Selection of legume varieties for ECSs (Efficient Cropping Systems)

***Sofia Ghitarrini**, PhD, R&D ISEA Srl, Legume species specialist*

ECSs are agricultural systems in which the use of environmental resources (e.g., organic matter, nitrogen, water) is optimized, in order to contribute to climate change mitigation. Among the possible strategies of efficient cropping, the introduction of legumes in rotation plays a role of primary importance. N-fixing capacity of these species could be exploited to increase soil N availability, while improving its structure and fertility and producing healthy, sustainable food products. For this reasons, AGRESTIC project has put among its objectives the selection of new legume varieties with suitable performances for ECSs.

Protein pea, chickpea and lentil have been chosen as model legume species for the project activities.

Élite groups of new, local and rare genotypes have been identified by ISEA in its germplasm collections and have been evaluated in 2020-21 season. Identical trials were set up with all the three species in five different locations from Central-Northern to Southern Italy (Ravenna, Osimo-AN, Tolentino-MC, Foggia, Montemurro-PZ), and consisted of 1 m^2 plots in randomized block design with 3 replicates for each line. The characterization addressed key morphological and agronomical traits such as: biomass, protein content, plant height, resistance to biotic and abiotic stresses, length of the vegetative cycle.

In total 5 pea, 9 chickpea and 5 lentil lines were evaluated. Despite the season being characterized by several adverse climatic events (e.g., spring frosts, severe summer drought) all along the Italian peninsula, collected data allowed the preliminary identification of candidate lines for the registration in the national Plant Variety List in all the species.

In 2021-22, trials will be repeated in four out of the five experimental stations, to complete the characterization of the lines and integrate data about other important traits (e.g., plant N- and C- content, C/N ratio, root length). In the meanwhile, the selected genotypes will be multiplied maintaining the seed purity.

Once the best pea, chickpea and lentil lines (one or more for each species) for ECSs will be identified, the process of registration in the Italian Plant Variety List will be initiated, in order to make the selected genotypes commercially available to the farmers as soon as possible.

La modellistica e l'uso dei DSS

*Tito Caffi***,** *UCSC*

I ricercatori del gruppo di DIPROVES dell'Università Cattolica del Sacro Cuore, guidati dal Prof. Vittorio Rossi, sono responsabili dell'Azione C2 del progetto AGRESTIC. Questa azione prevede lo sviluppo di Sistemi di Supporto alle Decisioni (DSS, dall'inglese *Decision Support System*) per la coltivazione delle specifiche colture e per la gestione del sistema colturale e delle rotazioni, al contempo riducendo l'emissione di GHG e migliorando la sostenibilità aziendale. Negli ultimi anni, i DSS sono diventati uno strumento chiave per fornire informazioni tattiche ed operative agli agricoltori, che possono così ottimizzare e razionalizzare gli interventi di gestione della coltura. Nell'ambito delle filiere produttive, i DSS per la gestione sostenibile delle colture rappresentato una piattaforma ormai divenuta strategica per gli agricoltori, alla quale è possibile collegare tutti gli strumenti di raccolta dati per l'agricoltura di precisione e le macchine di distribuzione degli input, in modo tale che l'agricoltore è in grado di prendere decisioni informate e attuare le scelte più opportune, non solo per raggiungere la massima qualità di produzione ma minimizzando al contempo gli impatti.
Per raggiungere gli obiettivi dell'Azione C2, i DSS di Horta già utilizzati da numerosi agricoltori e agronomi italiani e stranieri, sono stati analizzati per identificare nuove funzionalità da sviluppare quali: un tool per la selezione varietale, un tool per la gestione del suolo, un tool per la selezione della coltura di copertura più adatta e diversi modelli matematici previsionali per la difesa da specifiche malattie fungine delle colture coinvolte nelle rotazioni. Il tool per la selezione varietale aiuta l'agricoltore ad individuare la varietà più adatta per la sua coltivazione, considerando i parametri colturali e di filiera, le caratteristiche varietali quali tolleranze e parametri qualitativi, e le esigenze climatiche. Il tool per la gestione del suolo supporta l'agricoltore nella scelta della lavorazione più opportuna sulla base delle caratteristiche del suolo, della coltura coltivata e delle condizioni climatiche. Il tool per la rapida copertura del suolo stima il numero di giorni richiesto alla coltura seminata per la sua emergenza, al fine di supportare l'agricoltore nella scelta del momento ottimale per la semina considerando i parametri varietali e le condizioni metereologiche. I modelli matematici previsionali per la difesa delle colture sviluppati presso l'Università di Piacenza racchiudono tutte le più recenti conoscenze sulla biologia ed epidemiologia degli agenti patogeni, fornendo informazioni di dettaglio sulle loro dinamiche. Sono in corso di sviluppo i modelli per la rabbia del cece (*Ascochyta rabiei*), la ruggine nera del grano (*Puccinia graminis* f. sp. *tritici*), la sclerotinia (*Sclerotinia sclerotiorum*) e per altre malattie di crescente interesse e diffusione tra le colture coinvolte nel progetto.
Inoltre, è in corso la realizzazione di un DSS specifico per la gestione delle catch-crop utilizzate nelle rotazioni che verrà unito ai DSS crop-specifici per la realizzazione di un'unica piattaforma per la gestione dell'intero sistema colturale.

La gestione dei sistemi colturali nei tre siti del progetto e analisi dei primi risultati

Pierluigi Meriggi, *Horta*

Horta è il responsabile dell'azione C3. Lo scopo dell'azione C3 è quello di sviluppare e testare, in 3 ambienti rappresentativi, sistemi colturali innovativi (ECS) rispetto ai tradizionali (CCS) al fine di ridurre le emissioni di gas serra e aumentare il sequestro di Carbonio, attraverso:

- sostituzione di mais/frumento con legumi da granella (pisello, cece, lenticchia) per ridurre l'uso di fertilizzanti N, riducendo l'impronta di carbonio;
- semina di colture intercalari di legumi e/o altre (singola specie/miscela) in successione a grano e orzo per aumentare il sequestro di C e la fissazione di N;
- ottimizzazione delle tecniche colturali attraverso l'utilizzo dei DSS.

Gli agronomi di Horta sono stati coadiuvati nell'azione C3 dai ricercatori del Sant'Anna durante tutte le fasi di lavoro, in particolare per quanto ha riguardato il sito di Pisa.
Le attività specifiche sono state: 1) la gestione di entrambi i sistemi di coltivazione attraverso protocolli agronomici definiti. Le operazioni agronomiche sono state effettuate dagli agricoltori (o contoterzisti) con la supervisione di HORTA in E1 (RA) e E3 (FG) e SSSA in E2 (PI); 2) la effettuazione nei plot ECS di tutte le operazioni colturali in base agli avvisi/output forniti dai DSS; 3) la raccolta dei dati di resa delle varie colture: grano duro, orzo distico da birra, pomodoro da industria, mais, girasole, cece, pisello proteico, lenticchia e soia; 4) la fenotipizzazione delle specie coltivate e delle colture di copertura; 5) la raccolta input esterni per la coltivazione (tecnici, economici, energetici e di manodopera) da utilizzare come input per il calcolo dei KPI; 6) il monitoraggio delle condizioni meteorologiche: pioggia, bagnatura fogliare, temperatura e umidità relativa dell'aria, vento e radiazione solare; 7) Analisi iniziale del suolo in tutti gli appezzamenti (tessitura, C organico, pH, calcare, CSC, nutrienti principali, ecc.); 8) l'analisi del suolo in autunno di ogni stagione colturale per valutare la densità apparente del suolo, il contenuto di azoto e di carbonio organico; 9) l'analisi dell'azoto minerale nel suolo con campionamento mensile; 10) la raccolta dell'acqua di lisciviazione raccolta da camere porose o drenaggio e analisi dell'azoto e del fosforo; 11) la misurazione in continuo di temperatura e umidità del suolo misurate attraverso sensori posizionati in ogni plot; 12) la gestione ottimale del prototipo per la misurazione delle emissioni di gas serra e 13) l'analisi statistica dei dati registrati dagli ECS e i CCS.
Sono stati presentati i principali risultati ottenuti nei 3 siti sperimentali in modo tale da caratterizzare i 3 sistemi colturali differenti. Inoltre è stata presentata un'analisi climatica dei 3 areali ospitanti le piatatforme. Relativamente al Sito di Ravenna si è proceduto in un maggiore dettaglio di risultati del biennio confrontando i vari sistemi colturali e le performances delle varie specie.

The Agrestic prototype for the measurement of GHG emissions from soil

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Nitrous oxide (N_2O) is the third most important of the long-lived greenhouse gases in terms of contribution to global warming and it is an ozone depleting substance (Ravishankara et al., 2009). Most of anthropogenic N_2O emissions are coming from agricultural soils (about 60%) (Ciais et al., 2013).

Many studies have been focused on the monitoring of greenhouse gases (GHG) from agricultural soils with the aim of quantify emissions from different cropping systems and to identify management practices able to mitigate these emissions. The most common methodology to measure GHG emissions from soil is the chamber technique with manual sampling of the gas during closing time. This technique is cheap and easy to use, but may bring biases in the estimation of fluxes, mainly due to (i) the influence in the flux measured, (ii) high noise of gas chromatograph and mostly (iii) the discontinuous measurements (Bosco et al., 2015). Indeed, GHG emissions from soil, especially those of N_2O are event based and largely influenced by e.g., rainfall, changes in air temperature, tillage and fertilization.

Within the project AGRESTIC, Scuola Superiore Sant'Anna (SSSA) developed in collaboration with West Systems srl and AEDIT srl a prototype to improve monitoring and data analysis of GHG emissions from agricultural soils. The prototype consisted in (i) two GHG monitoring stations, with automatic chambers (15 minutes closing time) and detectors (LI-850 for CO_2 and Teledyne GFC-7002TU for N_2O) to measure the gas concentration within the chambers in real time, and (ii) an IT infrastructure to control the functioning of the stations, collect and elaborate the large quantity of data collected.

The raw data collected from the two stations, one installed in the Caione farm (Foggia, Italy) and the other one in the Cà Bosco farm (Ravenna, Italy), are integrated with meteorological data and the register of agricultural operations in a database stored in a server of SSSA. An automatic procedure of R and Phyton scripts calculates fluxes and controls data quality (e.g., correct closing of chambers, linearity of CO_2 increase during chamber closing, malfunctioning of soil temperature and soil water content). Raw and elaborated data are visible on a web site accessed by SSSA to control the correct functioning of the stations and download data. For each site and cropping system, Efficient Cropping System (ECS) and Conventional Cropping System (CCS), elaborated data are used to calculate cumulative N_2O and CO_2 emissions for each soil use, e.g., from sowing to harvest of durum wheat, with the aim of assessing the potential mitigation of ECS.

Sustainability in agriculture and ecosystem services: benefits for farmers and producers

Alessandro Bosso, *ART-ER*

The Millennium Ecosystem Assessment (MEA, 2005) defines the ecosystem services as "*the benefits people obtain from ecosystems*". Resilient agricultural practices tested in AGRESTIC project have effects on following ecosystem services: pest management, pollination, erosion protection, carbon sequestration, climate regulation, nutrient cycling and soil fertility, biodiversity preservation, fresh water storage, landscape quality. Considering the demonstration activities implemented in the pilot sites, all these ecosystem services will be quantified in physical and monetary terms.

A survey has been carried out in order to define the *willingness to pay* of citizens to get some ecosystem services. 660 people have been involved and have expressed their willingness to pay an extra-cost for agrifood products that enhance ecosystem services. The WTP is the following, differentiated for each considered ecosystem service:

- pest management: +15%
- biodiversity preservation: +12%
- pollination: +10%
- landscape quality: +5%

In order to support maintenance of ecosystem services, some feasibility studies of PES will be carried out. A PES (payment for ecosystem service) is "*a voluntary transaction for a well-defined ecological service, with at least one buyer, at least one provider, and based on the condition that the buyer(s) only pay if the provider(s) continue to deliver the defined ecosystem service over time*" (Wunder 2005).

Three feasibility studies are developing:

- access to voluntary carbon credit market for projects of agricultural practices that enhance carbon sequestration
- rent for honey producers interested in positioning beehive near crops with additional flowers availability or vegetation more attractive for bees due to cover crops or soil cover vegetation
- opportunity offered by new EU Common Agricultural Policy through result based schemes of funding for farmers that reduce pesticides use.

PES are schemes aimed at paying farmers for generating benefits for the community.

To reward producers that use raw material cultivated through resilient agri-practices, AGRESTIC project has developed a quality label based on carbon footprint and ecosystem services.

Great Life - Growing Resiliance Agricolture

Giovanni Dinelli, *Department of Agricultural and Food Sciences – University of Bologna*

GREAT LIFE (LIFE17 CCA / IT / 000067) is a project co-financed by the European Union that was born within the LIFE program for adaptation to climate change. The project is coordinated by the Department of Agricultural and Food Sciences of the University of Bologna in collaboration with Kilowatt, Alce Nero, Life Cycle Engineering and the Municipality of Cento.

The overall objective of GREAT LIFE is to implement an innovative and integrated approach, from crops to market, to tackle the effects of climate change on agricultural activities in the Po Valley (Emilia-Romagna) and in Italy as a whole. The project aims to demonstrate how by replacing high-impact crops sensitive to climate change (maize) with resilient crops (sorghum and millet) produced with sustainable agro-techniques (crop rotation, light mechanization, minimum tillage) it is possible to reduce water consumption, support farmers' income, increase biodiversity and access to healthy food.

GREAT LIFE has also developed a web tool where data is collected to perform the life cycle assessment of agricultural production. The web tool facilitates, centralizes and standardizes input data collection (cultivation operations, seeds, phytochemicals, fertilizers, drying grain and labor) providing a user-friendly interface as well as detailed output reports for specific environmental and economic assessments (global warming potential, acidification potential, eutrophication potential and direct costs).

At both national and European level, GREAT LIFE aims to raise awareness of the contribution of food consumption to adaptation and resilience. To do this GREAT LIFE brought resilient foods to the menus of the canteens of the nursery schools of the Municipality of Cento and involved the entire community of people who revolve around the school (teachers, educators, parents, canteen operators, etc.). The project also sought to encourage the introduction of "resilience" within the public criteria that regulate the policies of Green Public Procurement (GPP) and the purchases of public canteens.

GREAT LIFE approach looks at the whole value chain, certain that, for a successful achievement of the above stated impacts, it is necessary to simultaneously stimulate demand and supply, boosting the still niche market of resilient food.

Soil threats and climate related issues in a mountain territory specialized in livestock farming

Luca Filippi, *Consorzio di Bonifica dell'Emilia Centrale*

LIFE agriCOlture investigates the contribution that livestock farming can play, in mountain areas, for soil protection and climate change mitigation. For this aim, by working in a paradigmatic context of mountain livestock, it tests and evaluates: i) best practices related to breeding indicated by scientific research as effective for the protection of soil organic carbon and the reduction of GHG emissions; ii) a contract solution for the production of agro-environmental-climatic goods.

The forage and livestock system of the Emilian Apennines represents, for LIFE agriCOlture, an ideal context for testing a transition, at the territorial scale, towards a sustainable management of agricultural soil – made possible by the high level of productive and social organization expressed here by the Parmigiano Reggiano supply chain – but, at the same time, a paradigmatic case study of soil threats due to the spread of agricultural practices that in many situations prove not to be suitable with the hydrogeological fragility of this southern European mountain territory. As a consequence, the loss of fertile soil and its organic matter content – due to erosion, landslides, abandonment – seems to undermine the material reproduction of this landscape and, immediately, to compromise the productive, energetic and therefore climatic performance of livestock farms.

To counteract the hydrogeological impact of the livestock sector in the Emilian Apennines and, conversely, to fully reveal its potentialities in terms of soil protection and climatic performances, LIFE agriCOlture proposes to re-think the entire production cycle of the milk production supply chain of this specific context consistently to a more rational and efficient use of soil

Within this framework, LIFE agriCOlture elaborates and proposes, for each of its 15 demo-farms, a *work protocol (WP)* that, with respect to the specificities of each farm organization model, defines and regulates the application of a set of *best practices (BPs)* indicated by scientific research as effective for the protection of soil organic carbon, for the reduction of GHG emissions and, at the same time, for increasing economic and environmental performances of mountain livestock farms.

In parallel with their application and evaluation, LIFE agriCOlture systematizes and upscales the application of its best practices within an *innovative territorial contract* – the *"Pact for Soil"* – stipulated between public bodies with a mandate for land management and farmers, accredited as *"soil guardians"*, that accept to implement specific work protocols based on LIFE agriCOlture best practices. A contract that can leverage, in its initial stage, on LIFE agriCOlture's partnership composed by two large Watershed Management Authorities, Emilia Centrale and Burana, a research center of excellence in the livestock sector such as CRPA, an environmental conservation body such as the National Park of Appennino Tosco Emiliano, and 15 demo-farms, representative of the social and productive complexity of this territory.

Divefarming – Crop diversification and low-input farming cross Europe: from practitioners' engagement and ecosystems services to increased revenues and value chain organisation

Raul Zornoza Belmonte, Universitad Politècnica de Cartagena

With the long-term view of increasing diversification and biodiversity in Europe and fostering sustainable development of bioeconomy, the Diverfarming H2020 project has come together to develop and deploy innovative farming and agribusiness models. Diverfarming will increase the long-term resilience, sustainability and economic revenues of agriculture across the EU by assessing the real benefits and minimising the limitations, barriers and drawbacks of diversified cropping systems (intercropping, multiple cropping and rotations) using low-input agricultural practices that are tailor-made to fit the unique characteristics of six EU pedoclimatic regions (Mediterranean South and North, Atlantic Central, Continental, Pannonian and Boreal) and by adapting and optimising the downstream value chains organization through executing 13 field case studies and 7 addition long-term experimental plots. This approach will provide: i) increased overall land productivity; ii) more rational use of farm land and farming inputs (water, energy, machinery, fertilisers, pesticides); ii) improved delivery of ecosystem services by increments in biodiversity and soil quality; iii) proper organization of downstream value chains adapted to the new diversified cropping systems with decreased use of energy; and iv) access to new markets and reduced economy risks by adoption of new products in time and space. With regard to soil greenhouse gas (GHG) emissions and soil carbon sequestration and storage, results from case studies are quite diverse, highlighting how the inherent characteristics of soil, crops, climate and management can control these variables. As a general pattern, there is a trend to increase soil organic carbon in soil with crop diversification and low-input management practices. However, soil GHG emissions are highly variable, with some increases in CO_2 and N_2O emissions when adopting crop diversification, mostly due to higher activity in the rhizosphere.

LIFE ADA (Adaptation in Agriculture)

__Stefania Faccioli,__ UnipolSai Assicurazioni spa

LIFE ADA project aims at boosting the resilience to climate change along 3 agricultural supply chains through the implementation of an innovative Public-Private Partnership (PPP) between Producers Organizations (POs), public administration, scientific institutions, insurers.

ADA will build a tool designed for POs and individual farmers to support their decision-making process to define and implement effective and concrete adaptation plans at farm level and at supply chain level.

ADA will be a demonstration project that will implement, test, evaluate and disseminate an innovative model of adaptation governance. Following a pilot test in the Emilia-Romagna Region, the project will be replicated in additional Regions (Lazio, Tuscany and Veneto).

Main project's targets are individual farmers and POs in three value chains: dairy (Parmigiano cheese), wine, fruit and vegetables, with some focus on quality chains and Geographical Indications Products given their specific vulnerability and value for the local economy and environment.

Through the building of a PPP between insurers, public administration (Regions), scientific institutes and POs, main project's objectives are:

- transferring knowledge on climatic scenarios together with risk management and adaptive measures to enhance farmers' capacity to tackle current and future climate risks;
- building proper tools to support their decision-making process in shaping efficient adaptation plans at farm and supply chain level;
- framing a coherent policy strategy at regional level to support farmers' adaptive planning;
- fostering an innovative approach in the insurance sector aimed to build farmers' capacity on risk reduction, in order to maintain their insurability in the long-term, despite the increase of catastrophic and systemic risks.

Coordinating Beneficiary of the project is UnipolSai Assicurazioni S.p.A, associated beneficiaries are Agenzia per la Prevenzione, l'Ambiente e l'Energia dell'Emilia-Romagna; C.I.A. - AGRICOLTORI ITALIANI; Consiglio per la Ricerca in agricoltura e l'analisi dell'economia agraria – Centro Politiche e Bioeconomia; Circolo Festambiente; Legacoop Agroalimentare Nord Italia; Leithà S.r.l; Regione Emilia-Romagna.

The AGROMIX project - AGROforestry and MIXed farming systems - Participatory research to drive the transition to a resilient and efficient land use in Europe

Alberto Mantino, *SSSA*

The H2020 AGROMIX project (Grant Agreement n°862993) aims to deliver participatory research to drive the transition to a resilient and efficient land use in Europe. It focuses on practical agroecological solutions for farm and land management and related value chains. AGROMIX makes use of a network of 83 sites with Mixed Farming (MF), AgroForestry (AF) or value chain stakeholder networks, which are used to measure, design, model, test and improve these systems. A nested approach will be used to conduct 12 codesign pilots across Europe. In addition, 6 replicated long-term trial sites are used for detailed analysis (crops and livestock).

AGROMIX has six specific objectives: 1) Unlock the full potential of synergies in MF/AF systems. 2) Develop and promote value chains and infrastructure for MF/AF produce. 3) Develop the MIX-A toolkit to co-design and manage MF/AF systems in practice. 4) Identify and model transition scenarios. 5) Develop policy recommendations and action plans for a successful transition. 6) Maximise the impact and legacy of the project for building low-carbon climate-resilient farming systems. AGROMIX uses a transdisciplinary multi-actor research approach with 10 universities, 7 research institutes and 11 multiactor partners. It will use Reflexive Interactive Design methodology to include stakeholders in participatory co-design and implementation of MF/AF systems. The research starts with a work package (WP1) on context, co-creating a resilience framework. WP2 on systems design and synergies is at the heart of project. WP3 on indicators and scenarios will refine the greenhouse gas inventories for MF/AF systems and model transition scenarios. WP4 develops and tests the MIXapplication/ serious game. Further WPs are on economics and value chains, and on policy co-development, action plans and dissemination delivering impact and exploitation through practical innovations on farms, in value chains, at different policy levels and through communication and knowledge hubs across Europe.

The “4 per 1000 - Soils for Food Security and Climate” Initiative & The Twin Regions Action

***Marc Bernard** - Network & Global Facilities Coordinator at the Executive Secretariat of the “4 per 1000” Initiative*

The "4 per 1000 - Soils for Food Security and Climate" initiative was launched by France at COP21 in 2015. The initiative provides a global multi-stakeholder platform for developing partnerships and alliances that support and promote transformative actions to improve soil health and carbon sequestration. Today, "4 per 1000" has 666 member organizations, including 40 governments.

2020, "4 per 1000" developed its strategic plan. The initiative then conducted a Delphi study for the joint development of the implementation strategy. The implementation strategy defines the activities to achieve the 24 goals of the strategic plan. 124 experts from all world regions and stakeholders participated in the study. They produced 191 studies outlining the underlying problems of the 24 objectives, their causes, the actions that need to be invested in to address them, and the critical success factors and barriers that need to be considered to achieve the 2030 and 2050 goals. The experts responded anonymously, contributing to the completeness, objectivity, and credibility of the resulting implementation strategy.

In 2022, the initiative will focus on developing partnerships and alliances to improve the enabling environment for transformative action on the ground. Partnerships with governments, international organizations, and donors will focus on providing so-called core facilities that provide legal and financial support for transformative action by beneficiaries: producers, citizens, and intermediaries. Research and development organizations, NGS, producer organizations, and the private sector will forge alliances to provide global facilities that provide beneficiaries with scientific and technical support to develop and implement projects, improve access to carbon markets, monitor progress, and evaluate the impact of transformative actions. "4 per 1000" takes a decentralized and integrated approach to promoting, mobilizing support for, and strengthening ownership of the action. To achieve this, regional roadmaps are developed with partners, aligned with existing funding mechanisms, instruments, and regional and national institutions, organizations, programs, and initiatives.

To accelerate and scale action on the ground, "4 per 1000" promotes the introduction of the concept of so-called "twin regions" in member countries, in addition to traditional approaches to scaling. A twin region consists of two contrasting places that come together to overcome their mutual environmental, economic and social constraints by leveraging their complementary skills and resources. Typically, a place in a region with low living standards, low emissions, but high ecological potential to sequester carbon, a CO2 sink region, teams up with a place in a region with high living standards, high emissions, but low ecological potential to sequester carbon, a CO2 source region. Together, they are pursuing the goal of becoming carbon neutral by 2035, paying off their historical carbon debt as of that date, and building a system of environmental stewardship and global equity.

Modelling the GHGs emissions from agricultural soils

Marco Acutis, *University of Milano*

The most relevant GHG emitted from an agricultural system are CO_2, N_2O and CH_4. There are other relevant emissions from soil, as NO_x and NH_4, but they have an indirect role in term of greenhouse effect.

Modelling the GHG emission from agricultural soil is a challenging task. Several drivers are conditioning the performances of an agricultural systems in terms of a GHG emissions; moreover, the measure of GHG is critical due to complexity of experimental devices needed and low concentration of GHGs itself, in particular for N_2O.

All the processes correlated to the GHG emission are strictly correlated to the microbiota activity so, soil water content and soil temperature are common driver to all processes even if with different effects on CO_2, N_2O and CH_4. All the constituents of the C and N cycle are involved too, as C and N in the organic and mineral pool, pH, and lime content. Crop management interact with biota activity thorough the choice of the crops in the rotation, tillage operation, organic and mineral fertilization, irrigation etc.

In spite of this complexity, there is the need to estimate the GHG emission from agricultural soil at different scales, from field to region and continental scale. Consequently, different approach was developed, as for example the IPCC approach developed for GHG national inventories, based simply on coefficients (the so called "emission factors"). When the need is to perform what-if analysis at a specific cropping system scale, the appropriate instruments are the process-based models. Process-based models predict daily GHG's fluxes, important for a priori evaluation and designing of actions to reduce emissions. However, they are complex and heavily rely on site and version-specific parameterizations that are sometimes ad hoc tunings. Moreover, algorithms of popular biogeochemical models (e.g., DayCent, DNDC, EPIC) are usually derived from laboratory-based responses to individual environmental factors and not consider the real complexity of the agricultural systems. The range of available process-based models able to simulate at least CO_2 and N_2O emission is wide, but none of these models overperform the others. In general, the reliability of the CO_2 emission simulation is quite good, while N_2O emission are simulated with a higher degree of approximation. When a large dataset of measured data is available, few predictors can give good estimate of N_2O emissions using machine learning algorithms. The more recent development in GHG estimation is to couple a process-based model to obtain some variables, as soil water content, used after in the machine learning process.

Actually, we have promising option for the simulation of GHG emission from soil, but there is a strong need to have high quality measurement at real cropping system scale and extended from long time to improve the quality of the model simulation and to make it a real instrument for evaluation of alternative options, able to support policy makers.

Il consorzio

Coordinatore:

Partner:

Ecosystem services provided by legumes in Mediterranean intercropping systems

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Legume living mulches are often reported as a promising tool to support sustainable intensification of conventional cereal based cropping systems. Living mulches can sensibly reduce the use of herbicides and at the same time support the optimization of nutrient cycling, resource conservation and CO2 fixation without causing negative impacts on crop productivity. Despite numerous benefits provided by legume living mulches at crop rotation level, the adoption of this cultural practice is limited because often it fails to meet performance expectations of farmers. In fact, it is known that the use of living mulches is a more knowledge-intense cropping practice and farmers needs to be supported for a successful establishment and management of the living mulch. The three key questions are 1) the choice between contemporary and relay establishment of the living mulch with respect to the main crop, 2) the choice of the most effective sowing method between broadcast and drill sowing and 3) the selection of the two components of the living mulch system (subsidiary and main crop) at species and cultivar level. These three points determine the successful uptake of the living mulch by farmers, and it needs to be fine-tuned to the local context. Results from a 2-years experiment on the selection of legumes for living mulches with durum wheat (cv. Minosse) carried out in Pisa at the Centre for Agri-Environmental Research “Enrico Avanzi” (CiRAA, San Piero a Grado, Italy) and Ravenna at Horta (Horta, permanent platform for enhancing results from research in the agro-alimentary sector, Cà Bosco farm, Italy) in the EU project IWMPRAISE (No. 727321), were able to highlight various practical aspects determining the successful adoption of living mulches in Mediterranean cereal based cropping systems. In the presentation various considerations regarding the three key questions will be discussed with the support of the available results and the relationship with the different environmental conditions and management practices of the local reference cropping system will be highlighted. For example, contemporary sowing is more adapted to competitive wheat stands and in that case legumes tolerant to the wheat competition such as M. sativa and T. repens should be selected. In a low-input or organic cereal cropping system the competition of wheat is generally lower. In that case provide a temporal advantage to the main crop by the relay establishment of living mulch is the best option in order to avoid negative effects of the living mulches on yield. Regarding the sowing method, broadcast sowing is easier but is only successful under optimal soil conditions and it may require an increased seeding dosage which increases the cost. Perennial and annual self-seeding legumes like M. sativa, H. coronarium and T. subterranum are more effective in suppressing weeds and providing nitrogen to the following crop than annual legumes. Some annual self-seeding species are interesting alternatives to the use of perennial legumes in areas with a low water availability in summer.