Communication strategies for delivery of the benefits of cooperative research in the CIMMYT Suite of Projects

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INTRODUCTION

As Australia's major food crops are not native to this country, the international centres provide valuable sources of genetic diversity. Under the sMTA of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), users of imported germplasm are obliged to return information to the providers, and to fulfil benefit-sharing requirements[1]. This requires a system for tracking distribution and collecting and communicating results.

Australian wheat breeding programs' access to, and use of germplasm from the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT: International Maize and Wheat Improvement Centre) is facilitated by a suite of projects supported by the Grains Research and Development Corporation (GRDC). These projects span scientific exchange, quarantine of selected material and international nurseries, and coordinated increase, trial, phenotyping and genotyping. They also include the International Adaptation Trial (IAT) and projects for evaluation of synthetic hexaploids and sources of root disease resistance. These have provided valuable data to assist selection of material suited to Australian conditions, with appropriate tolerances and resistances.

COMMUNICATIONS

All projects in the Suite communicate regularly with each other and the central communication and database development projects ensure that both Australian breeders and CIMMYT staff have rapid access to this data, to inform their decisions. The purpose of the communication project is to facilitate a two-way flow of information between Australian breeders and CIMMYT via an informative website, email digests, visits to CIMMYT by a group of breeders each March, and biennial interactive forums with interested breeders (average 46 registrants), voIP-videoconferenced to CIMMYT.

Minutes and presentations from all meetings have been loaded to the web[2,3]. Breeders and CIMMYT staff are notified by email of any updates and a subscription function is being added. With the improved communication flow, breeders are returning trial data in a timely fashion ready for analysis and discussion at the next meeting, which will assist CIMMYT in taking results into account in their breeding cycle. Sixteen breeders representing the various wheat breeding programs in Australia were sponsored to visit CIMMYT between 2006-2008 and made selections for importation.

This initiative has greatly improved interactions between Australia and CIMMYT.

INFRASTRUCTURE

An informative website for CIMMYT-Australian Germplasm Evaluation (CAGE)[4] is hosted on a University of Queensland server and is linked to the CAGE database. The site contains information on lines imported, progress through quarantine and seed multiplication, details of distribution locations and quantities, progress of trials and progress of database development.

A module capable of handling high-throughput genotyping data was developed to integrate with the existing pedigree, germplasm evaluation and sample tracking modules of the open-source International Crop Information System (ICIS). A wide range of database systems is in use by the breeders in collaborating organisations. Hence, the Bioinformatics Sub-committee of the Australian Winter Cereals Pre-Breeding Alliance[5] recommended that the CAGE web site should not require specific knowledge of ICIS for use. The CAGE team has therefore worked collaboratively with CRIL - the IRRI/CIMMYT Crop Research Informatics laboratory – to develop a user-friendly, web-accessible front-end to ICIS so that users do not need specific knowledge of ICIS to extract data for analysis in their preferred software.

Visualization tools for genotype and phenotype data are based on the Koios web search engine architecture[6]. The backend architecture was based on the ICIS Datasource developed in the CGIAR Generation Challenge Program and is implemented on an Apache Tomcat Web server, this is a fast interface to enable the breeders to download data in a format that is portable to their chosen application. Detail of its development is documented on the ICIS Wiki[7].

The new interface integrated into the Joomla![8] content management system allows the selection of studies and datasets within studies, as well as retrieval, display and downloading of the data. Development is ongoing and the open-source framework is available[9] for other interested breeding programs to implement if they wish. ICIS-based systems are now used by both CIMMYT and the International Center for Agricultural Research in the Dry Areas (ICARDA), so clean data transfer between the Australian hub and collaborating international centres will thus be facilitated.

DIVERSITY ANALYSIS CASE STUDIES

The project also added value by whole-genome genotyping and by testing for late maturity amylase, yellow leaf spot and rust. Diversity Arrays Technology (DArT®) genotyping was conducted on the IAT lines, and on the germplasm field-trialled from the sets imported in 2005 and 2006. The Wheat CRC separately funded DArT genotyping of 180 primary synthetics so as to identify further relevant polymorphic markers to add to the DArT array available to breeders. DArT genotyping was also done on control lines for a number of the traits in this set which was previously phenotyped in the Synthetics Evaluation project and the Australian Winter Cereals Molecular Marker Program. All DArT data is loaded to the CAGE web and made directly available to interested researchers in Australia and at CIMMYT for association studies.

Rich marker-trait associations for 21 traits, analysed on the basis of evlauation over the six global mega-environments using pedigree information and DArT genotyping of lines from CIMMYT's Elite Spring Wheat Yield Trial (ESWYT) over 25 years, was reported at the February 2008 CIMMYT User Group meeting[10].

Before conducting any detailed analysis, preliminary data analysis is important, to pick up mistakes in the data or to discover unexpected values. R-scripts written to automate preliminary data analysis for the large data sets generated by high-throughput genotyping, utilising a combination of Microsoft Access, Microsoft Excel and R-Statistics software, are available and the process for downloading, reshaping and visualizing DArT data using R-statistics has been documented[11]. Links are provided to existing stand-alone open-source visualization tools suitable for genotype or phenotype data: R-statistics[12]; GGobi[13]; Graphviz[14]; Mondrian[15]; GGT[16]; and GVT[17].

CONCLUSION AND RECOMMENDATIONS

The impact of this communication initiative has been to:

- Reduce duplication and fragmentation.
- Improve communication /focus/ transparency.
- Promote efficient delivery of material relevant and targeted to specific areas.
- Enable faster uptake by breeding programs.
- Communicate results between collaborating organisations.
- Capitalise on pre-breeding strengths by incorporating DArT whole-genome, rust and abiotic data in the database.
- Consolidate seed requests to fit quarantine capacity and timing.
- Provide feedback on Australian data relevant to CIMMYT crossing.
- Provide a level playing field for access to CIMMYT lines by all Australian breeding programs

The future communications project should ensure that lessons are learned and followed through from the documented outcomes of the IAT and ESWYT studies. It would also be advantageous to coordinate information flow between the Australian Wheat and Barley Molecular Marker Program, the CIMMYT Suite, and the Australian Winter Cereals Pre-Breeding Alliance.

ENDNOTES

1. International Treaty on Plant Genetic Resources for Food and Agriculture. www.planttreaty.org/
2. Minutes from CIMMYT User Group meetings. http://mendel.lafs.uq.edu.au:8080/ICIS5/GWIS_CAGEmeetings.htm
3. Presentations from CIMMYT User Group meetings. http://mendel.lafs.uq.edu.au:8080/ICIS5/GWIS_CAGEpresentations.htm
4. CIMMYT-Australian Germplasm Evaluation (CAGE) web. http://cage.lafs.uq.edu.au
5. Australian Winter Cereal Pre-Breeding Alliance Bioinformatics Review, July 2006. http://www.grdc.com.au/uploads/documents/bioinformaticsreview0706.pdf
6. Koios Search Engine Prototype. http://rice.generationcp.org/portal/views/main.jsp Generation Challenge Program, CGIAR.
7. ICIS Wiki - Wheat CRC Project. http://cropwiki.irri.org/icis/index.php/Wheat_CRC_Project
8. Joomla! Content Management System. http://www.joomla.org/
9. ICIS Wiki http://cropwiki.irri.org/icis/index.php/Main_Page
10. Global Wheat Information System – CAGE Presentations. http://mendel.lafs.uq.edu.au:8080/ICIS5/GWIS_CAGEpresentations.htm
11. ICIS Wiki - R-script for preliminary data analysis. http://cropwiki.irri.org/icis/index.php/R-script_for_preliminary_data_analysis
12. The R Project for Statistical Computing. http://www.r-project.org
13. GGobi data visualization system. http://www.ggobi.org
14. Graphviz - Graph Visualization Software. http://graphviz.org
15. Mondrian - statistical data-visualization system for LARGE data. http://rosuda.org/Mondrian
16. Graphical GenoTypes (GGT). http://www.plantbreeding.wur.nl/UK/software_ggt.html , Laboratory of Plant Breeding, Wageningen UR and Biodiversity and Breeding, Plant Research International.
17. Genotype Visualisation Tool (GVT). http://bioinf.scri.ac.uk/germinate , Scottish Crop Research Institute Plant Bioinformatics Group.