Utilization of Intelligent Systems for Plant Protection Project

Progress Report
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1. EXECUTIVE SUMMARY

This ICT-KM project, focusing on expert systems for plant protection, is a partnership between CLAES, ICARDA, ICRISAT and IRRI. It was approved in December 2004, and officially started on 1 January 2005, although actual activities commenced only in March 2005. The main activities during the period 16 March 2005 to 15 March 2006 related to knowledge acquisition and development of the expert systems and e-learning modules. During the project phase I period, considerable effort was made in the acquisition, collation and formatting of the knowledge bases through interactive meetings with experts (pathologists, entomologists, virologists and breeders) from ICARDA and ICRISAT, NARS scientists, and literature surveys.

Knowledge acquisition tools were developed for barley, wheat, and chickpea. Most of the pest management knowledge bases have been acquired for the three crops. Expert system generic task tools, for easy generation of expert systems, and barley e-learning modules were developed. Utilizing the barley knowledge base, a Barley Plant Protection Expert System beta version was developed using the expert system generic task tools.

Since integration of various components of UISPP is of immense value in decision-making in barley, wheat, and chickpea plant protection, intensive training for end-users is of prime importance, we hope this activity would be taken-up in the next phase of the project. Thus, we are confident that the project is on the right track to facilitate effective management of pests and diseases for safer environment, better health and increased profits.

2. Introduction

Crop losses caused by biotic stresses are estimated to be in tens of billions of dollars across the world in spite of spending several millions in plant protection. Even after huge investments in plant protection, pest epidemics continue to occur in several locations causing sever hardships to poor farmers and to the developing countries economies.

This project was aimed at the development of plant protection expert system with the support of several CGIAR centers to help in knowledge dissemination to manage biotic stresses, minimize crop losses and increase productivity without jeopardizing environmental safety. This project has already facilitated strong communication amongst research communities and proceeding with the nest phase of the project will facilitate this process with other stakeholders (extension staff, farmers and private sectors) for better utilization of knowledge systems in plant protection. Dissemination of technologies developed would be greatly enhanced through the use of expert systems and other artificial intelligence technologies. Thus the project chose to focus on developing a series of expert systems addressing plant protection in wheat, barley and chickpea crops.

The basic objective of the project is to strengthen international capacity in plant protection by enhancing the dissemination of the knowledge and research results accumulated in the CGIAR centers using information and communication technology – knowledge management (ICT-KM) tools. The ultimate goal is to reduce crop losses and protect the environment with the following specific objectives:

1. Capture the domain knowledge of experienced scientists in the co-operating centers on crop protection
2. Develop a multi-crop pest management expert system (CPMES) that will address knowledge of various crop disorders leading to better diagnostics, improved forecasting and actions leading to better management.
3. Build and enhance the capacity for developing and using expert systems in the CGIAR and the national agricultural research and extension systems (NARES)
4. Develop an intelligent agent that can be used to search through the mass of data accumulated in the centers in the plant protection domain.
5. Develop e-learning capacity in crop protection

Commodity expert systems have been developed in the past for wheat, faba bean, soya bean, tomato, strawberry, melon, and cucumber. Other problem-specific expert systems, such as for water drainage, water resources management, etc, have also been

developed. ICARDA and the Central Laboratory for Agricultural Expert Systems in Egypt (CLAES) have been actively co-operating in the development of such systems.

3. Financial Management and Reporting

3.1. Financial Disbursements

Financial Report is available upon request.

4. Project Performance

Project scientists at ICARDA and ICRISAT participated in interactive meetings with knowledge engineers to acquire the knowledge of plant protection for barley, wheat and chickpea. This first phase dealt mainly with the acquisition of knowledge bases and developing the generic tools.

I. Progress

All partners agreed on classifying knowledge into four major components namely: pest identification, pest control, cultural practices, and variety identification. The pest identification component includes pest name, scientific name, family, geographical distribution, expected economic damage, and symptoms with multimedia information, environmental conditions, and dispersal means. The pest control component includes cultural control after infection, biological control, pheromonal control, and mechanical control. The cultural practices component includes all operations, in order to prevent the occurrence of pest (preventive measures, before the crop is being infected). The variety identification component includes the important characteristics of the varieties like use, type, climate, planting date, color of grains, etc. and host plant resistance. All these knowledge bases have been acquired and .presented in XML format for barley, wheat and chickpea. The prints out of knowledge bases (barley, wheat and chickpea) are found in Annexure 1, 2, and 3 respectively.

An expert systems generic tool was developed by CLAES to facilitate generating expert system rapidly. A complete barley expert system software program was developed using the generic tool in two days.

During this project period, a kick-off planning meeting, a workshop, and a formal review meeting were organized to bring the partners together and discuss the progress of the project and review the knowledge bases. Many interactive meetings (formal and informal meetings) were organized with project scientists and NARS scientists to acquire and validate the knowledge bases as well as to validate the generic task tools, barley expert system and barley e-learning module.

Of the original plan of activities the table below shows the progress on the various activities:

Activity	**Responsibility**	**Status / Comments**
Kick-off meeting		
Agenda and discussions	ICARDA,CLAES,IRRI	Complete
Detailed agreement on deliverables and responsibilities	ICARDA,CLAES,IRRI	Complete
Adoption of project document and plenary	ICARDA,CLAES,IRRI	Complete
Knowledge base of experienced plant protection scientists acquired		
Detailed scoping of knowledgebase	ICARDA,CLAES	Complete Agricultural practices that can be included: variety selection, and pest control
Develop a format for knowledge acquisition	ICARDA,CLAES,ICRISAT	Complete Knowledge acquisition sheets must correspond to the last version of generic task tool
Design web format for acquisition	ICARDA, CLAES	Complete
Design interfaces to the knowledge base	CLAES, ICARDA	Complete For variety selection and pest control

Activity	Responsibility	Status / Comments
Filling of the format with knowledge	ICARDA,ICRISAT,NARS	Ongoing for barley and chickpea
Review of the acquired knowledge	ICARDA,ICRISAT	Complete for barley, wheat, and chickpea
Encoding	ICARDA,ICRISAT	Complete for barley, wheat, and chickpea
Knowledge acquisition from external sources	ICARDA,ICRISAT	External experts not yet addressed
Testing the knowledgebase system and the interfaces	ICARDA,CLAES,ICRISAT	Complete
Trialing the knowledge base with scientists and selected users	ICARDA,ICRISAT,CLAES,NARS	Complete for barley, wheat, and chickpea
Completed and tested knowledge base		Complete for barley, wheat, and chickpea Need minor validation
Generic software tool		
Review preliminary software specifications	CLAES	Complete
Conduct the requirement specifications study	CLAES	Complete
Exploration, agreeing and selection of a common development engine (C++, Prolog)	CLAES	Complete CLAES has proposed C++ language for the development
Requirement specifications	CLAES	Complete
Acquire hardware and software	CLAES	
Develop the common tool/shell	CLAES	Complete
Acquisition of ontology and development of knowledge model	CLAES,ICARDA,ICRISAT	Complete for application ontology, but for domain ontology it needs cooperation among CLAES, ICARDA, and ICRISAT
Providing the developed tool across Centers	CLAES	Next phase
Working generic tools	CLAES	Next phase
Prototype crop pest management expert system (specific to barley)		
Requirements specification	ICARDA,CLAES	Complete
Import and convert knowledge base of experienced scientists into a suitable format for use by the inference engine of the tool developed	CLAES	Complete for barley

Activity	Responsibility	Status / Comments
Integrate various components of the system	ICARDA,CLAES	Complete for barley
Test the integrated system	ICARDA,CLAES	Complete for barley
Sub-modules	CLAES	Complete fro barley
Integrated system	CLAES	Complete for barley
Prototype crop pest management e-learning module		
Identify the requirements, specifications for an e-learning module	IRRI	Complete
Modify IRRI e-learning system to match specified requirements	IRRI	Complete
Develop a prototype of an e-learning module	IRRI	Complete
Test the prototype e-learning module	IRRI,ICARDA,ICRISAT,CLAES	Next phase
Tested prototype e-learning module	IRRI	
Meetings & Workshops		
Training workshop	ICARDA,CLAES,IRRI,ICRISAT,NARS	Complete
Prototype testing meeting	ICARDA,CLAES	Complete
First phase review meeting	IRRI,ICARDA,CLAES,ICRISAT	Complete
Planning meeting for phase II	ICARDA,CLAES,IRRI,ICRISAT	Complete

Results

A web site was developed to post the knowledge base that have been acquired http://UISPP.ICARDA.CGIAR.ORG and at the same time to publish the status of the project activities.

Knowledge acquisition web tools have been developed to acquire knowledge for barley, wheat, and chickpea.

Prints out of knowledge bases (barley, wheat and chickpea) have been posted on the web http://UISPP.ICARDA.CGIAR.ORG

During this project period, a workshop, a meeting and several interactive meetings (formal and informal) were organized with project and NARS scientists to acquire and validate knowledge bases and barley e-learning module.

Every two months, e-mail news letters were used in the communication and follow up of progress.

A project paper entitled "Rapid Generation of Plant Protection Expert Systems" has been accepted for delivery in the "World Congress on Computers in Agriculture", http://www.wcca2006.org/, WCCA2006 in Orlando, USA, July 2006.

II. Project Design & Implementation

The expert system, would incorporate pest management knowledge accumulated by scientists in the CG centers and make it available to mainstream agriculture so that it can contribute decisively to agricultural productivity and profitability, with minimal threat to human health and environmental quality. It would facilitate communication within research communities, between researchers and other stakeholder groups, such as private sector/agrochemical industry and farmers' technical support groups, to guarantee quality control and informed use of pesticides and other control measures. Farmers would achieve higher and more stable yields by combining knowledge of biological and ecological processes with their indigenous farming experiences.

Developing knowledge acquisition tools:

- Two different versions of knowledge acquisition tools have been developed by ICARDA and CLAES
- The two tools cover text and multimedia knowledge
- The two tools can be used by expert using a simple level of security and authentication
- Knowledge acquisition tools cover the following main components:
    - Pest identification
        - pest name

        - scientific name
        - family
        - geographical distribution
        - expected economic damage,
        - symptoms hybrid with multimedia
        - environmental conditions
        - dispersal means
    - Variety identification
        - Include all important characteristics of the varieties like use, type, climate, planting date, color of grains, etc. and host plant resistance
    - Pest control
        - cultural control after infection
        - biological control
        - pheromonal control
        - mechanical control
    - Cultural practices

      Includes all operations, in order to prevent the occurrence of pest (Preventive measures, before the crop is infected)

Generic task tool for building expert system

- CLAES completed the software development of the Agricultural Task Specific Tool for the generation of expert systems.
- This tool generates expert systems depending on the outputs of the tools mentioned above
- Two different versions of the generic task tool have been developed by CLAES, a desktop application and a WEB application.

Expert systems for barley:

- Two different versions of barley expert system have been developed by CLAES. Barley expert system as a desktop application and another version on the WEB.
- These systems should be dynamic and they need to be updated continuously.

Barley e-learning component

- IRRI completed the software development of a prototype of an e-learning module for barley.
- It includes the following modules:
    - Improving crop quality and value
    - Effective plant protection
    - Knowledge and plant protection
    - Knowledge bases and expert systems
    - Use of the ICARDA /ICRISAT knowledge base and expert system

Knowledge captured:

- We have captured the knowledge on barley, wheat and chickpea crops
- We have covered the first three component of knowledge (Pest identification, Pest control, Variety identification) for the mentioned crops

Annexure 4-8 show the requirements specification and design documents for the tools developed by ICARDA, CLAES and IRRI.

Next phase of the project will cover the following main objectives:

- Construction of plant protection ontology (PPO)
- Development of intelligent search engine which depends mainly on PPO
- Validation and completion of knowledge bases
- Integration of expert systems, e-learning, and search engine components

- Training NARES researchers and extension staff in the use of the systems
- Evaluation in the field

III. Reflection and Learning

After Action Review

At the end of the project meeting held in Aleppo in March 2006, an After Action Review was carried out:

What went right?

- A Network of a community of enthusiastic researchers was established
- Interaction between CG and NARS researchers went well
- Exposure to expert systems technology to scientists who had no prior exposure
- Project meetings were very useful
- Multi disciplinary approach was undertaken for the project
- A Generic Expert System Tool was developed
- Knowledge acquisition for the three crops
- Publicity for expert system utilization
- Awareness of the potentialities

What went wrong?

- Delay in the knowledge acquisition process
- NARS scientists involvement could have been better sought
- Expectations were not very clear to some of the partners
- Underestimation of resources needed
- Stakeholders participation
- Time planning

What could have been done better?

- Better timing of the start of activities
- Better estimation of the resources required
- Orientation of the key resources in the project
- Alternative funding

Lessons Learnt

- Teamwork between players of the project is essential
- Scattered knowledge available at the centres
- Biological scientists and IT specialists can devise tools to identify constraints and opportunities to improve crop production
- Knowledge gaps in the plant protection area

Many informal meetings were held at ICARDA for acquiring the experts' knowledge and to discuss the project objective and strategies. The following are the formal meetings and workshops:

Title	Location	Date	comments
A planning/kick-off meeting	ICARDA headquarters in Aleppo, Syria	February 9-10th 2005	Attended by representatives from ICARDA, CLAES and IRRI. ICRISAT. During the meeting substantive discussions took place on the deliverables. A new work plan was developed with activities to be carried out clearly spelled out and responsibilities assigned to each center.
Workshop	CLAES, Cairo, Egypt	October 25-26th 2005	Attended by representatives from ICARDA, CLAES and IRRI. ICRISAT and NARS. All participants agreed that the workshop was a success and met its objectives. Considerable part of the knowledge base for barley was captured. The first prototype version of the barley expert system was demonstrated. The participants recognized that considerable work remains to be done to complete the first phase by March 2006 and an action plan was agreed to ensure that this will be done.
Meeting	ICARDA headquarters in Aleppo, Syria	March 6-7th 2006	Attended by representatives from ICARDA, CLAES and IRRI. ICRISAT and NARS. During the meeting the following points were discussed: • Latest knowledge bases for barley, chickpea and wheat were reviewed • The barley protection expert system was reviewed • E-learning module was reviewed • The project second phase proposal was discussed and broadly agreed on