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Expo Melilla 2023

Fostering more resilient systems to face climate change challenge: the South Regional Center (CRS) message at the Expo Melilla agricultural exhibition

Fomentando sistemas más resilientes para enfrentar el desafío del cambio climático: el mensaje del Centro Regional Sur (CRS) en la exposición agrícola Expo Melilla

Promovendo sistemas mais resilientes para enfrentar o desafio das mudanças climáticas: a mensagem do Centro Regional Sul (CRS) na exposição agrícola Expo Melilla

Colnago, P.[1]; Galván, G. A.[1]

[1]*Universidad de la República, Facultad de Agronomía, Centro Regional Sur (CRS), Canelones, Uruguay*

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Correspondence
Paula Colnago
pcolnago@fagro.edu.uy

The South Regional Center (CRS) (34°36' S Latitude, 56°13' W Longitude) is a location of the School of Agronomy of the University of the Republic, in southern Uruguay. It has been working since its creation on diverse topics related to the sustainability of the predominant family production systems in South Uruguay, both in the training of human resources at the highest level as well as in the generation of knowledge. Research topics comprise genetic improvement, soil management, and the design of production technologies adapted for the production of pigs, dairy cattle, sheep, horticulture, fruit production, viticulture, and irrigation, among others. For many of these productions, the southern region concentrates a high proportion of national production, with a high density of household family farming systems(1).

The concept of sustainability in production systems is dynamic. A production system is not sustainable per se, but is more or less sustainable in comparison with another; with itself over time or with some reference(2-4). It is a generic concept and can be completed depending on the object to which it is applied, so to become an operational concept it must be determined at a local and regional scale. Seeking sustainability involves processes where not all objectives will be achieved at the same time(5-6).

The main objectives for designing a sustainable system are to reduce energy use and ensure efficient flow, reduce resource degradation and nutrient losses, employ production methods that restore homeostatic mechanisms, optimize organic matter recycling rates and nutrients, make full use of the multi-use capacity of the system, promote the local production of food products adapted to the socio-economic and natural environment, reduce costs and increase efficiency and economic viability(6-7).

To establish an operational definition of sustainability it is crucial to identify properties or attributes of agro-ecosystems that allow guiding the analysis of relevant aspects and select sustainability indicators for evaluation. The main properties of an agroecosystem are: productivity; stability; resilience, reliability and adaptability; equity, and self-management[6][8-10].

Productivity and stability refer to the internal capacity of the system to produce a particular combination of goods and services efficiently and permanently, without degrading the resource base. Resilience, reliability, and adaptability report on the system's ability to maintain, return to or seek a new balance state. This group of indicators provides information on continuous operation when internal changes or interactions with the environment or with other systems occur. Equity property reports the capacity of the system to fairly distribute (within and between generations) the costs and benefits produced, and self-management is the capacity of the system to regulate and control its interactions beyond the farm.

Based on these properties, a system is sustainable when it produces goods and services (productivity) without deteriorating the resource base (stability), and is capable of maintaining it when facing normal environmental variations (reliability), compared to stress (resilience) or permanent changes in the environment or its functioning (adaptability)[6]. With the aim of enhancing farming systems' resilience, we are researching from different approaches and disciplines to better face current and future changes in environmental and economic production conditions.

1. The climate change challenge

Uruguayan economy is strongly based on agro-industrial chains and most of the territory is dedicated to open-air agricultural activities, exposed to climate variability and change[11]. Concern about climate change and its consequences is growing.

The main consequences of global warming are an increase in average temperature (2-3 °C), an increase in precipitation and its distribution (10-20% more, especially in summer), an increase in the intensity of precipitation, an increase in the frequency and intensity of extreme events, a slight decrease in the number of days with frost, a significant increase in the number of warm nights, and an increase in the duration of heat waves[12-13].

A higher temperature can reduce crop duration cycles, increase crop respiration rates, alter photosynthetic partitioning and harvest index, and affect the dynamic of pest populations leading to a new equilibrium between crops and pests. In addition, a higher soil temperature changes nutrient mineralization rates and fertilizer use efficiencies, and increases evapotranspiration. These changes press the greatest limiting factor in the growth and production of crops worldwide: the availability of water[12]. In this context, recent drought periods faced in Uruguay recall the importance of generating knowledge for the design of more resilient farming systems, with a greater capacity to adapt to climate variability[10].

Within the framework of a new exhibition of the Rural Association of Uruguay in the south of the country, and in the context of an extremely long drought period, we showed three research lines contributing to farm systems' sustainability. Research works on pastures, dairy, pigs, corn, irrigation, vegetable propagation (potato and onion), biodiversity, and biological control were exposed. In addition, three lectures were given: (i) "*What grapes and wines to expect with the drought?"* (Fourment and Piccardo); (ii) "*Supplementary irrigation in pastures: Towards sustainable intensification in productive systems with grazing"* (Puppo and Hayashi); and (iii) "*Strategies and tools for the transition to agroecological-based vegetable production systems"* (Scarlato and Colnago).

2. A brief review of the research exhibited at the stand

2.1 Rescue and conservation of landraces seeds from Uruguay

The diversity of landraces preserved by household traditional farming systems constitutes a Uruguayan genetic richness due to landrace adaptation to local conditions, including climate, main pests and diseases, crop management practices and their low demand for inputs. Landraces in Uruguay and surrounding areas comprise two main origins: landraces from originally New World species like maize, *Cucurbita* sp., and common beans (*Phaseolus* sp.) introduced to our territory by original inhabitants, particularly Guaraníes. The other main origin are those landraces derived from seeds introduced by diverse waves of immigrants, mainly European, like onions, carrots, and grass-pea (*Lathyrus* sp.), among others.

Landraces are, in turn, guardians of traditions and local knowledge, and they contribute to the economy of rural families. The research conducted at the School of Agronomy has three main objectives: (i) to contribute to the conservation, production, and access to native landraces maintained by family farmers; (ii) to characterize and value the landraces conserved in our territory; and (iii) to generate and disseminate information on the potential of our landraces.

An example in this area of research is the characterization and value of native popcorn landraces. Popcorn is based on specific corn types due to its expansion capacity (EC) of the grain when exposed to high temperatures. Farmers (particularly women) preserve and enjoy popcorn landraces (particularly children). Despite the broad genetic diversity we own, foreign popcorn hybrids predominate in the market. The research group at the Plant Biology Department is also working on assessing maize resistance against *Fusarium spp.* in landraces, as well as determining the toxigenic potential of contaminating fungal strains.

Throughout the ongoing projects, more than 70 Uruguayan maize landraces have been characterized and collected in cooperation with the Sao Paulo University (Brazil). It should be noted that some specific maize landraces have been preserved by a family for around of 80 years old[14].

2.2 Strengthening high-quality seed potato (*Solanum tuberosum L.*) multiplication and supply in family production systems

The availability of high-quality seed tubers for sowing is scarce. This shortage restrains the development of potato farming under minor production scale conditions. Imported potato varieties are susceptible to several main diseases. Additionally, genetic uniformity of commercial varieties, clonally propagated, facilitates the development and spread of viral and fungal diseases, seriously affecting productivity and crop quality, leading to frequent seed renewal. The low multiplication rate and potato seed degeneration hinder local supply of potato seeds and their use.

The research presented at the exhibition proposes to assess novel methods of potato multiplication to favor the availability and accessibility to alternative locally improved selections, resistant to major diseases and adapted to our farming systems. The ongoing project assesses the multiplication efficiency of different planting materials obtained from sexual progenies (TPS) and clonal varieties obtained through hydroponic propagation. Therefore, seedlings and mini-tubers are evaluated as propagules of sexual and clonal origin under field conditions and in high-density beds under a greenhouse, in different cycles[15].

2.3 Introducing floral species in greenhouse tomato production

Vegetable production in open greenhouses is often associated with high inputs of synthetic pesticides. Introducing flowering plants into such greenhouses may promote top-down pest suppression by natural enemies and reduce the reliance on pesticide use. From 2018 to 2020, greenhouses tomato crops were monitored in organic farms and conventional farms that used integrated pest management (IPM). The influence of introducing flowering plants into open greenhouses with organically and conventionally managed tomato crops was evaluated, measuring the abundance of pests, natural enemies (NE), pollinators, and crop yield. We worked with a participatory methodology.

The flowers had a positive effect on conventional farms but not on organic farms. Organic farms had fewer pests and more NE than conventional farms, with no yield differences between organic and conventional farms. The findings indicate that NE in IPM-conventionally managed greenhouses can benefit from resources provided by flowering plants, resulting in reduced pest abundance, while in organically managed greenhouses the conditions are already favorable for the suppression of pests and the addition of floral resources does not further improve the effectiveness of NE[16].

2.4 Reduced tillage in onion crops

Reduced tillage in combination with crop onset on green manure stubble without tilling reduces soil erosion, and increases water infiltration and retention, organic matter, and soil life. However, practical implementation is challenging, particularly for agroecological systems that seek not to use synthetic herbicides and fertilizers. The effect of reduced tillage compared to conventional tillage was evaluated in experiments at the CRS. A summer green manure of moha (*Setariaitalica*) and cowpea (*Vigna unguiculata*) was installed before an overwinter onion crop. Efficient native microorganisms (MEN, by its Spanish acronym) were applied to promote N mineralization, and the productive performance of the onion crop, soil cover and the physical, chemical, and biological quality of the soil were evaluated. The reduced tillage achieved more than 80% soil cover and did not generate physical limitations for crop development. However, crop yields were negatively affected by weed management and lesser nitrogen availability in comparison with conventional tillage. More research is needed to make reduced tillage technology viable under organic management.

2.5 Is there room to improve productivity while reducing the use of chemical inputs?

The relationship between the use of pesticides and fertilizers and the yield of five relevant vegetable crops in southern Uruguay was studied: short and long-cycle greenhouse tomato, onion, sweet potato and strawberry. Between 2012 and 2017, 428 plots in 82 farms were assessed. Nutrient mismatch was found in the five crops and high use of pesticides in four crops. There was no relationship between the use of inputs and the crop performance. Several cases achieving high yields and low use of inputs were identified. The 21% of the studied crops and 17% of the farms reached yields above the average, with below-the-average use of inputs. However, 19% of the plots and 16% of the farms reached below-average yields, with above-average use of agrochemicals. In these farms, strategies are needed for increasing yields and reducing the use of agrochemicals through ecological processes that sustain this[17-19].

2.6 Genetic improvement: the Pampa Rocha breed

The South Regional Center (CRS) of the School of Agronomy holds a Pig Production system since the year 1996. In this breeding system, all production processes are carried out in the open field. The diet is based on the use of by-products and grains (mainly soybean expeller) for all pig categories, combined with grazing. The Pampa Rocha pig is a Uruguayan landrace resource that has historically been linked to agricultural activities carried out by small and medium-scale producers. Its origin lies in the east of the country, an area characterized by extensive marshes and estuaries, with a huge population of palm trees (*Butia capitata*) and good conditions for natural grassland[20-21]. It is a black-coated pig with six white tips (legs, snout, and tail tip). It is characterized by its docility, maternal ability, rusticity, and adaptation to grazing. These last two characteristics are strongly associated with outdoor production and give it greater resilience against climate change. Sows stand out for their milk production[22] and productive longevity[23].

3. A brief review of the lectures

3.1 What grapes and wines to expect with the drought?

Droughts and high temperatures during the growing season can significantly impact the grapevine's reproductive and vegetative development. This could impact on reducing yields, on reducing canopy development and altering berry composition and typicity. The extent of the consequences depends on the severity and duration of the climate conditions. The paper reports the climatic context of the last vine-growing season in the region and its impact on the yield and composition of the berries. The presentation includes preliminary results from the research program emphasizing the importance of anticipating climatic events to predict the composition and the enological potential of the grapes. This would allow management adjustments in the vineyard. Harvest criteria and enological practices can be adjusted to mitigate the effect of climate change on the composition of grapes and wines (Fourment and Piccardo).

3.2 Supplementary irrigation in pastures: Towards sustainable intensification in farming systems with grazing

The Irrigation and Drainage Group of the Soils and Water Department is carrying out research to assess irrigation thresholds in fescue (*Festuca arundinacea*) and alfalfa (*Medicago sativa*) with direct grazing. The purpose is to define an irrigation strategy that allows high annual dry matter yields with efficient use of rainfall, while improving soil physical properties and the persistence of pastures. In addition, other studies are being carried out in collaboration with the National Institute for Agricultural Research (INIA, by its Spanish acronym) to determine evapotranspiration (ETC, by its Spanish acronym) in these species. ETC will be used to adjust crop coefficients (Kc) and stress coefficients (Ks), which will allow a more accurate irrigation management and define design flows. This new project is added to the ongoing one where the irrigation technology by beds is adjusted for the prevailing soil and topographic conditions in Uruguay and in optimization with the WinSRFR Model (Puppo and Hayashi).

3.3 Strategies and tools for the transition to agroecological-based vegetable production systems

The "conventional" model of production based on specialization and input-based intensification has degraded natural resources and generated health and environmental risks. The process of intensification and specialization followed by the horticultural sector in the last decades brought serious consequences, such as high soil erosion rates, reduced mineralizable soil carbon, low yields, low family incomes, low labour productivity, overwork, and work-related health problems.

Agroecology (AE) is conceived as an alternative involving various approaches, science, practice, and social movement, to solve current challenges of agricultural production. AE aims to maintain or increase production by enhancing ecological processes in the agroecosystem —such as carbon, nutrient and water cycling, energy flow, and biotic regulation—, reducing the use of external inputs and minimising negative impacts on the environment and society. Thus, AE proposes guiding principles for system design and management to be thought out and implemented according to each situation. The process of transition from the current situation towards agroecological systems can be conceptualised at different levels, from increasing the efficiency of "conventional practices", to reducing the use of inputs and redesigning the production system to operate based on a set of ecological processes. The paper presents some examples of the implementation of practices and processes to translate the conceptual framework into practice (Scarlato and Colnago).

4. Concluding remarks

The Expo Melilla exhibition is another opportunity to disseminate scientific knowledge, promote informed debate among different actors and with society, come up with technological solutions to real problems, and strengthen the university's connection with society. Throughout the stand exhibition and the lectures given, there have been suggested different adaptation strategies for agriculture to mitigate climate change. Further, the studies summarized in this paper provide references to recent local research that contribute with strategies and tools for supporting the design of more resilient farming systems.

Keywords: climate change, drought, resilient farming systems, sustainability

Palabras clave: cambio climático, sequía, sistemas de producción resilientes, sustentabilidad

Palavras-chave: mudanças climáticas, seca, sistemas de produção resilientes, sustentabilidade

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Author contribution statement

Both authors wrote the paper and contributed equally to the content.

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