GLOBAL RESEARCH ALLIANCE

Croplands Research Group

NEWSLETTER Nº12, December 2022

1. Cropland Research Group GRA Co-Chairs message

Close to the Christmas holydays we are delivering the 12 CRG newsletter announcing the next Cropland Research Group Annual Meeting that will be held in the beautiful city of Seville (Spain) the next January (17^{th} and 18^{th} January 2023) together with the Integrative Research Group. The meeting will be associated with the International Conference on Agroecology with sessions in English, Portuguese and Spanish. In this issue we provide very interesting papers dealing with the use of legumes to mitigate climate change carried out in Spain. Main result is how organic carbon in stored in soils and woody crops. The summary of the excellent International Symposium on Climate Resilient Agri-environmental Systems (ISCRAES) is also presented. Finally, the new book “Advances in temperate agroforestry” requesting for contributions is announced. The three co-chairs wish you Merry Christmas and a happy new year, 2023.

Source: María Rosa Mosquera-Losada (USC, Spain), Ladislau Martin-Neto (EMBRAPA, Brazil), Hero Gollany (USDA, USA).

2. Common bean (*Phaseolus vulgaris* L.) a crop model to contribute to the mitigation of climate change by reducing the use of chemical fertilizers

Biological fixation of atmospheric nitrogen

Nitrogen (N) is an essential element for all forms of life since it is part of such necessary compounds as proteins, nucleic acids, hormones, etc. It is also the fourth most abundant element in biomass after carbon (C), hydrogen (H_2) and oxygen (O_2). Although it is the most abundant element in the atmosphere, which it makes up 80%, its chemical state makes it biologically inert for most living things. Hence, N, except for water, is the most common limiting nutrient in agricultural practice. The N cycle in nature begins with the reduction of molecular nitrogen (N_2) to ammonium (NH_4^+), which is carried out exclusively by diazotrophic bacteria containing nitrogenase, the only enzyme capable of breaking the covalent triple bond of N_2. Through this process, N_2 passes from an inert to a biologically active form (NH_4^+) that can be used readily by microorganisms and plants for the synthesis of the nitrogenous compounds necessary for their growth (Olivares et al. 2013).

Nitrous oxide (N_2O) is a potent greenhouse gas (GHG) that, along with carbon dioxide (CO_2), methane (CH_4) and some chlorofluorocarbon compounds (CFCs), is implicated in global climate change. N_2O has a warming capacity 296 times greater than that of CO_2, and is responsible for 6% of current global warming (Erisman et al. 2011, 2015, Intergovernmental Panel on Climate Change IPCC 2019). The long residence time of N_2O in the atmosphere, with a minimum lifetime of about 120-150 years, makes possible its transport to the stratosphere where it is transformed by photolysis into nitric oxide (NO), which, in turn, removes ozone (O_3) to produce nitrogen dioxide (NO_2) that reacts with water to give rise to nitric acid (HNO_3). The HNO_3 dissolved in water falls on earth in the form of acid rain, which contaminates soils, water and sediments. It also affects vegetation, causing significant damage in forested areas. Nitrates contribute to the eutrophication of rivers, lakes, reservoirs and coastal regions, which deteriorate their natural environmental conditions and decrease their utilization (Erisman et al. 2015).

Agriculture and nitrous oxide

In pre-industrial times, for decades, soil fertility was maintained using manures, plant residues, and the use of legumes to supply the N needs of crops. However, the need to feed a growing population favoured the massive use of synthetic nitrogen fertilizers. In fact, estimations show that more than a quarter of the world's current population has been fed using these fertilizers to increase crop yields. Therefore, the benefits that they represent for the livelihood of the population on a global scale are undeniable (Erisman et al. 2015). Once in the soil, nitrogenous compounds, whether organic or synthetic, are converted to nitrate, which, in turn, results in the emission of N_2O to the atmosphere, mainly through the nitrification and denitrification processes.

Rhizobia legume plants symbiosis

Legumes played an important role in the early development of agriculture, were domesticated along with grasses, and today occupy diverse aquatic and terrestrial environments in nearly every biome on Earth, even the most extreme habitats (Lewis 2015). Currently second only to cereals, pulses are an important source of food for a large part of the world's population, providing protein, carbohydrates, minerals, vitamins, oil, fiber and other compounds with nutraceutical value and health-promoting properties. The recognition of the nutritional benefits of pulses, their importance in food security, sustainable agriculture and in mitigating biodiversity loss and climate change was recognized by the United Nations General Assembly, which designated 2016 as the International Year of Pulses.

A symbiotic association is established between rhizobia and legumes, resulting in the fixation (reduction) of N_2. As a consequence of the plant-bacteria interaction, a new organ, the nodule (Figure 1), is formed in the roots, sometimes in the stems and leaves, where the bacteria reduce N_2 to NH_4^+. Inside the nodules the rhizobia transform into bacteroids, specialized cells that synthesize nitrogenase, the enzyme needed to reduce N_2 to ammonium. The NH_4^+ formed is excreted into the cytosol of surrounding plant cells and used for the synthesis of amides (glutamine and asparagine) or ureides (allantoin and allantoic acid), which are the main nitrogenous compounds formed in nodules of indeterminate or determinate type, respectively, and exported to the rest of the plant for utilization (Poole and Udvardi 2013, Poole et al. 2018). Much of the N assimilated during plant growth returns to the soils where the next crop can take advantage of it. This explains why legumes are plants that fertilize the soil where they are grown, and their ancestral use in crop rotation and in current revegetation and reforestation programs (Rodiño et al. 2011).

Figure 1: Nodules in roots of common bean.

The common bean (*Phaseolus vulgaris* L.) is an annual legume native to Central and South America that is currently cultivated in countries on all continents by small farmers and large producers, with both green pods and dried seeds being marketed (Figure 2). This legume is among the three most important legume crops worldwide along with soybean (*Glycine max*) and peanut (*Arachis hypogaea*). Common bean grows in different soil-climatic conditions and there are varieties with contrasting ripening times and seeds with a wide variety of sizes, shapes and colours (De Ron et al. 2015). Despite the wide range of rhizobia with which the bean establishes N2-fixing symbioses, it is considered a poor plant with respect to N2-fixing capacity compared to other grain legumes, a problem attributed to the inefficiency of the rhizobia that nodulate it. In previous studies (Rodiño et al. 2011, 2021), the basis for obtaining an effective rhizobia biofertilizer for beans, with benefits for crop production and the environment, was obtained. Biofertilization implies a lower cost of nitrogen fertilizers and reduces water pollution and the emission of greenhouse nitrogen gases. These studies documented the important advantages of establishing an efficient Rhizobium-bean symbiosis but lack the field assessments needed to evaluate, identify and recommend high-performing biofertilizer strains.

Figure 2: On the left, experimental plots of common bean and on the right, diversity in common bean seeds.

In conclusion, it is necessary to make progress in improving the efficiency of the legume-rhizobia symbiotic system. In the case of the common bean, the most widely used legume for direct human consumption, it would be necessary to investigate the production of biological fertilizers based on rhizobia strains with increased symbiotic efficiency and reduced capacity for N_2O production. This would alleviate the use of nitrogen fertilizers, and therefore limit the emission of greenhouse gases and help mitigate climate change.

Acknowledgments

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Source: De Ron AM, Rodiño AP, López FJ (Misión Biológica de Galicia, National Spanish Research Council, Spain), Tortosa G, Delgado MJ, Bedmar EJ (Estación Experimental el Zaidín, National Spanish Research Council, Spain).

3. Organic carbon storage in Mediterranean soils and woody crops in the northeast of the Iberian Peninsula (Catalonia, Spain)

The northwest of the Iberian Peninsula (Catalonia/ Spain), an area characterized by a Mediterranean climate, has baseline values for organic carbon content in soils and in agricultural perennial woody structures thanks to a work developed between IRTA, CREAF, CTFC, DACC and ICGC in recent years.

Figure 3: Vineyards in Catalonia (Spain) by Robert Save M. (2020).

In this part of the world, woody crops (fruit trees, vineyards) occupy the space where the forest never grew, since the rainfall is in the range between 350 and 550 mm, the typical habitat of maquis.

The mean values measured in the soil are about 4.88 ± 0.86 kg C m^{-2}, with 47.89 Tg C (Tg= 1012 g) being the total storage in the soils of Catalonia and ranging between 6.49 and 3.90 kg^2 in the rice and vineyard, respectively (Funes et al. 2019).

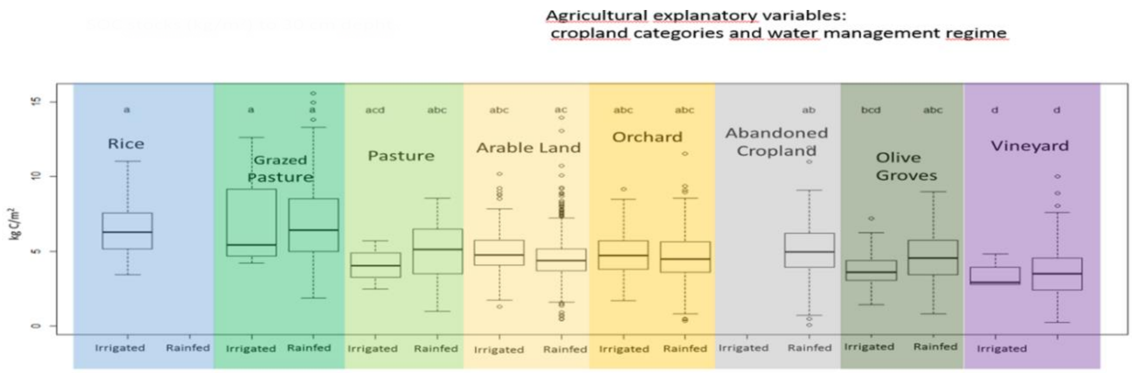

Figure 4: Soil organic carbon stocks (kg m^{-2}) under different crops at a soil depth of 30 cm.

The storage and sequestration values of C in the perennial structures of woody crops (roots and aerial part) were also evaluated in the same area and period (2013-2019), being these values 5.48 Tg C, with a mean value of 1.64 ± 0.2 kg C m^{-2} (Funes et al. 2022).

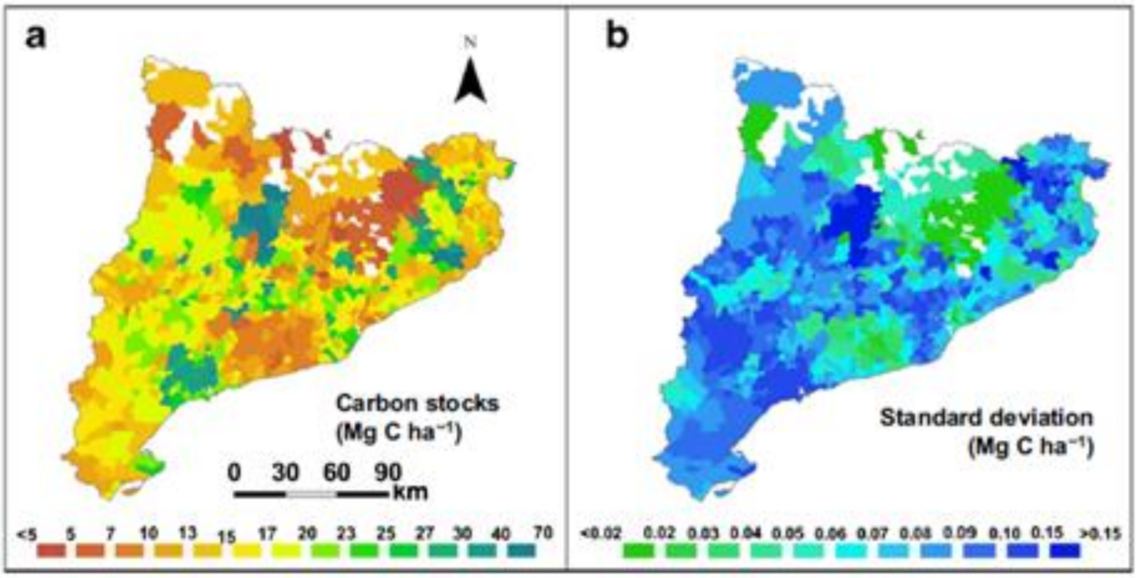

Figure 4: Spatial distribution of mean carbon density (Mg C ha-1) in the biomass of total woody crops in Catalonia (Spain) in 2013 (a) and uncertainty (standard deviation) of the estimations (b).

In the study period, despite a reduction of 2.8% per year in the agricultural area of these crops, the rate of organic carbon storage in their biomass grew by 3.8% per year.

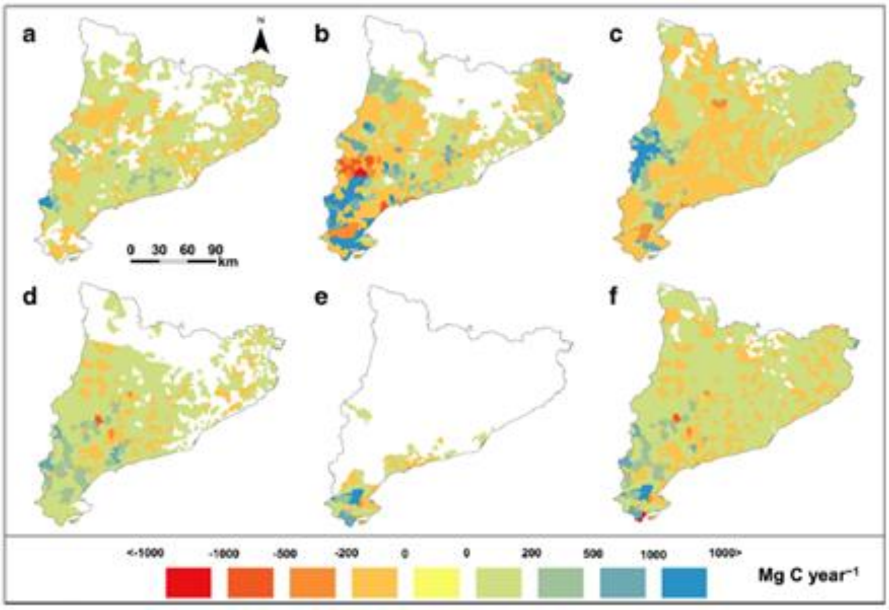

Figure 5: Spatial distribution of total carbon stock change for woody crops in Catalonia (Spain) from 2013 to 2019 (Mg C year^{-1}) in vineyards (a), olive trees (b), fruit trees (c), nut trees (d) citrus trees (e) and total woody crops (f).

These approximations on organic carbon reserves can contribute to the evaluation and management of carbon storage in crops (please see https://guiacarbocert.es/), as an ecosystem service in Mediterranean woody crops, being the baseline for the development of climate change mitigation strategies, like 0.4%, in the agricultural sector which is basic for food sustainability in this area especially affected and sensitive to climate change (more information in this link).

Source: Dr. Robert Savé Monserrat (l'IRTA Viticultura & Canvi Climàtic).

4. International symposium on climate resilient agri-environmental systems (ISCRAES)

The International symposium on climate resilient agri-environmental systems (ISCRAES) was held in Dublin, Ireland, during 28th – 31st August 2021. This symposium was organised by Dr Ibrahim Khalil, who formed the Climate-Resilient Agri-Environmental Systems (CRAES) group and sponsored by the OECD Co-operative Research Programme: Sustainable Agricultural and Food Systems. The main theme of ISCRAES was "Implementing the New Green Deal: The Path Towards Sustainable Agriculture", which refers mainly to the European Green Deal having the opportunity and resources to achieve the primary objective of a sustainable Europe and planet by tackling the current major environmental, climate, and societal challenges facing the world.

The symposium included 4 sessions to provide a basis for the testing and subsequent adoption of strategic ways for implementing sustainable GHG mitigation and environmental solutions: i) Arable cropping systems, ii) grassland Systems, iii) Agro-Silvo-Pastoral systems, iv) Decision support tools, v) Novel farming systems, vi) Carbon farming and nature-based solutions.

Dr Maria Mosquera-Losada, Co-Chair of the Croplands Research Group of the GRA, was a keynote speaker in the session on Agro-Silvo-Pastoral systems. The title of her presentation was "Agroforestry – European extent, policy and climate change". Moreover, on the last day of the symposium, Dr Maria Mosquera-Losada also gave a talk on the use of agroforestry for mitigating GHG emissions and the resilience of agricultural farming. She also participated in a discussion panel on "What is achievable: Towards net zero emissions without compromising Agricultural Sustainability".

The next international symposium on climate resilient agri-environmental systems (ISCRAES) will be in 2024. More information will be available very soon.

Figure 6: Dr María Rosa Mosquera-Losada at the International symposium on climate resilient agri-environmental systems (ISCRAES).

Source: Dr. Nuria Ferreiro-Domínguez (University of Santiago de Compostela, Spain).

5. Book on "Advances in temperate agroforestry"

Burleigh Dodds Science Publishing announces that Professor Maria Rosa Mosquera-Losada, Dr Ladislau Martin-Neto, Professor Anastasia Pantera and Dr Allison Chatrchyan have agreed to edit a forthcoming collection in a book on "Advances in temperate agroforestry". Others leading experts in the field will be invited to contribute to chapters that will be part of the book.

The new book builds on a previous volume published by Burleigh Dodds Science Publishing in 2019: Agroforestry for sustainable agriculture (ed. Professor María Rosa Mosquera-Losada, University of Santiago de Compostela, Spain; and Dr Ravi Prabhu, World Agroforestry Centre (ICRAF), Kenya).

More details will be coming soon.

Source: Dr. Ladislau Martin-Neto (Embrapa Instrumentação, Brazil).

8. Upcoming events

Croplands and Integrative Research Group Meeting

The annual meetings of the CRG and IRG will be held jointly in Seville (Spain) from **17th to 18th January 2023**. The theme of this joint meeting is: Towards Carbon Neutral Cropping Systems. The meeting will be held alongside the IX International Congress of Agroecology (19th – 20th January) at Pablo de Olavide University (register at the event website to attend this congress). The meeting will be held in a hybrid format.

2nd Summit of the Organic and organo-mineral Fertilisers Industries in Europe (SOFIE)

The 2nd Summit of the Organic and organo-mineral Fertilisers Industries in Europe will be held in Brussels, Belgium, during **17th – 18th January 2023**. SOFIE provides a unique opportunity to meet companies, technology suppliers, regulatory experts and other actors in this fast-developing sector. More information here.

IX International Congress of Agroecology

The IX International Congress of Agroecology will be held in Seville, Spain, during **19th – 21st January 2023**. This congress seeks to generate a space for exchange and collective debate that serves to monitor the progress of the agroecological transition and, more specifically, of the Agroecology-Based Local Food Systems. More information here.

4th Agriculture and Climate Change Conference

The 4th Agriculture and Climate Change Conference will be held in Dresden, Germany, during **7th – 9th May 2023**. The Conference will focus on the likely impact of climate change on crop production and explore approaches to maintain and increase crop productivity into the future. More information here.

XXV International Grassland Congress

The XXV International Grassland Congress will *be* held in Kentucky, USA during **14th – 19th May 2023**. The theme of the conference is Grassland for Soil, Animal and Human Health. The conference features academic presentations that highlight research on grassland ecology, forage production and utilization, livestock production systems, grassland sustainability and ecosystems, and grassland policies and social issues. Another highlight of the event will be tours of grasslands throughout the Midwest, Southeast, Northeast, and Pacific Northwest regions of the United States. More information here.

22nd European Grassland Federation (EGF) Symposium

The 22nd EGF symposium will be held in Vilnius, Lithuania, during **11th – 14th June 2023**.The symposium will focus on the future role of ley-farming in cropping systems. More information here.

This is your newsletter! If there's anything you think should be included, please send suggestions to mrosa.mosquera.losada@usc.es for the next issue

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