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THE INTERNET AS A TOOL FOR MANAGING GRAIN INSECT RESISTANCE TO FUMIGANTS ON AUSTRALIAN FARMS

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ABSTRACT

Integrated Pest Management on farms becomes more complex as new pests arise, pesticides are released or regulated and resistance inevitably develops. This complexity necessitates access to a wide range of information sources, which has been difficult for Australian growers given their remoteness from these sources. Widespread use of the Internet offers farmers the same extensive information resources used by government, industry and researchers. Currently 17% of Australian farmers have access to the Internet but this figure will grow rapidly as rural communication initiatives are realised. We believe that it is essential that pest management information be available as farmers arrive online to ensure that they will continue to use this valuable resource. Western Australia is heavily reliant on sealed storage and phosphine fumigation for grain insect control. This has enabled all grain exports since 1990 (~ 60Mt) to be achieved without the use of contact insecticides during storage. This reliance, both on-farm and in the central handling system, means that phosphine must be protected from resistance development. Resistance monitoring is the key and in 1996 the Australian Grain Insect Resistance Database (AGIRD) was developed. This database runs over the Internet and currently holds data from 23,000 Australian farms. It underpins the development of Integrated Pest Management plans for grain insect control in Australia. The website driving AGIRD continues to expand providing information on grain insect biology, control and storage practices. This information comes in the form of a database-driven identification key for grain pests, downloadable multi-language screensavers, frequently asked questions and a range information documents. The website is also delivered on CD-ROM for the 70% of farmers that have a computer but no Internet access, allowing farmers to familiarise themselves with the website and the hypertext interface without actually being online.

INTRODUCTION

Australian grain markets continue to demand grain that is completely free of grain insects. However there is also a market trend toward grain that is residue-free. Western Australia is well placed to meet this demand through its extensive use of phosphine (PH_3) fumigation in sealed storages and flow-through systems both on the farm and in the central handling network. In Western Australia

sealed storage has been widely adopted, with over 60% of central storages sealed (6.4Mt) (Burton, 1998) and a similar percentage of farms having at least one sealed storage on the property (Newman, 1994). This has enabled the entire Western Australian grain harvest to be exported without the use of contact insecticides during storage since 1990.

This widespread use of a single fumigant (PH_3) at all stages before export places Australia in a dangerous position with respect to resistance development. Western Australian research during the late 1970's identified the farm as being the source of most contact insecticide resistance in grain insects (Dean, 1994).

The best recourse is to monitor farms, merchants' and central storages for PH_3 resistance so that resistant strains can be eradicated before control failures occur. This work has been conducted in Western Australia since 1984. More recently international resistance researchers have recommended that this type of resistance monitoring be conducted on a national basis and that appropriate databases and software be developed for each country (Subramanyam, 1996).

In 1996 the Australian Grains Research and Development Corporation was the catalyst for the instigation of an Australia-wide grain insect resistance monitoring project which brought together state government agriculture agencies from three states; Agriculture Western Australia, New South Wales Agriculture and Queensland Department of Primary Industries. This project ensures that participating laboratories are able to exchange reference strains, validate resistance test methods across laboratories and use consistent methods for summarising and reporting data.

This national approach required the development of a central database to hold the results of resistance assays allowing secure access by research collaborators from any location around Australia. These database-driven web-pages needed to be unrestricted by platform, operating system, or web browser. This database, developed at Agriculture Western Australia became known as the Australian Grain Insect Resistance Database (AGIRD) and currently holds the results of over 23,000 resistance assays.

As AGIRD and its associated website grew, other parts of the Australian grain industry requested delivery of test results and other information *via* the World Wide Web. Currently all bulk handling companies in Australia have password-protected resistance reports available *via* the AGIRD website.

The advantages of the Internet for information delivery are by no means restricted to researchers and grain handlers; growers will be major beneficiaries of the Internet revolution given their relative geographical remoteness. The Internet provides them with access to the same extensive, dynamically updated information resources used by government, industry and researchers. In 1999 about 17% of Australian farmers had access to the Internet but this is expected to steadily grow as rural communication initiatives are realised.

MATERIALS AND METHODS

Sophisticated hardware, software and expertise were not required for management of the Australian resistance database and digital delivery of pest management information. Like Agriculture Western Australia, many organisations will have sufficient expertise for in-house development. AGIRD was developed and runs on an IBM compatible personal computer with a 266 MHz CPU, 128 megabytes of RAM, four gigabytes of disk space, connected to the Internet through a 256K ISDN link. A digital tape unit handles the essential

requirement for scheduled data backup. The cost of this configuration (excluding the ISDN link) is under AU$ 4,500.

Software used for AGIRD includes Microsoft® Windows NT Server 4.0 service pack 3, along with the incorporated Microsoft Internet Information Server which services World Wide Web clients, priced at ~ AU$ 1,500. Existing NT security is enhanced through the user authentication program Authentix®, at AU$ 450.

The database management system used is Microsoft® Access97, and the web interface managed with Microsoft FrontPage97, AU$ 400. There are many website development programs that provide the range of tools for writing web-pages, verifying links and connecting databases.

The AGIRD database has three main tables for sites, strains and assays. Fifteen other lookup tables are provided to normalise the data and avoid the same data being recorded across thousands of records. One other external table of 215,000 Australian place-names is included for latitude/longitude data.

Referential integrity is enforced in AGIRD, ensuring that: (i) assays cannot be assigned to a strain that does not exist, or a strain assigned to a non-existent site; (ii) records cannot be deleted from a primary table if matching records exist in a related table, without losing the related records as well. For example, deleting a site record will also delete related strain and assay details.

For verification purposes, user network address, date and time are recorded when data is entered or modified. The AGIRD database fields, structure and relationships have been published in Emery and Tassone, (1998).

Data input is the most time-consuming part of maintaining a database and typographical errors frequently occur when dealing with large amounts of data. To protect against this AGIRD uses drop down list boxes wherever possible. This allows choices to be selected with one or two keystrokes.

Distribution mapping is becoming an important part of resistance management programs requiring that mapping coordinates be recorded. AGIRD allows users to input latitude/longitude information either manually, if obtained with a global positioning system, or automatically via an attached database of Australian place-names. If the strain is collected from some distance away from the place-name, the lat/long will be corrected using a spherical navigation algorithm.

All queries and reports in AGIRD are dynamically generated, i.e. they run every time the web page is opened and will reflect data inputs immediately. This is achieved with Internet Database Connector (IDC).

DISCUSSION

Research web

Most resistance testing laboratories hold the results of their assays on in-house spreadsheets or databases. The difficulty is that consistency across states is required for a true national picture to be obtained. Uniform test methods are readily achieved through documentation in the scientific literature, but what of reporting results? For example: how many surviving insects or test insects are required for a strain to be considered resistant; are insects from different storages on the same property considered to be the same strain; is resistance summarised by counting strains or properties? A national central database can hold raw data from assays and allow presentation of results in a standard format and allow transparent information exchange across states for what is truly a national threat.

At the time of writing, the Australian Grain Insect Resistance Database held the results of 23,000 assays dating back to 1984 on 13,000 strains collected from 5,300 locations across Australia. Phosphine resistance tests accounted for 17,000 records. Species on which assays have been conducted are *Cryptolestes* spp., *Gnatocerus cornutus*, *Latheticus oryzae*, *Oryzaephilus surinamensis*, Psocids, *Rhyzopertha dominica*, *Silvanolomus gouphi*, *Sitophilus granarius*, *Sitophilus oryzae*, *Tribolium castaneum*, *Tribolium confusum* and *Typhaea* spp.

Interested researchers can evaluate the fully functional input forms and reports at the demonstration version of AGIRD at the web address below. Those interested in developing a similar database could use the data dictionary for AGIRD (Emery and Tassone 1998), which would allow ready exchange of information between participating overseas laboratories in the future.

The AGIRD website also provides several tools for researchers including an online PH_3 concentration calculator to determine microlitres of PH_3 required for assay doses at given desiccator volume, source concentration, temperature and pressure. There is also a surveillance contacts database that allows researchers and field staff to record contacts with growers. This tool is useful for auditing but invaluable when an old contact needs to be recalled to locate a grower or infestation.

Extension web

VanDyk (2000) discusses the impact of the Internet on extension entomology noting that the entomology discipline was an early adopter of the web. Excellent pest management information is available from websites like Information Network on Post-Harvest Operations (INPHo), IPM Australia and the National Integrated Pest Management Network (NIPMN). These websites are co-operative portals to pest management information and can only be as good as the information provided by collaborators. It is incumbent upon government departments of agriculture and research organisations to ensure that high quality pest management information is available now so that growers arriving on the Internet will be met by a valuable resource.

The AGIRD website started out managing information for a small group of Australian researchers, it continues to expand and now provides a range of extension information aimed at growers. This information comes in the form of:

(i) Database-driven identification keys for grain pests that return scientific/common name, description, lifecycle, damage and control information along with images in a consistent format. This approach allows experts to fill in a few fields in a database and have pest data sheet web pages dynamically built by the database giving a consistent look and feel to the information;

(ii) Downloadable multi-language screensavers. This unique, almost subliminal means of extension has proved very popular. GrainSaver is currently available in English, German and Chinese with Spanish and Vietnamese language versions under development. Software to build screensavers can be downloaded from the Internet for under AU$ 200. All that is required is a collection of scanned images. GrainSaver was developed with Stardust® Screensaver Toolkit;

(iii) Continuously updated frequently asked questions, which address the most common queries received from grain growers. These FAQs are submitted by research collaborators and ensure that a consistent message is reported;

(iv) A range of information reports and extension documents; these articles and links demonstrate good grain storage practices, insect identification, biology and control information;

(v) Online mpeg video and multimedia slideshow presentations;

(vi) A publicly accessible discussion web provides a forum for the grain industry to participate in online dialogue.

Web server logs show that the Agriculture Western Australia Entomology website is receiving 20,000 hits from 1,300 users per week, interestingly 4 times as many users from the U.S.A. as from Australia. This could be attributed to the fact that less than 20% of Australian farmers have access to the Internet. With this in mind, the Entomology website is periodically published on CD-ROM for the 70% of farmers that have computers with CD-ROM drives. This allows farmers to browse the Entomology website without actually being online. Currently these CDs are given away as part of 'Community Surveillance Initiatives' in the interests of educating growers about pest management issues.

The Stored Grain Website and Australian Grain Insect Resistance Database can be found on the World Wide Web at the " Entomology Projects" link at the Agriculture Western Australia, Entomology web site at:

http://www.agric.wa.gov.au/ento.

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