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BI4IPM:
A Business Intelligence System for the Analysis of Olive Tree's Integrated Pest Management

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ABSTRACT

The Agri-Food sector is facing global challenges. The first challenge is feeding a world population that will reach 9.3 billion people in 2050, according to UN projections. The second challenge is the demand from consumers for high-quality products obtained through more sustainable, safe and clear agri-food chains. Integrated pest management (IPM) could be an important instrument for helping farmers face these challenges. IPM requires the simultaneous use of different crop protection techniques to control pests through an ecological and economic approach. This work explores the possibility of developing a framework that combines business intelligence (BI) technologies with IPM principles to support farmers in the decisional process, thereby decreasing environmental cost and improving production performance. The proposed BI system is called BI4IPM, and it combines on-line transaction processing (OLTP) with on-line analytical processing (OLAP) to verify adherence to the IPM technical specifications.

KEYWORDS

Business Intelligence, Data Models, Integrated Pest Management, OLAP, Olive Tree, OLTP

1. INTRODUCTION

The Agri-Food sector is facing global challenges. The first challenge is feeding a world population that will reach 9.3 billion people in 2050, according to United Nations projections (United Nations [UN], 2013). The second challenge is the demand from consumers for high-quality products obtained through more sustainable, safe and clear agri-food chains (Grunert, 2005; Seuring & Müller, 2008). To address these challenges, farmers need to increase the quality and quantity of production and reduce the environmental impact through new management strategies and tools. In this context, farm management information systems (FMISs) play an important role. FMISs have been defined as a "planned system for collecting, processing, storing, and disseminating data in the form needed to carry out a farm's operations and functions." (Sorensen et al. 2010). According to (Fountas et al., 2015), FMISs provide functionalities for field operations management, best practice tools[1], finance, inventory, traceability, reporting, site-specific tools, sales, machinery management, human resource management,

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and quality assurance. FMISs can be viewed as OLTP (on-line transactional processing) systems for analyzing spatial data. The term OLTP refers to systems in which queries achieve transactions that read and write a small number of records from different tables (Harizopoulos, Abadi, Madden, & Stonebraker, 2008). An OLTP system must guarantee reliable transactions on data, recovery from every possible data fault and data consistency, all within a high level of "competition" (parallelism/concurrency of accesses) (Schaffner, Bog, Krüger, & Zeier, 2008). Incorporating the integrated pest management (IPM) framework into FMISs appears to be mandatory to help farmers face the challenges of sustainable agriculture. IPMs require the simultaneous use of different crop-protection techniques for the control of insects, pathogens, weeds and vertebrates through an ecological and economic approach (Prokopy, 2003). The aim is to combine different techniques to control pest populations below an economic damage threshold (Chandler et al., 2011). The relevance of the IPM is underlined by the EU, which has recognized IPM as having a central role in reducing the reliance on the use of conventional pesticides in the context of the Framework Directive 2009/128/EC (European Parliament [EP], 2009) on Sustainable Use of Pesticides.

Unfortunately, IPMs are manually fulfilled by farmers, and IPMs from different campaigns and farms are not shared and stored. Therefore, using past IPMs to research best sustainable practices appears difficult. This is an important limitation in supporting farmers in the decisional process for improving environmental and production performances.

Therefore, in this work, we extend previous research (Zaza et al., 2017) by exploring the usage of the data warehouse (DW) and on-line analytical processing (OLAP) systems for IPM analysis using an FMIS. Contrary to OLTP systems, DW and OLAP systems are business intelligence (BI) technologies allowing for online analysis of a massive volume of multidimensional data. Warehoused (spatial) data are stored according to the multidimensional model (Gallo, De Bonis, Perilli, 2010; Kimball & Ross, 2013). Data are organized by dimensions and facts. Dimensions are represented by the analysis axes and are organized into hierarchies (for example, cities, departments and regions). Facts are represented by the analysis subjects and are described by numerical attributes called measures (for example, the quantity of sold products). Measures are explored with the OLAP operators, which allow navigation into the DW. Common operators include Slice, which allows the selection of a subset of warehoused data, and Drill, which allows for the navigation into hierarchies aggregating measured values using SQL aggregation operators (i.e., MIN, MAX, SUM, AVG, etc.).

In particular, in this work, we present the FMIS used to verify compliance with the requirements included in the general part of the IPM technical specification. The result is a BI system, called BI4IPM, that combines the FMIS and OLPT approaches for the general IPM indications with the DW and OLAP systems that are focused on the IPM defense rules.

The paper is organized in the following way. Section 2 presents our data models for the analysis of the IPM General Part and Defense Rules; Section 3 details its implementations; Section 4 presents a state-of-the-art FMIS and OLAP application in the agricultural domain; and Section 5 concludes the paper.

2. DATA MODELS FOR OLIVE TREE IPM

The Framework Directive 2009/128/EC (EP, 2009) on Sustainable Use of Pesticides obliges all professional users of pesticides to apply the IPM approach in the European member countries since 1 January 2014. The task of the Member States is to combine the eight IPM principles (Barzman et al., 2015) to achieve the crop technical specifications. For example, in Italy, each region develops its own guidelines, taking into account the agro-environmental conditions, the present crops and the related pests.

The application of the IPM principles ensures farms a better performance from the sustainable and economic perspectives. Furthermore, in some regions, such as the Apulia Region with the Measure 10.1.1 of the Rural Development Programme (RDP) 2014–2020, the diffusion of certified integrated

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