A Decision Support System for Sustainable Vineyard Management

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ABSTRACT

vite.net[®] is an interactive, web-based DSS for sustainable vineyard management which was developed in such a way to overcome all the limitations (both technical and of low acceptance by end-users) met by the DSSs for crop management developed up to now. vite.net[®] is targeted to the vineyard manager (i.e., the person who makes decisions or provides consultancy about the vineyard management) and includes several components such as decision supports for canopy management and for disease and pest control, indicators of the eco-toxicological impact of the plant protection products, alerts on potential abiotic stresses (cold temperature damage and water stress), and estimates of the pending yield. Thanks to its holistic vision of the vineyard management problems, the accessibility and versatility of the service as well as the intuitive and interactive nature of the web-portal, vite.net[®] is a unique tool in the current panorama of DSS for grape production.

Keywords: Sustainable agriculture, integrated pest management, informed decision.

1. INTRODUCTION

Application of Decision Support Systems (DSSs) to crop management has gained increasing importance since the 1980s. Despite their promises, DSSs have contributed little to practical Integrated Crop Production because of the so-called 'problem of implementation', that is the "lack of sustained use in a way that influences practice" (McCown, 2002 and 2012). In particular, under-utilization of the DSSs can be ascribed to both technical limitations and farmers' attitude towards decision making and perception of DSSs (Gent et al., 2011; Matthews et al., 2008; Rossi et al., 2012).

vite.net® is a DSS for sustainable vineyard management, developed during the EU-FP7 project MoDeM_IVM and purposely designed to overcome such a problem of implementation.

2. MATERIAL AND METHODS

vite.net® was developed by adopting the approach described by Magarey et al. (2002), who depicted a twenty-first century DSS as a "super consultant" tool that: 1. incorporates overall management solutions for growers; 2. should not be designed or used to replace the decision maker but to help her/him in making choices by providing additional information; 3. must be delivered through the Web, for an easy and continuous updating; 4. should have greater automation of interpretation than the current DSSs. Moreover, the DSS focused also on aspects leading to a positive acceptance by the end-users. Specifically, vite.net® is targeted to the vineyard manager, i.e., the person who makes decisions about the vineyard management or suggests the proper actions to the grape-grower (e.g., technicians of growers consortia, cooperatives or large farm enterprises, or private advisors).

3. RESULTS

vite.net® is accessible via the website of Horta S.r.l. (www.horta-srl.com). The users consult the DSS whenever they need information for deciding whether to perform a management action or not.
vite.net® provides support tailored to a vineyard (or a part of a vineyard or number of vineyards) that can be managed in an uniform manner all season long and that is classified into the DSS as a "Crop Unit" (CU).
Only once, when they first access vite.net®, the users need to fill in for each CU a form with site-specific information that does not change over the season (*static information*), such as the cultivar, trellis system, distance between the rows, distance between vines within the row, soil texture, etc.

vite.net® collects, organizes, and integrates in an automatic way the static information provided by the user and the information constantly coming from weather sensors installed in the vineyard. The system analyses these data by means of modelling techniques and produces supports/alerts on the basis of model outputs. The mathematical models working within vite.net® were developed in the MoDeM_IVM project or retrieved from literature and adapted/calibrated for properly fitting the DSS architecture.

3.1 The Functionalities of vite.net®

After the log-in to the DSS, the user selects one of the CUs he/she is managing and gets access to the alerts and supports tailored on such CU. The system first displays a main page (Figure 1), from where it is possible to access the DSS functionalities, which

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provide information in real-time and can be explored at different level of detail. In general, two levels of details are available: i) a synthetic info, which shows the key information updated at the time of consultation and promptly communicates the level of alert (for most functionalities the synthetic overview is shown in the DSS main page of Figure 1, while for others it is accessible by clicking on dedicated buttons on the bottom-right side of the same page); ii) an in-depth info, which shows in graphic forms the seasonal dynamic of the outputs calculated by using both recorded meteorological data and weather forecast. The graphic layout of the outputs is simple and intuitive and makes a functional use of colours.

Figure 1 – Main page of vite.net[®]

For example, the synthetic information on diseases is provided in the form of small dashboards, one for each disease (see window on the top left in Figure 1), showing an index of alert, the level of which is represented by colours varying from green (low alert), to yellow, to orange and up to red (very high alert). The in-depth information is accessible by clicking on the disease dashboard and shows graphs of the temporal evolution, at daily interval, of the different phases of those processes which lead to the infection and the outbreak of symptoms (Figure 2). A third level of detail is represented by a support indicating the appropriateness of performing a fungicide treatment.

The functionalities embedded in the DSS are accessible from the dash board of Figure 1 (either from a window, showing a synthetic overview, or from buttons) and are the following.

Weather data (button): overview of the most recent hourly data recorded by the sensors installed in the vineyard and graphs of the daily values of rain, leaf wetness, air temperature and relative humidity from the beginning of the season (1st of March).

Field diary (button): chart for recording each management action and its relevant associated information, such as for instance the dose of the plant protection product distributed.

Pesticide impact (button): indicators of the eco-toxicological impact of the plant protection product distributed.

Scouting (button): summary of the information/data collected by means of the monitoring activities performed in the vineyard. Even though the DSS is stand-alone (it works without receiving data from a vineyard monitoring) the accuracy of the DSS output benefits from additional information collected in the vineyard during the season (e.g., the plant phenology, the presence/absence of insect pests or diseases) which can be inserted via the DSS portal in a specific section or by using scouting devices (e.g., cell phone, camera, tablet, etc.).

Crop Unit (button): list of all the CUs created by the same user and associated to the same weather station/sensors.

Vine phenology and growth (window): overview on the current phenological stage of vines and their vegetative-reproductive ratio; detailed graphs of the dynamic of phenology, leaf area and clusters weight; estimate of pending yield and decision support for canopy management in respect to summer pruning operations such as leaf removal and clusters thinning.

Cold temperature damage alert (window): overview of the minimum temperatures of the day; detailed graphs of the daily course of temperatures and potential damage to buds and shoots.

Water content (window): overview of the soil water content; detailed graphs of the dynamic of soil water content and water deficit associated with plant stress.

Insect pests (window): overview on the current phenological stage of insect pests (Grape berry moth, Mediterranean vine mealybug, American grapevine leafhopper); detailed graphs of the dynamic of phenology of the different forms (e.g., adults, eggs, larvae) in each generation; decision support for insect pest control.

Disease (window): overview on the current level of alert for the diseases (Downy and Powdery mildews, Grey mould, Black rot); detailed graphs of the dynamic of the disease components (e.g., inoculum dose, dispersal, infection, incubation); decision support for disease control.

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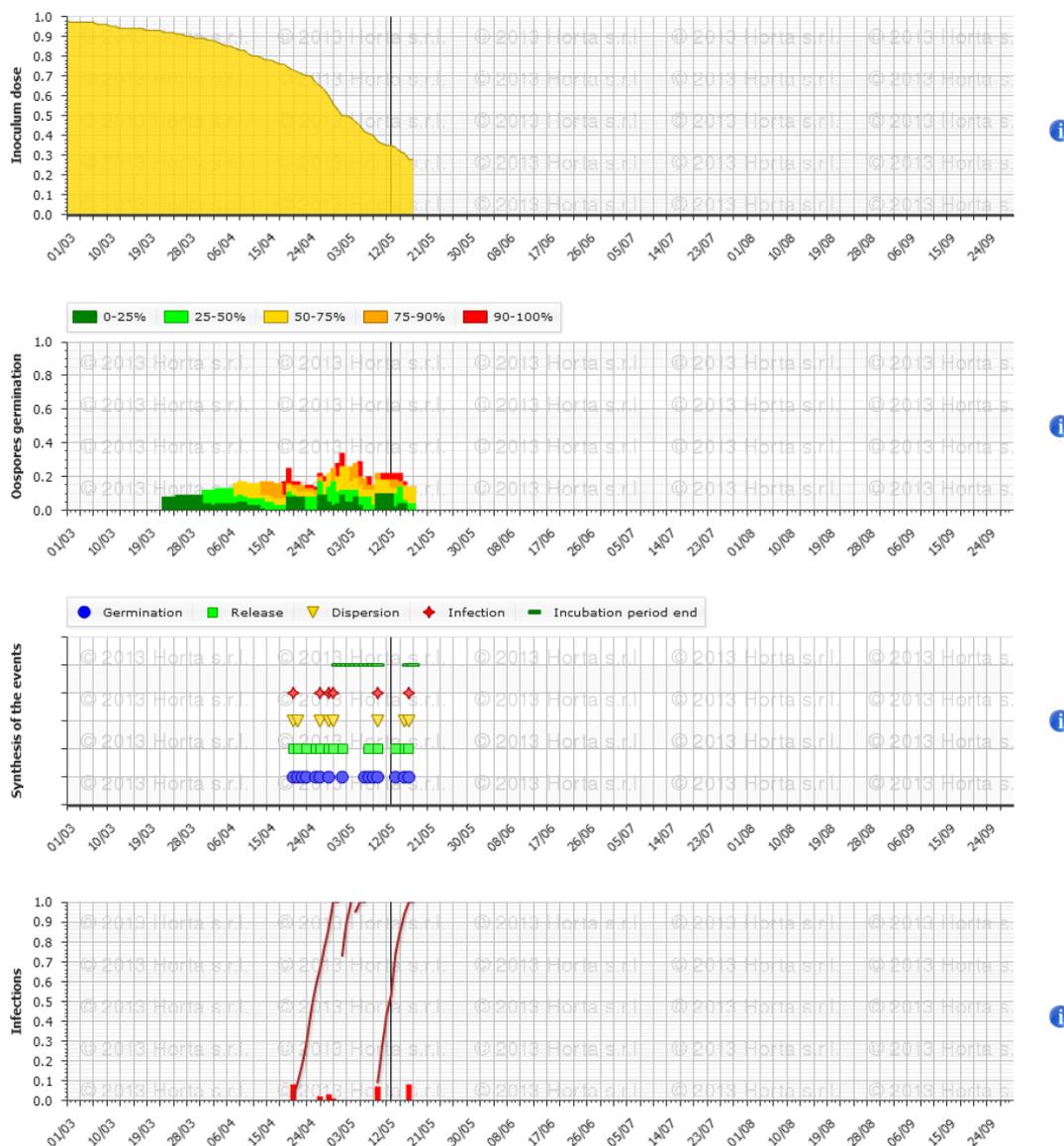## Sustainable Agriculture through ICT innovation

Figure 2 – Dynamic of the epidemiological components for primary infections of downy mildew: availability of inoculum, germination of oospores, release and dispersal of zoospores, occurrence of infections and the course of incubation (the model producing these outputs was developed by Rossi et al., 2008). The current day, when the user accesses the DSS, is shown on the graph by means of a vertical black line: the outputs on the left of the line are calculated on the basis of the meteorological records, whilst those on the right are based on weather forecast.

3.2 Main Characteristics of vite.net®

1. Aim: the DSS has been designed as a "tool" which provides additional and relevant information for decision-making and not as a "proxy" for the user's decision process.

2. Holistic vision: the DSS offers information on the key aspects of vineyard management: disease and insect pest management, plant growth and yield, canopy management, cold temperature and water stress.

3. Specificity: the decision supports and alerts provided by the DSS are tailored to a CU, that is a vineyard (or a part of a vineyard or number of vineyards) managed in an uniform manner all season long.

4. Interactivity: each CU is characterized by means of site-specific information both static, which do not change over the season and are inputted *una tantum* by the user, and dynamic, which change over the season.

5. Real-time update: the DSS receives in real-time the data collected in the vineyard and uses them as input variables for the mathematical models running within the system, so that the model outputs are updated hourly.

6. Accessibility: the DSS is delivered via the Internet and accessible by any browsers, available 24 hours a day, 7 days a week, and it does not require the installation of specific software.

7. User's interface: the surfing within the DSS is intuitive and dynamic and allows to choose the level of detail at which exploring the information. Graphics, colours and symbols communicate in an immediate, effective, and univocal way the state of each DSS component.

8. Updating: the accessibility via the Internet allows a timely update of the DSS functionalities, as soon as new results from research are made available and without requiring the user interventions.

9. Versatility: weather data for running the DSS can be collected by any meteorological station or by wireless sensor networks, irrespective of the manufacturer; similarly, scouting data can be collected by a variety of scouting devices such as smartphones, tablets, and cameras.

10. Co-innovation: the DSS has been designed and developed in close collaboration with external consultants and a panel of final users in order to appropriately address their needs. During the MoDeM_IVM project, potential end-users were involved in seminars and visits to demonstration vineyards and their participation was crucial for providing an insight on their decision processes and on the criteria they adopt to take actions.

4. CONCLUSIONS

vite.net[®] provides real time, multiple and detailed information on the status of the vineyard helping the managers to take "informed decision". Specifically, vite.net[®] allows i) to rationalize the use of resources, both natural (e.g., water) and technical inputs (e.g., plant protection products), implementing a cropping system consistent with the principles of sustainable agriculture (including Integrated Pest Management as acknowledged by the 2009/128/EC directive), and ii) to keep trace of the rationale behind each management action.

The main characteristics, such as the holistic vision of vineyard management, the accessibility and versatility of the service, as well as the intuitive and interactive nature of the web-portal, make vite.net[®] a unique tool, yet unavailable on the current market, for supporting the vineyard manager in implementing sustainable viticulture.

5. ACKNOWLEDGEMENTS

6. REFERENCES

Gent, D.H., E. De Wolf and S.J. Pethybridge. 2011. Perceptions of Risk, Risk Aversion, and Barriers to Adoption of Decision Support Systems and Integrated Pest Management: An Introduction. *Phytopathology* 101: 640-643.

Magarey, R.D., J.W. Travis, J.M. Russo, R.C. Seem and P.A. Magarey. 2002. Decision Support Systems: Quenching the Thirst. *Plant Disease* 86(1): 4-14.

Matthews, K.B., G. Schwarz, K. Buchan, M. Rivington and D. Miller. 2008. Wither agricultural DSS? *Computers and Electronics in Agriculture* 61(2): 149-159.

McCown, R.L. 2012. A cognitive systems framework to inform delivery of analytic support for farmers' intuitive management under seasonal climatic variability. *Agricultural Systems* 105(1): 7-20.

McCown, R.L. 2002. Changing systems for supporting farmers' decisions: problems, paradigms, and prospects. *Agricultural Systems* 74: 179-220.

Rossi, V., T. Caffi and F. Salinari. 2012. Helping farmers face the increasing complexity of decision-making for crop protection. *Phytopathologia Mediterranea* 51(3): 457-479.

Rossi, V., T. Caffi, S. Giosuè and R. Bugiani. 2008. A mechanistic model simulating primary infections of downy mildew in grapevine. *Ecological Modelling* 212: 480–491.