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## Redesigning a dairy system based on agroecological principles using a collaborative method

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### 1 Introduction

Dairy farming in Western Europe has to cope with increasing societal demands (*i.e.* not only milk production but also environment preservation, scarce resources savings, livestock welfare, maintenance of landscape...) in a context of growing uncertainty (climatic hazards, price volatility of farm products and inputs, epizootics...). To face these new challenges, the French National Institute of Agronomy (INRA) tasked three researchers with devising and building, together with experts and stakeholders, an innovative forage system breaking away from existing patterns. This paper explains the methodology used as well as the main objectives and principles of the devised system.

### 2 Materials and Methods

In order to favour a real break from existing systems and to improve in deep the sustainability of the whole forage system, we decided to redesign it in a systemic way, as proposed by Hill & Mc Rae (1995). This approach allows widening the scope of possibilities and fits in with the „*de novo*’ design as conceptualised by Meynard *et al.* (2012).

The method consisted first to cross-fertilise the ideas of a group of fifteen participants, gathering farmers, extension agents, technical institute engineers, a farm manager of an agricultural school, environmental association and agency representatives and researchers from various disciplines.

In 2012, three one-day workshops based on creativity, listening and kindness permitted to these participants from various disciplines and horizons to i/ agree on the general objectives which have to be targeted by the new dairy system, and ii/ propose new ideas jointly deepened by the group to meet these goals. Thereafter the three appointed researchers render coherent these multiple proposals, by considering an agroecological approach at the system level (Novak *et al.*, 2013). From the end of 2012, a second group gathering seven experts in agronomy, animal production, forage systems, environmental assessment, and agroforestry already present in the first conception group, built the system operationally. Technicians devoted to the implementation of this new system were also involved in this work. The building of the system began by a clarification of its objectives and by a deepening of the first ideas using a similar methodology as that conceptualised by Hatchuel and Weil (2009) in terms of innovative design. During this work the reflection was broadened to include the livestock farming system which was designed to be consistent with the new devised forage system. The second group also clarified the research hypothesis tested in this project.

### 3 Results – Discussion

#### The main objectives of the system

The participants in the design process decided that the main objective of the resulting system will be to permit farmers to live from milk production in a context of climatic hazards while saving scarce resources (water and fossil energy) and contributing to a sustainable agriculture. The sustainability of the system is appreciated regarding its ability to preserve the diverse compartments of environment and to contribute to the attenuation of climate change, while satisfying the demands of farmers and civil society, and improving the welfare of animals. We decided to call such systems aiming to use efficiently natural resources while respecting them and satisfying the expectation of its users as “bioclimatic systems” (in analogy with bioclimatic architecture).

This system aims thus to deliver a diversified panel of ecosystem services and especially, as classified by Zhang *et al.* (2007), provisioning services (milk, cash crops, timber production), supporting services (soil fertility, nutrient recycling, biodiversity) and regulating services (pollination, natural control of pests, water purification).

### The main principles of the system

The system relies on an agroecological approach at the farm level aiming to optimize the interactions between forage, crop and livestock systems, so as to save water and energy resources and to secure the forage production. It is based on the diversification of forage resources, the development of grazing, a larger use of legumes, the recycling of water and nutrients, and on a consistent strategy for the livestock system. The production of forage resources relies on three crop rotations (Novak *et al.*, 2014a), one being totally grazed, with diversified multispecies grasslands and annual crops, associated with legumes, and also on the grazing of fodder trees and shrubs. The herd reproduction (Novak *et al.*, 2014b) is based on two calving periods centered on spring and autumn, to ensure the coherence with the availability of grazed forage resources, and to overcome climatic hazards which could occurred at one period. The lactation length is extended to 16 months (calving interval of 18 months) for limiting the non-productive time during cow lifetime, and the negative environmental impacts associated. As this dairy system needs more robust cows, with good reproduction capacity, and well adapted to grazing and to forage resources of contrasting quality, we decided to use a three-way crossing of dairy breeds (Holstein, Scandinavian Red, Jersey).

The innovations relate thus mainly with:

1/ the **diversification of the elements of the system**, from the vegetal component (various crop species, cultivars and mixtures), to the animal component (crossing of three breeds, two calving periods), through the functions these elements may fulfill (*e.g.* fodder trees, dual purpose crops, weed control by grazing). These ideas agree with the current trend that diversity in farming systems could reduce their vulnerability to climate change (Mijatovic *et al.*, 2013) while contributing to provide multiple ecosystem services (Kremen *et al.*, 2012).

2/ a **valorisation of all the spatial dimensions** of the system, by introducing a vertical axis thanks to agroforestry which allows a more efficient use of solar radiation and nutrient and water resources. The **temporal dimension** of the system is also reconsidered either in the cropping system by limiting periods of bare soil in the crop rotation, or in the livestock system by taking into account the milk production at the cow lifetime instead of at one single lactation.

The main research hypothesis tested is that the increase of diversity in a dairy production system allows to conciliate good production levels and high environmental performance, and to improve the resilience of the whole system.

This new system began to be implemented in June 2013, at an INRA facility located in Lusignan (Poitou-Charentes, France) on 90 ha and with 72 dairy cows devoted to it. The first calvings resulting from the crossing of the initial Holstein herd with semens of Scandinavian Red and Jersey, as well as the first implementation of agroforestry plots occurred in 2014.

### 4 Conclusion and perspectives

This innovative dairy system brings together a new combination of elements, some of them being original and sometimes risky while being promising. Its implementation and long term study at the farm level opens the way to innovative approaches in terms of experimentation, indicators and partnership. Collaborations with scientists in agronomy, livestock research, animal and plant genetics and in environmental assessment will be developed in order to characterise this agroecological system and its evolution. This project also aims to give farmers the keys for a successful transition as well as operational results on these new diversified and saving off-farm inputs systems.

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