Development of a decision support toolkit for improving the implementation of integrated crop management (ICM) in brassica vegetable crops in Australia and China

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ABSTRACT

Integrated crop management (ICM) is a whole crop management approach which recognises the interaction of crop management strategies and is used from before planting to post-harvest, while considering the impact of the management practices on economic returns and the environment. Using ICM, decisions are based on monitoring and reviewing the system rather than calendar-based management practices, and therefore can involve complex decision-making by the farmer. Accessing information on good ICM practices is difficult because of the lack of experienced decision makers and decision support tools, or lack of information in cross-discipline format, relating to problem solving and meeting decision-makers’ actual, not perceived needs.

To improve the implementation of ICM in brassica vegetable crops in China and Australia, a project was developed that expanded existing integrated pest management activities in China and Australia, to provide a decision support toolkit designed and developed with the end users, using an action research approach.

The four project objectives were to clearly identify the key constraints to implement ICM, to identify the role that information can play in overcoming these constraints, to develop and field test information tools that address the end users’ needs, and lastly, to conduct an evaluation of project activities. The resulting toolkits were developed in English and Mandarin. In Australia, the toolkit was a prototype CD containing factsheets, a diagnostic key, images, tutorial, search tool and weblinks, with a plan to develop the prototype for release to the Australian industry. In China, the toolkit consisted of similar information to Australia on a CD, but in a different framework, and there was a paper-based field guide produced, both of which have been distributed and are available to extension officers in China.

INTRODUCTION

In the past, extension material associated with crop management problems has largely been produced in the form of booklets or pamphlets on specific problems or a class of problems, such as insect pests, diseases, etc. Apart from the costs of producing and updating this paper-based form of extension material, a major problem has been the lack of integration of different disciplines (e.g. entomology, plant pathology and
physiology) in developing a single approach to diagnosing crop management problems, and the difficulty
users have in accessing the specific information will be useful to their situation.

A variety of decision support tools have been developed for the Australian brassica vegetable industry.
These include a number of paper-based publications and fact sheets that are discipline-based (e.g.
diseases, pests and nutrient disorders), or provide agronomic information with limited detail for problem
identification purposes. Some examples are a DBM management handbook (Anonymous 2000), club root
management factsheets (Anonymous 2003), a field guide for identifying pests, natural enemies, diseases
and disorders in vegetable brassica vegetable crops (Donald et al. 2000) and a pest monitoring guide
(Heisswolf and Brown 1997). In addition, computer-based information includes an Australian web-based
pest and disease identification guide (Keller et al. 1997) aimed primarily at students. Audiovisual material
on IPM concepts for growers and industry has been delivered via video and CD (Institute for Horticultural
Development 2002a, 2002b).

A paper-based approach dealing with the knowledge management issue is used in the information
products, Brassica Grower’s Guide (Heisswolf et al. 2004b) and Brassica Problem Solver (Heisswolf et al.
2004a). These products were developed in response to an increasing need for “stand alone” decision-making
kits targeted at advisers, consultants, growers and students. The packages encompass some of the principles
of adult education by taking a problem-centred approach to presenting information, catering to different levels
of user skills and preferred methods of searching for answers to problems. The Brassica Grower’s Guide is
divided into sections which target various information needs and provide different entry points to a specific
problem which are cross referenced to other relevant information within the kit. The Problem Solver section of
the product represents a paper-based diagnostic key. It allows the user to work through a collection of images
arranged according to symptoms seen in the field—the problem—rather than presenting images arranged along
discipline lines—as a disease, pest or disorder.

The adult education approach used for these paper-based products, together with the idea of addressing
key competency standards, has been incorporated in a computer-based product, RiceIPM CD (IRRI and
CPTIT 2001) and a diagnostic package for sweet potato (Vasquez et al. 2004), but this is not available for
brassica crops.

In China, a survey of literature about insects associated with brassica vegetable crops in 1996 showed
that while an extensive literature existed on individual species of pests, there had been little literature on
brassica IPM at the cropping system level (Liu et al. 1996, Liu and Yan 1998). There have also been many
manuals on insect pests and diseases in vegetable crops. However, most of these manuals only give
information on the morphology, biology and control of individual species, and only a few of them, such as
the manual by Liu et al. (1995), offered limited coverage on the management of insects and diseases at the
crop level. Recently, there have been some efforts to develop training and decision-support systems in the
form of a multi-media CD in China. Two of the products that have been most frequently shown and quoted
are CN-Vegepest (1998) and PestDiag (1998), developed by the Integrated Pest Management Information
and Software Technology Laboratory (IPMIST) of China Agricultural University. CN-Vegepest is a database
of 134 species of insect pests of all vegetable crops, and PestDiag offers di-pathways keys for identifying 80
species of insect pests on all vegetable crops. The staff at Zhejiang University and the extension service in
Zhejiang have tried to use these two products in teaching and extension respectively, but found them little
practical value because:

(1) the two discs have limited compatibility with various computer operating systems and consequently
could not be run on most computers,

(2) the information enclosed is limited, for example, in CN-Vegepest, under the entries of many
species, there is only a short description of morphology and biology,

(3) the CD offers little versatility and scope for user interaction.

Similarly worldwide, a number of websites provide extension material for brassica crop protection, particularly in the USA. Many of these sites deliver either an electronic form of pamphlet or fact sheet that is discipline-based and does not treat the issue as comprehensively as required. There is also a problem in navigating to the material most appropriate to the user’s problem.

A project was developed to fill the information gap identified by project officers in China and Australia, and to improve the implementation of ICM in brassica vegetable crops in China and Australia, by providing a decision support toolkit designed and developed with the end users, using an action research approach (Dick 2002).

The four objectives were to clearly identify the key constraints to implementing ICM, to identify the role that information can play in overcoming these constraints, to develop and field test information tools that address the end-users’ needs, and lastly, to evaluate the project.

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**MATERIALS AND METHODS**

**Needs Analyses to Identify Constraints to ICM and Information for Overcoming Constraints**

Needs analyses in Australia were conducted using four focus groups and personal interviews in the two major brassica vegetable regions in Queensland, the Granite Belt and the Lockyer Valley. The focus groups consisted of farmers, farm advisers (crop consultants, resellers, seed and chemical company representatives, research officers and extension staff) and volunteers from the industry.

In China, due to the population size, extension officers were the predetermined toolkit audience. A core group of extension officers were identified to become involved in the project, and were brought together for a training workshop on how to conduct a needs analysis with their colleagues and clients. At the workshop their assessment of constraints to ICM implementation and required information needs were assessed. After the workshop the extension officers conducted needs analyses with other extension officers, some technicians and farmers.

The feedback gathered during the needs analyses in China and Australia provided the overall framework, entry points and linkages within the toolkit, as well as the type of information needed (Li 2005).

**Testing Cycles to Develop and Field Test Information Tools**

After identifying the information and format required by farmers and farm advisers, the focus then shifted to bringing together information and knowledge into a suitable framework. A prototype CD was a suitable format for archiving and integrating the electronic format of the required information tools as one, multi-disciplinary flexible knowledge management system, providing a source and means of disseminating information on brassica integrated crop management, with the following characteristics:

- provides a “one stop shop” for information
- provides greater flexibility and capacity
- can be used directly as an interactive learning and decision support tool
- adds to current information, easier to update, and offers links to websites
- provides a resource for problem diagnosis and identifying “best management” options, with the option of printing paper-based advisory leaflets as needed
• provides an alternative way of searching, navigating and linking between related material
• contains information identified by decision-makers as critical in influencing their ICM decisions

Information tools were developed in Mandarin and English in parallel with collaboration between teams during the development cycle.

Several software packages, including Dreamweaver 7.01, Lucid3, Search Engine Builder Standard 2.06, Debbs 7.0.0 Sp2, Camtasia Studio 3.0.2, and Factsheet Builder were used in the development of the multimedia system.

In Australia, as new information or tools were developed, a testing version was produced and distributed to the testers with feedback sheets. Testers were volunteers identified during the needs analyses. For the first cycle, a small internal group was used to test the process. For the second cycle, the project leader visited each tester and went through the steps involved and introduced the framework of the toolkit and the structure of the feedback sheet. The testing version was left with the tester for up to 6 weeks and then feedback collected. During this time the developers continued to collect information. Once feedback was received it was also incorporated in the toolkit. There were two more cycles conducted with testers. For the final cycle, a group feedback session was used.

In China, field testing involved a two-day training workshop for researchers, students and extension staff in Hangzhou, followed by half-day training activities for farmers in Hangzhou, Wenzhou, Ningbo and Jinhua in 2004, and other regions in 2005. The toolkit was then modified in response to feedback from these training activities, resulting in a master copy of the Chinese Version, and was ready for final production and distribution.

Evaluating the Project

Consultants contracted by the project, oversaw the project evaluation, and developed the activities with the project leader. The three components that were considered to affect the impact on the project, and therefore included in the assessment were:

1. the impact of the project’s activities to improving integrated crop management in brassicas
2. the use of modern extension processes such as action research and participation, and
3. the project’s management.

Evaluation plans in China and Australia were developed using a participatory process and based on Bennett’s Hierarchy (Bennett 1975). Data was collected via questionnaires, reports, e-mails, meeting notes and personal interviews with team members and industry collaborators.

RESULTS

The Australian toolkit prototype is contained on a CD which contains tools to correctly diagnose and evaluate problems in brassica vegetable crops, and these are supported by 326 fact sheets, over 800 images and links to State, National and International websites as identified by the end-users, to provide information for managing crop problems. An index, glossary and tutorial for using the key maximises the user’s experience of the toolkit.

The fact sheets cover topics from crop establishment to harvest, including crop management practices such as plant protection, nutrient and water management, marketing, for the major and minor brassica vegetables, varietal selection, spray technology, and “Common Questions”.

The Chinese toolkit, in Mandarin, consists of a CD-based decision-support toolkit and training multimedia system, and plus a paper-based field guide to integrated management of vegetable brassicas.
(Chen et al. 2005). The CD consists of 7 subsystems: crop cultivation, fact sheets, pesticides, diagnosis and identification, pesticide application, glossary, and other information. “Crop cultivation” introduces the morphology, growth characteristics, species and cultivars, and methods of cultivation for 11 common species of crucifer vegetables. “Fact sheets” present the information and knowledge of 43 species of plant diseases, 18 species of insect pests, 14 species of weeds and 14 species of natural enemies. “Pesticides” introduces the frequently used pesticides. “Diagnosis and identification” provides an effective platform for diagnosis of plant diseases and disorders and identification of insects and weeds, using Lucid as the major interface. “Pesticide application” introduces the correct methods and regulations of pesticide application, including the basic information on each pesticide, safe and strategic application of pesticides, information of sensitivity of crops to various pesticides, and pre-harvest withholding periods of various pesticides, etc. “Glossary” provides 300 entries of common terms used in the system. “Other information” includes system help, basic knowledge of integrated crop management, useful websites, references, and acknowledgements.

The field guide offers concise descriptions and practical reference for identification of brassica pests, diseases and disorders, with 221 high resolution photos to assist in field identification. Apart from offering background information and general management strategies for individual pests and diseases, the field guide presents management protocols for individual crops through a season, especially the strategic application of pesticides. One thousand copies of the field guide were distributed to farmers at the 10 major vegetable production areas in Zhejiang. In each locality, 60-70 farmers attended the half-day training activity. The field guide was welcomed by the farmers at the field days.

Changes to the toolkit as a result of end-user feedback included formatting the fact sheet template to be more readable, inserting common names as the primary reference point, increasing the number of fact sheet topics, providing links to websites with related information such as chemical permits, increasing the number and quality of images, debugging software and fine-tuning pathways in the diagnostic key tool.

The evaluation showed the project met its objectives of identifying the key constraints to a farmer’s or farm adviser’s ability to implement ICM, the role that information could play in influencing these constraints, and developing and field testing with end-users a brassica decision support toolkit for China and Australia, and conducting a detailed evaluation of the impact of the project’s activities.

The evaluation found the impact of the toolkit on improving integrated crop management provided a useful, suitable, end-user friendly decision support tool to farm advisers and farmers for providing crop management advice, evident from the feedback of the end-user testers. In China similar CDs are being developed for cucurbit, legume and solanaceous crops.

The participative processes and action research incorporated into the project activities ensured a focused and industry relevant information product, provided cyclic and flexible planning that was able to respond to end-user and project team needs and encouraged critical reflection resulting in more focused project activities. These processes also improved needs analysis skills of the project team, developed an extension process for the provision of information to respond to identified client needs and benefited team members and other industry stakeholders.

Additionally they created a sense of ownership and commitment among stakeholders towards the project, increased recognition of the value of participatory processes, action research and evaluation by stakeholders and team members, as well as facilitating the use of resources to achieve optimal performance and increasing networking and communication among stakeholders in the industry.

The evaluation process in the project revealed that there was an underestimation of the time required to develop the toolkit as well as to conduct participatory testing cycles. However, the evaluation process also captured an end-user development team intent to use the toolkit in the future, which along with experiences
with other information packages developed with end-users, and the participative process used for the toolkit’s
development, suggests that there is the potential for the toolkit to be used and therefore improve management
in crops, given time.

**DISCUSSION**

In Australia the prototype provides a basis for mass producing and distributing a comprehensive decision
support toolkit to brassica industry stakeholders. It complements existing Australian information and is
presented in a format in consultation with industry. The flexibility of the toolkit means that access to the tools
will be directly by farm advisers and farmers, or indirectly to farmers from farm advisers.

In China, the toolkit (CD and field guide) has received considerable popularity in the vegetable
industry and has helped to increase the interactions between farmers, extension officers and researchers.
These interactions have helped to improve integrated crop management by the farmers. Through the
interactions during the development of the toolkits, the extension officers in Zhejiang improved their
knowledge of brassica crop management and skills of communication.

The needs analyses highlighted the role of field guides and other paper-based information as well as
computer-based information as decision support tools for farmers and their advisers. The need for a field
guide, as identified in China, was also seen during the development of the Sweetpotato Diagnoses (Vasquez
et al. 2004). In addition, the strength of using information in conjunction with training, field days and
demonstrations for discussing, developing and information delivery seen and identified in this project, has
also been documented with other industries (Anonymous 1997; Vasquez et al. 2004). Similarly the need for
regionally specific and in regional language has been highlighted during discussion with other regions
interested in the toolkit and the experience of Vasquez et al. (2004).

In both China and Australia, the integration of information and storage in a digital format has meant a
more flexible delivery mechanism that can be accessed and used to deliver the most suitable format of
information for the end-users needs. This will form part of the knowledge management system to improve the
complex decisions required for meeting the demands of environmental sustainability and competitive
advantage to sustain economic returns for brassica vegetable farmers.

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REFERENCES


Institute for Horticultural Development. (2002a) Integrated Pest Management for Brassicas CD. Department of Natural Resources and Environment.

Institute for Horticultural Development. (2002b) Integrated Pest Management for Brassicas Video. Department of Natural Resources and Environment, 41 min.


Liu, Shu-sheng and Yan, Su. (1998) Brassica IPM in Asia: Successes, challenges and opportunities.

