment of ecosystem services;
4) Exploit new market opportunities, thank to the new crops introduced in the rotation and to the product quality label developed, and promote business networks through the involvement of stakeholders in the project activities;
5) The potential to replicate the adoption of Efficient Cropping Sysytems in other areas, spreading the same positive effects.

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LIFE17 CCM/IT/000062

Total project budget: 3,940,804 Euro
EU financial contribution requested: 2,362,231 Euro
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