EXPERIENCES ON USING WEB-BASED DATA MANAGEMENT SYSTEM FOR AREA-WIDE MONITORING NETWORK IN OLIVE-FLY IPM.

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ABSTRACT

The system aims to organize area-wide monitoring networks on olive fruit-fly infestation (Bactrocera oleae) useful to help the project coordination, to standardize the service, to distribute data and on-line elaboration to all users, and to create a large data-set to be used in applied ecology studies. Two different projects, in Liguria and Tuscany, have been realized using the same system.

The system has been conceptualized hierarchically using an Object Oriented Paradigm (OOP). We developed the database with a relational database management system and the web interface using Java™ Servlet technology. Technical results have been the improvement of communication among the project partner between from local to center and from center to local.

INTRODUCTION

Using web based database in agriculture could produce benefits in the communications among different subjects geographically dispersed (Splike and Köstler, 1999). Other projects showed the possibility in using Internet to disseminate information for plant protection (Thysen et.al.1999). We intend to develop a system that allow users to insert, share, elaborate and distribute data collected by means of monitoring networks.

The aim of the developed system is to manage area-wide monitoring networks on olive fruit-fly (Bactrocera oleae), the olive key-pest in Italy (Neuenschwander et.al. 1986). The specific objectives are: 1) to facilitate the project coordination at regional and farmer organization level and the communications among partners; 2) to standardize the service using the same data categories and similar working protocol; 3) to distribute data and elaboration to final user; 4) to provide further tools to support decision and evaluation in IPM during the growing season: 5) to create a large data-set for applied ecology studies, in order to allow analysis and comparison of biological phenomena and the efficacy assessment of IPM strategies.

The partners, who have been involved, expressed different requests that influenced the system architecture: Regional Administrators, for project coordination and controls both technically and administratively, Producer Organizations to have real time information and to perform an effective pest control, Technicians to produce a user friendly interface and good data elaboration to support their technical advises, and the Researchers to obtain good quality data sets for scientific investigations.

EXPERIENCE

Two different projects have been realized using an area-wide monitoring network having different features (Tab 1). The projects have been performed from 1999 to 2000 in Liguria (120 monitored farms and 15 technicians) and during 2000 in Tuscany (80 farms, 7 technicians). They have been conducted within Regional Programs of Olive Oil Quality Improvement to organize an area wide monitoring network of olive-fly infestation. Projects have different geographical distribution, being the Ligurian project organized as a unique region-wide monitoring network, with monitoring points...
sparsely located in all the olive grove cultivated area; the Tuscany IPM monitoring network is concentrated in some locations of the regional territory, with a high number of monitored farms.

TABLE 1 Differences among the projects that have used the web-based database.

<table>
<thead>
<tr>
<th>Projects comparison</th>
<th>Liguria</th>
<th>Tuscany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project years</td>
<td>1999-2000</td>
<td>2000</td>
</tr>
<tr>
<td>Number of farms</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>Number of technician</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Farm distribution</td>
<td>Spread all over the region</td>
<td>Clustered in 7 Areas</td>
</tr>
<tr>
<td>Pest Control Strategy</td>
<td>IPM</td>
<td>Organic (mass trapping)</td>
</tr>
<tr>
<td>Coordination</td>
<td>Regional Coordination</td>
<td>Region and Producer Organization</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Intranet</td>
<td>Internet</td>
</tr>
</tbody>
</table>

The Pest Control Strategy adopted in Liguria farms is conventional IPM, while in the Tuscany project, Mass-Trapping (MT) is adopted. The implementation of MT is done by application of baited traps and sex pheromone, which have to be displaced in a contiguous group of farm in order to be effective. The Ligurian Project is coordinated by the Regione Liguria Agriculture Office, technically supported by the Regional Service of Applied Agro-meteorology (CAAR) and is implemented by District Agricultural Departments. In Tuscany, the coordination of Technical Support Service is multilevel, because the Information Project is coordinated by the Regione Toscana Agency for Agricultural Development (ARSIA), but the monitoring implementation is realized by two Olive Growers Associations, through their own technicians. The different typology of projects and monitoring networks needed a tailored Web-based data management system. The Ligurian Web-based database has been realized using a Intranet infrastructure, and the Tuscany project, in order to allow an easy access to different level of users, utilized Internet.

METHODOLOGY

System architecture

We conceptualize the system hierarchically using an Object Oriented Paradigm (OOP) to improve the system generalization and flexibility. The system Entity-Relationship diagram is represented in fig 1. We developed the database with a relational database management system.

![Diagram](image-url)

FIGURE 1 Entity-relationship system diagram. There are three different kind of relationship represented with line of different style. The observation entity is the single observation related to a sample point, a date and a variable.
The **User Hierarchy** allows a privilege differentiation among different users. Four different kind of users are created: 1) “Coordinator User” has global-administration privilege, can define the geographical entity (Area and SubArea), crops and variables that have to be monitored, userID and password for all the system users. He can visualize on-line all data; 2) “Organization User” is a coordinator of a group of technicians and farms. The Organization can be a farmer cooperative, a trade union or a local government. Each organization’s coordinator can insert new farm and field to be assigned to organization’s technicians, and he can visualize all the data inserted them; 3) “Technician User” make the observation, insert the data periodically, and visualize his own data on all the monitored farm; 4) “Farmer User” can be a farmer-technician (insert his own data and visualize them) or can just visualize data inserted by a technician.

The **Spatial Hierarchy**, has a containing relationship among the spatial entity which are: 1) *Area*, which is the first level of spatial organization, usually is the administrative internal border (e.g. in Liguria and Tuscany Region we adopted the *Provincia* administration border); 2) *SubArea* that generally is the spatial unit that a technician can follow periodically; SubArea level is usually adopted for summarize the data observed in order to produce a bulletin for local farmer; 3) *Farm* is a surface belonging to a farmer and with uniform pedo-climatic conditions. At farm level it is possible to define some variable like geographic coordinate, quota, surface, owner; 4) *Field* is a continuos surface inside a farm with a single crop and uniform condition; 5) *Observation unit* is a monitoring point inside a field. Usually fields have only one observation units, but sometimes more then one point is needed (e.g. a field with several insect traps, a data replication, different observation on different cultivar in the same field).

**Data Hierarchy** considers the relationship between the observed variables. The different entity are: 1) *Crop*: it represents the single crop, and it allows to organize different input pages for each crop considered (in our case we choose olive as the unique crop monitored); 2) *Data Group*: it is a set of variables referred to a single feature related to a single crop. Usually a dataGroup it is related to a crop key pest (e.g. the olive fruit fly infestation) or a group of minor pests (e.g. presence of olive moth and scales); 3) *Observed Variable*: each dataGroup contains different variables, as variables we consider the maximum detailed unit of information; in order to allow the system to deal with general variables, the database store data only in a numeric double format.

The servlet interface allows to insert and visualize data also in other kind of format: a) simple variable: a numeric (double) value related to an observation (e.g. number of olive infested or number of flies trapped); b) date variable: a date related to an event occurred (e.g. a date of spraying or fertilizer distribution); the date variable allows also a null value meaning that no date can be expressed (no event occurred); c) predefined value: for non-numeric data it is possible to define a set of predefined value for each variable (e.g. for a chemical product used for spraying the list of available products, or the list of crop or pest phenological phases).

The database has been implemented using the RDBMS Microsoft Access. This software is broadly used and it easily allows to save data in well known format (ASCII, excel) for post-project data diffusion. Considering the database dimension, the software performance fits the necessity. The database interface has been programmed using Java Servlet Technology (Sun, 2001) to create interactive html pages, and Open DataBase Connectivity (ODBC) to interact with the database. Apache has been used as web server and Tomcat as servlet engine.

**DATA ENTRY AND VISUALIZATION**

Two data entry forms are defined: a form for *single farm data* (FIGURE 2) to insert observations about all the dataGroup of a single farm and a form for *single dataGroup* (FIGURE 3) allowing to insert observations about a single dataGroup on all the farms monitored.
FIGURE 2 Form for single farm data entry, with an example of data observed in a farm with an olive field. The pop-up menu allows selecting among pre-defined values.

FIGURE 3 Form for single dataGroup entry.

Visualization are referred to a single dataGroup of variables, the difficulties related to visualization are mainly the necessity of select which data consider fixed and which variable. Data are represented using html tables; the column and rows label present button that allow user to access a table in with the value on the button are fixed. We choose three kinds of representation: 1) fixed-farm: you have to choose a farm and you can see all the variable observed for all the data available; 2) fixed-date (FIGURE 4): you choose a single observation date (or week) and you can visualize all variable observed in all the monitored farms; 3) fixed-variable (FIGURE 5): you fix a single variable and visualize data observed in that variable in all the farms for all the data.

The system is able to recognize the user privilege selecting each time data available for that user. In order to visualize multiple choices of variable we adopted an icon table, in which each possible variable value correspond to a tiny icon, allowing to easily visualize information.

Massa-Carrara: Trattamenti del 2000-09-13

FIGURE 4 Example of a fixed-date table: after choosing 13 September as a date and Massa Carrara as an area, the system shows all the variables in Trattamenti dataGroup for all the
farms. It is possible to browse data in time and, clicking on column header button, to look the fix-variable table (e.g. clicking on “trattamento” button, you get FIGURE 5).

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FIGURE 5 Example of fix-variable icon table, after choosing a variable (“Trattamenti ad Olivo” = spraying on olive orchards) and an Area (Massa Carrara) the system show the chemical treatment made in the 6 farms (Berta, Cana etc…) from the 31th to the 45th weeks during 2000. The legend helps to understand the representation (“nessuno”=nothing, “rame”=Cupper, “posizionamento eco-trap” = positioning of mass trapping devices).

RESULTS

Main Technical result has been the improvement of communication between the Technical Assistance Regional Service and the Producer Organizations, establishing a double direction flow of updated information. From local to center: the quality of infestation data coming from technicians has been improved for both technical and administrative purpose. The infestation data have been transmitted to the elaboration center where data have been quickly supervised. The information collected from different localities, technicians and organizations have been organized and systematically stored in a unique format. The system facilitates the relationships between different typology of organizations and the local community. From center to local: the system produced and diffused elaboration and bulletins. The collected and supervised data have been elaborated to provide several infestation index and indication of pest dynamic with a color visualization of $B.oleae$ infestation for each monitored farm. About spatial analysis, the representation of infestation composition has been done by mean of pie chart using a vector map of the monitored area. These elaboration and the weather data have been integrated in order to prepare weekly bulletin of infestation and to formulate technical advises on $B.oleae$ control.

Scientific results: a critical mass of good quality data has been collected to perform interesting data analysis. We applied neuro-fuzzy techniques to perform predictive classification on data in order to give a Decision Support tool to IPM manager (Salmerón et. al. 2001). The availability of geo-referred data allows us to perform geo-statistic analysis, useful to analyze the data spatial relationships. At present we are using data to calibrate an agro-ecosystem simulation model and a Decision Support System on olive IPM and we are working to implement the heuristic fuzzy rules for data reliability assessment, a central problem in monitoring data. We defined an Extended Markup Language (XML) specification to describe the system data structure, that in next developments could be used to improve the system flexibility, allowing different project to exchange the projects specification and observed data.
CONCLUSION

In the last year the system has been applied in several real-life problems showing good performance and meeting with needs coming from different farmers, technicians and coordinators. During the system follow-up, different project’s people made us a lot of suggestion on system improvement. The flexible structure of the system has allowed us to easily correct errors and add features. The system has been developed considering a general multi-crop-monitoring network. We are working to apply the system in a Tuscany Regional IPM project on olive, grapevine, apple, peach, pear and plum. The project engages 50 technicians to monitor about 500 farms and the system performance will be tested to suggest us next developments. The implementation of the database using an Object Oriented Database Management System (OODBMS) could be interesting to test if this new approach could improve flexibility, performance and suggest new applications of the system.

Our experience shows that the implementation of a Web-based data management system for area-wide-monitoring-network is successful only if accompanied by technical formation of operators and a mutual interaction between system users, project managers and software architects for the refinement of the system. Moreover the on-going training of technicians is very important to solve users problems in itinere, to simplify the system following the local need. Finally the training has to empower on IT knowledge users at local and central level. The two projects allowed the creation of an information and communication infrastructure and the empowerment of different operators. Consequently the system is susceptible of future integration with other source and typology of data, allowing an increasing system complexity and the provision of further elaboration and services.

REFERENCES


