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Co-innovation of family farm systems: A systems approach to sustainable agriculture

S. Dogliotti [a,*], M.C. García [a], S. Peluffo [b], J.P. Dieste [a], A.J. Pedemonte [c], G.F. Bacigalupe [c], M. Scarlato [a], F. Alliaume [d], J. Alvarez [c], M. Chiappe [c], W.A.H. Rossing [e]

[a] Departamento de Producción Vegetal, Facultad de Agronomía, UDELAR, Av. Garzón 780, 11200 Montevideo, Uruguay
[b] Comisión Nacional de Fomento Rural, Dr. S. García Pintos 1138, 11800 Montevideo, Uruguay
[c] Departamento de Ciencias Sociales, Facultad de Agronomía, UDELAR, Av. Garzón 780, 11200 Montevideo, Uruguay
[d] Departamento de Suelos y Aguas, Facultad de Agronomía, UDELAR, Av. Garzón 780, 11200 Montevideo, Uruguay
[e] Farming Systems Ecology group, Wageningen University, Droevendaalsesteeg 1, 6708 PB Wageningen, The Netherlands

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ABSTRACT

Meeting the goals of sustainable growth of food production and reducing rural poverty requires assisting family farmers to develop more productive, profitable, resource efficient and environmentally friendly farms. Faced with decreasing product prices and increasing production costs during the last two decades family farmers in south Uruguay tried to maintain their income by intensifying their farms, growing larger areas of fewer crops and increasing the use of irrigation and agrochemicals. Soil degradation was aggravated by this process, limiting crop yields, undermining the farmers' aim of maintaining their income. A model-aided explorative study had shown that decreasing the area of vegetables, introducing crop rotations, cover crops and manure applications, and including beef-cattle production would be a better strategy. To test this hypothesis, a project was started at the end of 2004 and expanded in 2007, involving farmers, technical advisers and scientists in a co-innovation process that combined systemic diagnosis and redesign of the farm systems, social learning and dynamic monitoring and evaluation. The project involved 14 farms representing a large range of variation in resource endowment. Main problems found on all farms were deteriorated soil quality and low labour productivity, which resulted in low income and high work load. At the end of 2–5 years of redesign farmers had been able to implement most innovations planned. Irrespective of endowment with land, machinery, irrigation water or labour resources, re-design increased the per capita family income (FIp) and the income per hour of family labour (IH) on 13 out of 14 farms, by 51% and 50%, respectively, averaged over all farms. Soil organic carbon content had increased on 11 out of 14 farms and estimated erosion rates in vegetable fields had halved. Farmers considered 'multi-year planning' the most important change introduced into their practice by the project. They concluded that the role of the extension service agents should change from mere consultants of operational–tactical, crop-centred decisions to supporters of the process of farm planning and evaluation. The project showed that even on commercial farms operating under highly competitive conditions, substantial improvements in economic and environmental indicators can be achieved when a whole farm strategic redesign is elaborated.

1. Introduction

The larger part of the global rural population lives on family farms, which are responsible for more than half of the world's food production (FAO, 2011; IFAD, 2012). Meeting the goals of sustainable growth of food production to provide for the increasing needs of the world's population and the alleviation of poverty requires assisting family farmers to develop farm systems that are more productive, profitable, resource efficient and environmentally friendly (IFAD, 2011). However, in many regions of the world family farmers are threatened by decreasing economic returns, deterioration of the natural resource base, and lack of access to markets and knowledge (Lipton, 2005; IFAD, 2011). Thus, 'innovation' in family agriculture, understood as a process of technical and institutional changes at farm and higher levels that impacts on productivity, sustainability, and poverty reduction, is required (Rölling, 2009).

The south of Uruguay has the highest concentration of family farms in the country, many of them with vegetables as the main source of income, and the highest degree of soil erosion, with 60–70% of the area classified as moderately to severely eroded

* Corresponding author. Tel.: +598 23584560; fax: +598 23542052.
E-mail address: sandog@fagro.edu.uy (S. Dogliotti).

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(MGAP, 2004). Around 88% of the farms with vegetable production as the main source of income are family farms (Tommasino and Bruno, 2005). During the past two decades the socio-economic context was unfavourable; decreasing product prices and increasing costs of energy and agro-chemicals reduced family income both in an absolute sense and relative to the surrounding rural population. To maintain their income the strategy of most farmers was to specialize and intensify their systems growing larger areas of fewer crops and increasing the use of irrigation and agro-chemicals. Soil degradation was aggravated due to increased tillage, reduced soil cover and organic matter supply, and lack of erosion control measures. The state of the soil limits attainable crop yields and overall farm productivity and undermines farmers' strategies to maintain their income (Dogliotti et al., 2004). A major cause of this downward spiral is that the adaptation of farmers to changing conditions is mostly incremental, short-term oriented and only rarely involves strategic re-design of their rural livelihood strategies as a whole (IAASTD, 2009). As a result, livelihoods have become locked-in on unsustainable development tracks.

To identify options for sustainable development of vegetable family farms, we developed a whole-farm optimization model and carried out a model-aided explorative study in earlier work. The study showed that decreasing the area of vegetable crops by introducing long crop rotations with pastures, introducing green manures and animal manure applications during the inter-crop periods, and integrating beef-cattle production into the farm system would be a better strategy than the farmers' prevailing practice of increasing the area of vegetables and specialising in a few crops (Dogliotti et al., 2005). These results strongly suggested that there is opportunity to increase farm systems performance both in terms of productivity and impact on soil quality, even within the constraints imposed by the current socio-economic context and farm resource endowment.

To test this hypothesis we started a project at the end of 2004 with funding of INIA (national agricultural research institute) and CUDECOOP (union of production cooperatives) and participation of CNFR (a major farmers' union). The project was expanded in 2007 with support of the European Union (EULACIAS) and participation of Wageningen University. The project started from three basic assumptions. Firstly, the sustainability problems described above cannot be solved by isolated adjustments or modifications in some system components such as pest management or soil tillage. The relevance of the changes occurring in the socio-economic context and in the quality and availability of production resources at the farm level, requires the adaptation of the farm systems as a whole.

Secondly, it is possible to improve the sustainability of vegetable and mixed vegetable-beef cattle family farms by changing the organization and operation of the production systems, even in a context of low resource endowment and limited access to markets, financing, services and information. In other words, there is enough room for manoeuvre inside the family farm systems to generate significant improvements in sustainability. A per crop analysis of the 'yield gap' provides insight into the main bio-physical causes of yield variability in a region (Lobell et al., 2005; Tittonell et al., 2008). However, farmers allocate their limited resources to the different production activities to optimize performance of the whole farm, and this may conflict with maximizing yields of individual crops.

The third assumption was that solutions to problems of this level of complexity do not come as 'take it or leave it' validated packages; they need to be designed with the direct involvement of farmers in all stages of the innovation process to ensure relevance, applicability and adoption (Gibbons et al., 1994; Masera et al., 2000; Leeuwis et al., 2002). Changes in agricultural practices towards more sustainable production systems are seen as a result of a collective learning process of all actors involved in the process of change, including the researchers. We refer to this process as 'co-innovation' (Rossing et al., 2010), an approach that combines complex systems theory, social learning and dynamic project monitoring and evaluation to stimulate strategic re-orientation of family farm systems. A predecessor approach for systematic development of farming systems named 'prototyping' (Vereijken, 1997; Wijnands, 1999) has been criticized for not making an explicit effort to take into account the existing diversity among farmers in resource endowment and strategy, and for being strongly dominated by researchers (Leeuwis, 1999). The approach used in this paper involved farmers and other stakeholders from the beginning and in every phase of the process, and it was sensitive to differences in farmers' priorities and access to production resources.

The main objective of the project was to contribute to improving the sustainability of family farms in south Uruguay by engaging farmers and scientists in a joint innovation process. In this paper we present the approach developed to diagnose and re-design vegetable and mixed family farm systems and the impact on farm sustainability indicators after 2–5 years of system change.

2. Materials and methods

The study involved 20 families living on 14 farms located in Montevideo and Canelones provinces in south Uruguay, within a radius of approximately 60 km from Montevideo city. The climate in the area is temperate sub-humid with a mean annual temperature of 16.4 °C, and a mean annual precipitation of 975 mm fairly evenly distributed throughout the year but with major variation between years (Furest, 2008). Water deficits occur frequently between October and March and water surpluses between May and August. Topography ranges from very gently undulating to undulating (slopes 0–6%).

The 14 farms were selected to represent a large range of variation in resource endowment, soil quality and distance to the market. Willingness of the farmers to discuss strategic choices, and their involvement in local farmer's groups were further important selection criteria. The approach involved characterization and diagnosis of the farm system's sustainability, re-design, implementation, and monitoring and evaluation of system evolution.

2.1. Characterization and diagnosis

During characterization and diagnosis we described the structure and functioning of the farm systems based on the idea that a farm is composed of two interacting subsystems: the management subsystem and the production or bio-physical subsystem (Sorrensen and Kristensen, 1992). The management subsystem is composed of the persons who make decisions about the farm, their objectives, decision criteria and decision rules. The production subsystem includes the production resources: family and hired labour, energy and other inputs, machinery and infrastructure, soil area and quality, and water availability; the allocation of these resources to different production activities in time and space; and the desired and undesired results from the production activities in terms of performance indicators.

We studied the management system through two in-depth interviews with the farmers and their families and by studying their farm records. We assessed the management team (MT) composition, the farm succession and life cycle stage, the type of bookkeeping used, the distribution of tasks among MT members, the education level and the main sources of technical information. The production system was characterized through several interviews with the farmers and by direct observations and measurements on the farms. Farm field sizes and their slopes were