Integrated protection of fruit crops
IOBC-WPRS Bulletin Vol. 91, 2013
pp. 531-535

Application of DEXiPM® as a tool to co-design pome fruit systems towards sustainability

Aude Alaphilippe[1], Frédérique Angevin[1], Jan Buurma[2], Tito Caffi[3], Yvan Capowiez[1], Gabriele Fortino[1], Bart Heijne[2], Herman Helsen[2], Imre Holb[4], Martina Mayus[5], Vittorio Rossi[3], Sylvaine Simon[1], Jörn Strassemeyer[5]
[1]INRA, UE0695 Unité Expérimentale de Recherches Intégrées de Gotheron, 26320 St-Marcel-Lès-Valence, France, INRA UAR1240 Eco-Innov, 78850 Thiverval-Grignon & INRA, UR1115 Plantes et Systèmes de culture Horticoles Domaine St Paul, site Agroparc, 84914 Avignon Cedex 9, France; [2]Applied Plant Research, Wageningen UR, P.O. Box 200, 6670 AE Zetten, The Netherlands; [3]CNR, Consiglio Nazionale delle Ricerche and Istituto di Entomologia e Patologia vegetale, Università Cattolica del Sacro Cuore, via Emilia Parmense 84, 29122 Piacenza, Italy; [4]University of Debrecen, Centre of Agricultural Sciences, 4032 Debrecen, 138 Boszormenyi street, Hungary; [5]JKI, Julius Kühn-Institute, Federal Research Centre for Cultivated Plants, Stahnsdorfer Damm 81, 14532 Kleinmachnow, Germany

Abstract: The design of fruit production systems considering the latest innovations is a real challenge. Before being tested in an experimental station or in real farm conditions, the global sustainability of these newly designed orchards needs to be evaluated.

Based on the DEXiPM® model, the DEXiPM-pomefruit tool has been designed to make an *ex ante* assessment of the sustainability of innovative orchard systems. This model is based on a decision tree breaking the decisional problems of sustainability assessment into simpler units, referring to the economic, social and environmental dimensions of sustainability.

Based on two case studies, we present here the steps and thought process of our group to improve fruit production systems towards innovative and integrated production systems. DEXiPM-pomefruit tool has been tested on apple and pear production systems in the frame of a working group of European researchers. It proved to be sufficiently reliable to select the most promising innovations in a given context. DEXiPM-pomefruit was also used as a dashboard to determine strengths and weaknesses of the tested production systems and therefore to identify improvements.

Key words: multicriteria evaluation, sustainability, *ex ante* assessment, fruit production system

Introduction

The European agricultural policy requires the implementation of integrated pest management (IPM) by 2014. As defined by IOBC guidelines (Malavolta & Cross, 2009), IPM aims at improving the environmental efficiency of protection strategies by promoting the use of alternative methods (*e.g*. mechanical weed control) and non synthetic active ingredients (e.g. microbiological products against moths), whereas the use of synthetic pesticides is permitted as last resort or under conditions. However a survey among the European partners of the PURE programme (Pesticide Use-and-Risk reduction in European farming systems with Integrated Pest Management) reveals low adoption of non-chemical tools such as granulosisvirus and sanitation in pomefruit production. Consequently, there is still a high potential to reduce pesticide use. This reduction requires the implementation of existing non-chemical tools as well as innovative methods within a comprehensive management strategy addressing all major pests and diseases. This implementation process relies on a design-assessment-adjustment cycle, that will be adapted to ensure continuous validation and improvement of the IPM solutions.

The aim of this paper is to present the methodology used along such a cycle, focussing on the tool developped to design then to provide an *ex ante* assessment of the sustainability of innovative pomefruit farming systems. The design process comprises two steps. Firstly, thanks to an expert approach, different production strategies that integrate or not various IPM tools are described. Secondly, an *ex ante* assessment of the proposed production strategies is performed to determine the most suitable systems considering the objectives (reducing pesticides and increasing/enhancing the overall system sustainability).

Two practical applications are presented and used to discuss the interest of the tool.

Methods

This section is structured as follows: firstly, the multi-attribute model is described by its components and structure; secondly, the two case studies (one for apple production and one for pear production) are detailed.

DEXiPM® tool for pome fruit

DEXiPM® (Pelzer *et al.*, 2012) is a hierarchical and qualitative multi-attribute model (or multi-criteria model) permitting the evaluation of cropping system sustainability according to several and sometimes conflicting goals. DEXiPM® has been implemented within the DEXi decision support system (Bohanec, 2009). Briefly, the overall sustainability is divided up into smaller and less complex problems, characterized by attributes (or criteria) that are organized hierarchically into a decision tree.

In DEXi, attributes are characterized by their name, a description and a scale, *i.e.*, possible qualitative values for the attribute (discrete values described as words rather than numbers, *e.g.*, ‘low, medium, high’). Even if scales are qualitative, some can be based on quantitative values (*e.g.*, the yield). Attributes are either basic (attributes that the user will inform when describing a production system) or aggregated (resulting from an aggregation of immediate descendant attributes, aggregation rules being described in utility functions). For DEXiPM-pomefruit, the choice of attributes (including basic attributes), their hierarchy in the decision tree and the qualitative classes have been validated by experts from various disciplines including agronomy, economy and sociology. The choice of utility functions determining the aggregation of attributes consists in “if-then” rules. Basic attributes are inputs of the model, describing the system as well as the context of the assessment (climatic conditions, taxes, regulation, supply chain organisation, *etc*). These context attributes might be modified to assess which changes in the context will make an innovative system acceptable for the farmer, when this system is not acceptable in the current context.

DEXiPM-pomefruit can be used to evaluate the global sustainability of production systems and also as a «dashboard» to analyse and improve a given system: all aggregated criteria are stand-alone indicators, when compared to a referent scenario. Analysing these criteria values gives explanation on the final result and performances of the assessed systems.

Pear case study

Two pear production systems located in The Netherlands were compared: one standard system with a high number of insecticides applications targeted to pear psylla and one innovative IPM system, which combined a number of strategies to prevent infestation of this pest. The presence of natural enemies was promoted not only by planting extra hedgerows, but also by sowing companion plants. The advantages of flower strips in the direct vicinity of pear trees is similar to that of hedgerows: they offer alternative food like alternative preys, nectar and pollen. Apart from the anthocorid bug (*Anthocoris nemoralis* Fieber, 1837), the flower strips also benefit the earwig (*Forficula auricularia* Linnaeus), an important predator of pear psylla. Furthermore, broad-spectrum insecticides were replaced by selective ones to avoid negative side effects on natural enemies.

Apple case study

Two apple production systems were compared: one with exclusion netting against codling moth and one without. Both farming systems were representative of fruit grower practices.

Briefly, the studied orchards located in the South-East part of France were planted with the cultivar Pink Lady® cultivar. Globally, exclusion netting decreased the pesticide use measured by the treatment frequency index (TFI) by 30 % (Severac & Romet, 2009). Exclusion netting also represents a good protection against yield loss risk due to climatic conditions (*i.e.* hail). However, it has a non-negligible cost and requires therefore an important investment capacity. Experimental results did not display a potential increase of diseases or quality loss of the fruit production under nets.

Results and discussion

Pear case study

The introduction of an advanced system for pear psylla control did not affect social aspects, but the environmental performances improved (Figure 1).

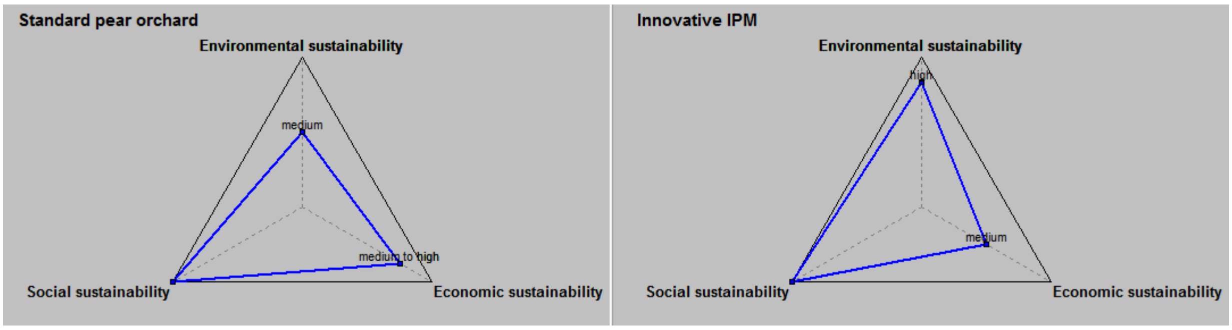

Figure 1: Performances for the three pillars of sustainability – Two case studies of pear production in the Netherlands.

The economic performance was strongly affected by the size of the orchard surface area that was assigned for planting extra hedgerows, which divides large scale orchards into smaller units (Figure 2). Especially in fruit growing areas with a high cost of land use, the reduction of the productive area had a strong effect on the economic and overall performance of the system.

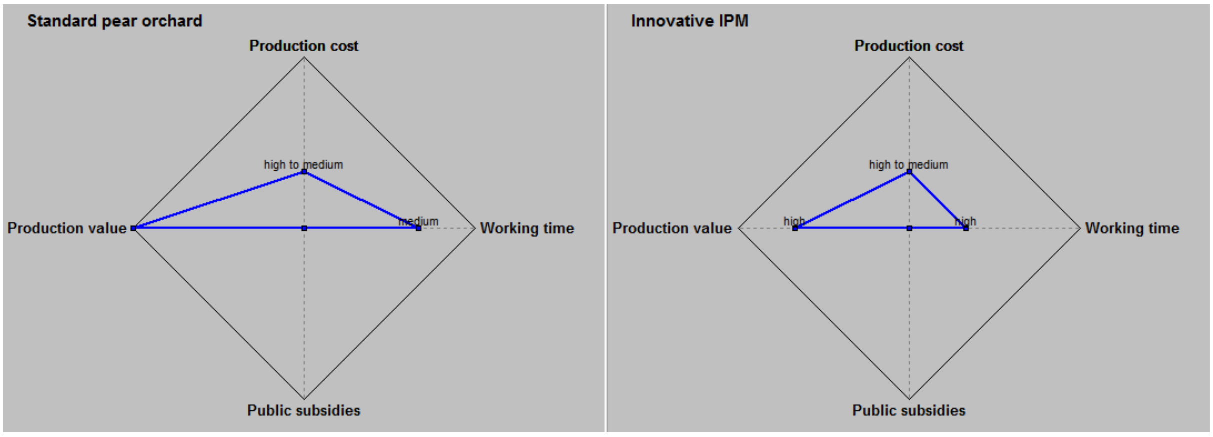

Figure 2: Comparison of four economic indicators in the two production systems studied for pear production in the Netherlands.

Apple case study

The global evaluation of the Rhône Valley apple case studies ranked the exclusion netting system better than the uncovered system (Figure 3). The social assessment was similar for both production systems, since valuable cultivars were planted in the considered orchards. In contrast, environmental and economical performances were improved in orchards covered with nets. The important decrease in pesticide use contributed to decrease all environmental impact attributes.

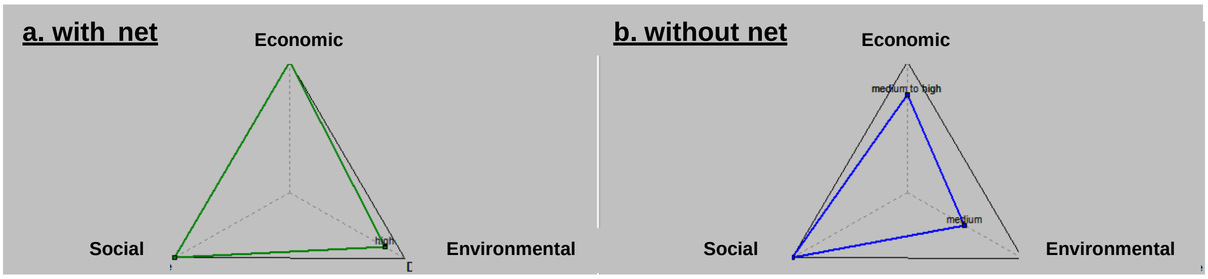

Figure 3: Global result of DEXiPM model for sustainability performance of (a) exclusion netting and (b) uncovered systems in apple production in the Rhône Valley, France.

The global economic stability (Figure 4) was identical for both production systems, but all other attributes were different. Exclusion netting was more favourable compared to the uncovered production systems, since the nets represent a good protection against climatic risk of yield loss. However, the investment capacity and the potential profitability of netted systems were decreased compared to the uncovered reference due to the heavy financial cost of this protection method. Labour cost was also increased under nets, since they globally constrain some cultural practices (*e.g.* hand thinning) in the orchard.

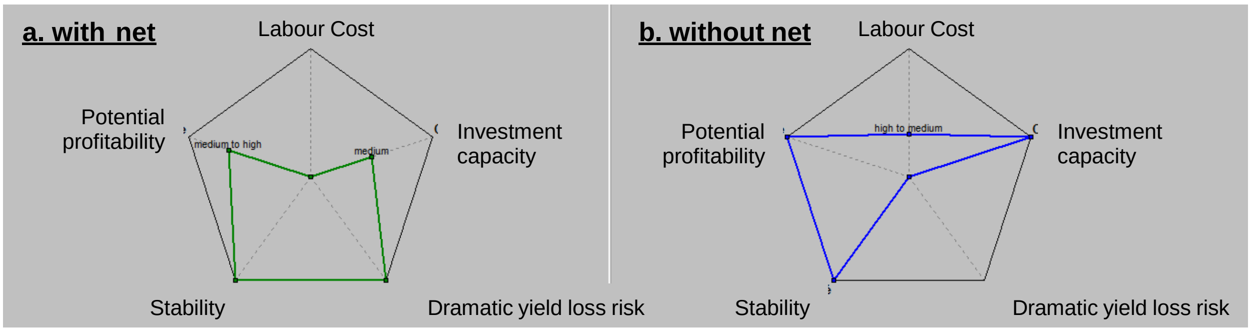

Figure 4: Detailed results of DEXiPM model for economic sustainability performance of (a) exclusion netting and (b) uncovered systems in apple production in the Rhône Valley, France.

Conclusions

DEXiPM-pomefruit will be further improved through the assessment of several other production systems over several agro-climatic contexts in Europe. But it already proved to be easy to use and not too time consuming. DEXiPM-pomefruit has also been used as a dashboard to determine strengths and weakness of the evaluated orchard systems and to identify possible improvements.

Last, DEXiPM-pomefruit represents an opportunity for simulation-based design, since it supports co-design approach. It also encourages interactions among users and thus facilitate communication and knowledge transfer.

Acknowledgements

This work is partly included in the PURE project, supported by the European Commission through the Seventh Framework Programme under grant agreement number: FP7-265865. We also thank the French office for Water (ONEMA) for funding this work within the frame of the research call 2009 of the program "Risk evaluation and reduction of pesticides use", axis 3 of the French “Ecophyto 2018” plan.

References

Bohanec, M. 2009: DEXi: program for multi-attribute decision making, Version 3.02. Jozef Stefan Institute, Ljubljana. http://www-ai.ijs.si/MarkoBohanec/dexi.html

Malavolta, C. & Cross, J. 2009: Guidelines for Integrated Production of Pome Fruits. IOBC Technical Guideline III. IOBC-WPRS Bull. 47: 13.

Pelzer, E., Fortino, G., Bockstaller, C., Angevin, F., Lamine, C., Moonen, C., Vasileiadis, V., Guérin, D., Guichard, L., Reau, R. & Messéan, A. 2012: Assessing innovative cropping systems with DEXiPM, a qualitative multi-criteria assessment tool derived from DEXi. Ecol. Ind. 18: 171-182.

Severac, G. & Romet, L. 2009: Dossier pomme. Alt'Carpo: Dire définitivement « halte » au carpocapse. L’arboriculture fruitière 633: 22-24.