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Multicriteria evaluation of innovative IPM systems in pome fruit in Europe

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ABSTRACT

Pesticides represent the major input in pome fruit across Europe. They are mainly used on a calendar-based approach in order to control a large number of pests and diseases causing both direct and indirect losses. This situation has stimulated research for innovative tools and methods for pest management and the PURE project (www.pure-ipm.eu) organised a biointensive framework to demonstrate that several solutions are now available but they need to be properly transferred to the growers to be applied on a large scale. This paper presents the experience of the PURE project across demonstration orchards in different countries. The aim was to develop a multicriteria evaluation to help more clearly define the advantages and disadvantages of applying innovative Integrated Pest Management (IPM) systems, for different pests (pear psylla and apple codling moth) and diseases (pear brown spot and apple scab) on pome fruit, compared to standard IPM (i.e. currently adopted IPM system). The multicriteria approach permitted to assess environmental risks, economic effects and sustainability impact for each of the innovative systems tested. This multicriteria assessment showed that, in general, innovative performed better than standard for environmental quality and provided similar yield and pest management without any significant extra costs.

1. Introduction

The EU Directive 2009/128/EC (European Parliament and council, 2009) sets rules for the sustainable use of pesticides to reduce the risks and impacts of pesticide use on human health and the environment by promoting low pesticide-input strategies for disease and pest management including non-chemical methods. This directive requires the implementation of Integrated Pest Management (IPM) from 2014 onwards. As defined by IOBC (International Organisation for Biological and Integrated Control) guidelines, IPM aims at improving the environmental efficiency of protection strategies by promoting the use of alternative methods and non-synthetic active ingredients (e.g., bio-control agents, BCA), whereas the use of synthetic pesticides is as a last resort and under restrictions (Malavolta and Cross, 2009). These objectives were clarified in eight general IPM principles (Barzman et al., 2015).

The basic IPM strategy focuses on minimising the use and impact of pesticides. Therefore, emphasis is put on preventive (indirect) measures before direct control measures are applied (IOBC/WPRS, 2012). For direct control methods, preference is given to all forms of non-chemicals: including biological (natural enemies and BCAs) and physical as listed in Lamichhane et al. (2016).

However, surveys conducted among the European partners of the project PURE (http://www.pure-ipm.eu/) and within the ENDURE Network of Excellence (http://www.endure-network.eu/) revealed low adoption of non-chemical and there are still low-input farming systems in Europe (Femenia and Letort, 2016).

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Consequently, there is a high potential to reduce pesticide use. This reduction requires the adoption of existing non-chemical tools as well as innovative methods to be integrated into a comprehensive approach (i.e. target all major pests and diseases), reaching the third level of adoption as defined by Prokopy (1994). In the last decades, many studies focused on phasing out broad spectrum insecticides toxic to natural enemies of pests, enhancing the use of mating disruption, and increasing the quality of monitoring tools and methods to forecast pest epidemics (Way and van Emden, 2000). All this has permitted a significant progress towards a rationale use of pesticides. However, the growers lack objective information on the performances of those new methods, with a risk of poor field adoption. Among promising IPM, leaf shredding and fungal antagonist application significantly decreased the inoculum dose of *Venturia inaequalis* in apple orchards and made apple scab management easier (Holb, 2006, 2008). Similarly, application of BCAs to the pear orchard ground cover resulted in the reduction of the overwintering inoculum of *Stemphylium vesicarium* (Rossi et al., 2005, 2008; Rossi and Pattori, 2009; Llortente et al., 2010). In addition to sanitation, other IPM tools have been developed for pest/disease monitoring and forecasting: the BSP disease model for brown spot on pear (Llorente et al., 2000a,b), the A-Scab model for apple scab (Rossi et al., 2007), the codling moth *Cydia pomonella* phenological model (Rock and Shaffer, 1983), the sequential sampling for classification procedure to classify scab incidence (Carisse et al., 2009). Exclusion netting has been successfully used against codling moth on apple (Severac and Romet, 2009).

The work on fruit production within the PURE project aimed at demonstrating the readiness to use and the on-farm applicability of innovative IPM system for key pests and diseases on pear and apple orchards. The tested methods had already been proven to be effective. They were either preventive as the use of a warning system for scheduling fungicide applications (Llorente et al., 2000a; b), the use of antagonists to reduce the overwintering inoculum of brown spot of pear (*Stemphylium vesicarium*) (Rossi and Pattori, 2009) and the promotion of natural enemies to control pear psylla (*Cacopsylla pyri* and *C. pyricola*) or direct with sanitation against overwintered conidia of *V. inaequalis* (Holb et al., 2004) and physical barrier such as exclusion nettings against codling moth (*Cydia pomonella)* (Severac and Romet, 2009; Chouinard et al., 2016).

Demonstration experiments were set up in Italy, France, Hungary and the Netherlands during the PURE project in order to analyse the pros and cons of the adoption of the innovative IPM systems directly on-farm. The approach was based on cropping system experiments, which are used in agricultural research in order to address complex issues related to the sustainability of cropping systems (Simon et al., 2016). System experiments differ from factorial experiments because they are focused on the evaluation of consistent sets of technical choices and their interactions in a given context (i.e., the system) and not only one or a few factors and their variations. As a consequence, the performances of the designed cropping systems are not assessed using one or a few agronomic variables, but through a multicriteria evaluation in a comprehensive perspective (Alaphilippe et al., 2013). Although scarce and recent in perennial crops, system experiments have proven to be effective in highlighting advantages and limits of tested sets of technical choices (e.g. Simon et al., 2011).

Technical results, as well as pesticide use reductions for each system, are only briefly presented in this paper because our main objective was to apply the multicriteria approach to evaluate innovative systems and/or techniques. This multicriteria approach combines i) the environmental risk assessment, ii) the economic cost-benefit analysis and iii) the overall sustainability estimation of the innovative system compared to the standard. The use of a precise methodology for multicriteria approach is essential to help advisors design and implement the most sustainable IPM strategies (Vasileiadis et al., 2013). The present assessment results on the pome fruit case study can be used to show the fruit growers the advantages and disadvantages in adopting innovative IPM strategies. Furthermore, the tested approach can be extended to other crops and pathosystems. The main goal of this study was to evaluate innovative IPM systems in pome fruit production – compared to standard – using a set of indicators provided by SYNOPS-WEB, Cost/Benefit Analysis and DEXiPM-pomefruit® with a multicriteria assessment approach.

2. Material and methods

2.1. Standard and innovative IPM systems

The innovative IPM system was compared to the standard representative of the area along two growing seasons (2013 and 2014). Both systems are briefly described for each country and for the management of each insect pest and disease.

2.1.1. Pear brown spot (Italy)

S. vesicarium is the causal agent of brown spot disease on pear which represents a major threat for the growers in Italy, in particular in the North-East of the country. The disease can cause relevant yield losses since affected fruits cannot be sold as premium quality and its management is entirely based on fungicide applications, usually performed on a calendar basis, at 7–14 day intervals for an average of 15–25 times/year (Llortente et al., 2010).

On-farm experiments were conducted in commercial orchards in Modena (2013) and Ferrara (2013 and 2014) districts. Two pest and disease management systems were compared for one season in each location:

i) Standard system: It is based on fungicide applications scheduled according to the weekly public extension service bulletin and represents the current practice of the production area in Northern Italy;
ii) Innovative IPM system: It is based on the use of a Decision Support System (DSS) for scheduling fungicide applications (Llorente et al., 2000a,b) combined with leaf litter removal and periodical applications of BCA (commercial formulates of *Trichoderma* spp.) (Rossi and Pattori, 2009; Llortente et al., 2010).

2.1.2. Pear psylla (Netherlands)

Pear psylla (*C. pyri* and *C. pyricola*) is the main arthropod pest in European pear orchards. It has multiple generations per year, a large reproductive capacity, and it readily develops resistance to pesticides. The main damage is due to the production of large amounts of honeydew on which sooty moulds develop, leading to soiled and russeted fruits. IPM systems aim at keeping the psylla populations at an acceptably low level throughout the year. Many factors may regulate pear psylla to some extent. However, sufficient control is achieved only when the presence of a range of active natural enemies is combined with cultural control measures and the use of certain selective pesticides (Trapman and Blommers, 1992).

A study group of pear growers was formed and winter meetings with growers, advisors and researchers were organised. Innovative pest and disease management system was discussed and agreed upon for adoption. Growers chose to adopt a selective pesticide scheme to avoid undesired side effects on natural enemies. Two pear psylla management systems were compared in five farms:

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