Use of conserved rice germplasm

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Summary
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In a 1995 survey of users of germplasm from the International Rice Genebank Collection at IRRI between 1989 and 1994, 48 respondents (from about 200 surveyed) reported evaluation and use of almost 4000 samples. Only a small number were used directly for rice improvement. Most were evaluated for biotic and abiotic stresses. The research generated 59 publications.

Keywords: Conservation, *ex situ*, *Oryza*, rice

Résumé
Utilisation du germoplasme de riz conservé
Dans une étude menée en 1995 auprès des utilisateurs du germoplasme de riz issu de la Collection de la banque de gène internationale de riz à l'IRRI et concernant la période 1989-1994, 48 personnes interrogées sur les 200 sollicitées ont décrit l'évaluation et l'utilisation de presque 400 échantillons. Il apparaît que seul un petit nombre de ces échantillons sert directement à l'amélioration du riz. La plupart sont évalués pour les stress biotiques et abiotiques. La recherche a généré 59 publications.

Resumen
Uso de germoplasma de arroz conservado
En una encuesta realizada en 1995 entre usuarios de germoplasma de la Colección del Banco de Germoplasma Internacional de Arroz del IRRI entre 1989 y 1994, se recibieron 48 respuestas (entre unos 200 encuestados) sobre evaluación y uso de casi 4000 muestras. Sólo unas pocas se utilizaron directamente para la mejora del arroz. En la mayoría se evaluó el estrés biótico y abiótico. La investigación dio lugar a 59 publicaciones.

Introduction
Crop breeders draw on genebanks to raise yield potential, improve nutritional quality and tackle a broad range of challenges to agricultural productivity (Plucknett *et al*. 1987). Genebanks backstop breeding programmes by regularly supplying new materials for specialized breeding pools. When the desired genes are not found in elite breeding lines, scientists turn to conserved germplasm that comprises farmers' or landrace varieties, old cultivars and wild species.

In 1977 the International Rice Research Institute (IRRI) established the International Rice Genebank (IRG) committed to the long term-conservation of rice genetic resources. Today, over 107 000 accessions of *Oryza* are conserved in the genebank. These are duplicate collections of the national programmes from more than 110 countries in Asia, Africa, Oceania / Pacific, and North and South America.

The value of conserving rice genetic resources may be measured in how these genetic resources are used in crop improvement, and eventually in a released variety. The studies by Evenson and Gollin (1994) indicated that the rice germplasm collection at IRRI had a direct impact on the international flow of improved rice varieties, which in turn was directly associated with an increase in varietal releases and yield growth. They concluded that the collection, preservation and cataloguing of rice germplasm directly and unambiguously led to a higher production of rice around the world, and hence played a significant role in feeding millions of people.

The use of rice genetic resources is not limited to plant breeding or crop improvement. Each year, thousands of germplasm samples are sent out for some kind of evaluation and research by users (Chang 1992). Documentation of the reported results, however, is scarce (Jones 1984). Many of the accessions requested from the International Rice Genebank are used in a wide variety of research projects that expand our understanding of the rice genepool and its value.

Survey of rice germplasm users
In October 1995, we began a survey among scientists in seven countries who received germplasm from 1989 to 1994. The objectives were to document how the requested germplasm was used, what traits were identified and used in breeding or crop improvement, what methodologies were developed, and what other contributions were made to rice science. More than 200 letters were sent to recipients of germplasm in Bangladesh, Indonesia, Japan, Korea, Thailand, UK and USA; 48 users responded to our queries (Table 1).

Use of germplasm
Scientists who received conserved germplasm generated 59 publications. These scientists used 3921 samples of cultivated rice (some 3800 distinct accessions) and 139 samples of wild species (105 distinct accessions) in various research activities. Recipients used about 130 accessions of cultivated rice for crop improvement. The traits transferred were resistance to brown planthopper and bacterial leaf blight, low amylose, seedling vigour, germination ability at low temperature, waxy endosperm, smooth hulls, and milling and cooking quality. Breeders are usually interested in using only a small fraction of the total germplasm at any one time to meet immediate and often pressing objectives (Gill 1989). To use germplasm effectively, breeders need variability available in an agronomically desirable background.

Most of the accessions requested were used in the evaluation for biotic and abiotic stresses (Table 1). For example, in Thailand, plant breeders evaluated 122 accessions for grain quality and found one (Acc. 9032) that could possibly be released to farmers directly without further improvement. Researchers from the University of Wales-Bangor in the UK evaluated more than 2300 accessions for cold tolerance, with the objective of using the varieties identified as parents in a breeding programme in Nepal. The data generated will be stored in a database for other breeders

Table 1. Use of conserved germplasm from the International Rice Genebank Collection at IRRI between 1989 and 1994.

Institution/ country	No. of samples	Purpose	Traits identified†	Traits transferred	Varieties released and contributions to rice science‡
Bangladesh					
Bangladesh Rice Research Institute (BRRI)	69	Evaluation, breeding	BPH, WBPH, callus induction & plant regeneration (Acc. 55814)	Acc. 55814 used in crossing programme	None
BRRI	123	Evaluation	BPH resistance	BPH resistance gene	None
BRRI	4	Research	Bacterial blight resistance	None	Plan to use as differential varieties in Bangladesh
BRRI	8	Research (PhD thesis)	Resistance to tungro virus		No publication
University of Chittagong	37	Research	Work on hold		
Indonesia					
Inter University Center for Biotechnology	7	Research	Awaiting sponsorship		
Soegijapranata Catholic University	57	Re-introduced to farmer's field	None	None	
Japan					
Chugoku National Agricultural Experiment Station	19	Evaluation & research	RTSV, GLH		(49)
Gifu University	27	Research	Shade tolerance		Deriphat-SDS page technique for chlorophyll protein
Hokkaido University	20	Research	Cold tolerance at booting stage		No publication
Kagawa University	35	Research	Nitrate reductase Nitrite reductase		(2)
Kobe University	16	Research	Genetics of BPH resistance		No conclusive results
Kyushu University	5	Research	Comparison on floating ability		No publication
Nagoya University	1	Research	Allergenic protein		(1)
Nagoya University	7	Research	Salt tolerance		Physiology and morphology of root system
National Agricultural Research Center	4	Breeding	Low amylose	Low amylose	None
National Institute of Agrobiological Resources	62	Research	Blast resistance		RFLP/RAPD, experiment terminated
University of Tokyo	248	Research	Rooting ability		Used by graduate student
Korea					
Seoul National University	2	Research	Highly resistant to rice blast		Physiological plant pathology, (46)
Yung Nam Crop Experiment Station, RDA	39	Evaluation, breeding, research	Seedling vigour (4 acc.), BPH resistance (1), germination ability at low temperature (1)	Seedling vigour, germination ability	None
Thailand					
Department of Agriculture (DA)	151	Breeding, evaluation	BPH (6 acc.),SB resistance (1 acc.), BLB resistance (2 acc.), grain char. (2 acc.) grain quality (1 acc.)	BPH resistance (Acc. 237), BLB resistance (Acc. 611)	Acc. 9032 may be released to farmers
DA	8	Breeding	BPH resistance		
DA	8	Evaluation	None	None	None
DA	2	Evaluation	Gall midge resistance		Biotype study of rice gall midge
DA	3	Research	BPH-resistant check		
United Kingdom					
IACR-Rothamsted	147	Research	Root growth in response to mechanical impedance		Root physiology in rice, screening method for root elongation rate

Institution/ country	No. of samples	Purpose	Traits identified[†]	Traits transferred	Varieties released and contributions to rice science[‡]
John Innes Centre	1	Research	Susceptible to isolates of two RTV & all biotypes of *Nephotettix virescens*	Used for agroinoculation of rice tungro bacilliform virus	Molecular biology & variation of the two tungro viruses
University of Cambridge	13	Research	To confirm work of Yeo & Flowers		For further study
University of Dundee	4	Research	Artificial symbiotic association between rice & cyanobacteria		Research group phased out
University of Nottingham	64	Research			Biotechnology, (3-7,9-16, 20-22,25,26,30-40,47,50-52)
University of Reading	21	Research			Seed storage, seed germination, & seed production; (17, 18, 19)
University of Sussex	116	Research & evaluation	Salinity	Results were used by IRRI breeders	(23, 24, 27, 28, 29)
University of Wales-Aberystwyth	1	Research	Ethylene responsive		Tissue probed for ethylene receptor proteins
University of Wales-Bangor	2,363	Evaluation	Superior cold tolerance	Varieties identified will be used as parents in a future breeding programme in Nepal	Replicable method for screening cold tolerance. Useful as a database for other breeders
University of Wales-Bangor	6	Research	Long, thick roots		Hydroponics root screening
United States					
Private citizen	11	Evaluation, research	Long grain size		
Brigham Young University	4	Research done at IRRI	Observed wax crystal patterns		
California Cooperative Rice Research Foundation, Inc.	96	Breeding	Still being evaluated for stem rot & sheath spot resistance		
California Cooperative Rice Research Foundation, Inc.	6	Breeding	Waxy endosperm (Acc. 76311); early maturity, cooking & milling quality, short grain (Acc. 76312)	Waxy endosperm, smooth hull (Acc.76311); milling & cooking quality (Acc. 76312)	Many advanced lines for cooking quality.Methodology developed: cooking quality screening
Cornell University	167	Research	BLB-R locus, *Xa21*		Genetic mapping, gene tagging, evaluation of genetic diversity using molecular markers, RFLP. (8,41,45,48,53,54,59)
Michigan State University	5	Research & training	Proteinase inhibitor II, bar gene	Genes transferred were proteinase inhibitor II and bar gene	Varieties were used to train Rockefeller Foundation students in genetic engineering
The Scripps Research Institute, California	13	Research			Characterization of rice tungro virus. Partial desiccation of mature embryo-derived calli to improve indica rice regeneration. Improving frequency of plant regeneration. (43, 44, 53)
University of California	24	Research	Drought-induced proteins (8 accs.)		Extraction of seedling dehydrins (6 accs.)
University of Washington	4	Research			Genetic engineering using *Agrobacterium*
Virginia Polytechnic Institute & State University	20	Research	To evaluate photosynthesis, leaf growth and water use		Use in physiological studies of a PhD thesis. (42)
Washington State University	5	Research	Explant used to develop embryogenic calli		Experiment not successful
USDA-Maryland	4	Research	Rice blast reaction		Virulence screening methods refined
USDA-Idaho	3	Conservation & distribution to researchers			

[†] BPH = brown planthopper, WBPH = white-backed planthopper, GLH = green leafhopper, BLB = bacterial leaf blight, SB = stem borer, RTSV = rice tungro spherical virus, RTV = rice tungro virus, RFLP – restriction fragment length polymorphism, RAPD = random amplified polymorphic DNA.

[‡] The number in parentheses refers to the publication in the list of publications generated.

to use. The group also developed a methodology for screening cold tolerance, a vital tool in a breeding programme for this trait. Likewise, another group of researchers worked on 24 accessions of cultivated rice and 11 wild species to understand the mechanism of salinity tolerance, and evaluated germplasm accessions and breeding lines. IRRI breeders used the results of these studies in the breeding programme for salinity tolerance. Plant breeders in the USA identified waxy endosperm, smooth hulls, and milling and cooking quality from two accessions. They developed a methodology to screen and identify advanced lines and varieties for cooking quality.

Use of conserved germplasm is not limited to evaluation and crop improvement. Experimental biologists and biotechnologists also use this conserved germplasm to advance rice science. In some cases, germplasm was used solely in research or for teaching purposes, as at Michigan State University, where the five rice varieties requested were used to train students in genetic engineering. At Virginia Polytechnic Institute and State University, a PhD student used the requested accessions to evaluate photosynthesis, leaf growth and water use of rice.

Conclusions

The value of conserved germplasm thus lies not only in how it has contributed to varietal improvement but also in rice science itself by expanding understanding of the physiological, morphological and genetic diversity of the crop and adaptation to its environment. The distributed germplasm has contributed immensely to knowledge on the physiology and morphology of the root system, physiology of plant resistance to rice blast, a biotype study of rice gall midge and other areas. It also has enhanced the use of molecular tools and biotechnology in evaluating crop diversity and improving the crop. The research work of Ellis *et al*. (1993) at the University of Reading, UK, and at IRRI, on seed physiology has contributed to the production of high-quality seeds for *ex situ* conservation, especially for long-term storage. Moreover, screening methods for different biotic stresses have been refined and further developed. These tools are helping rice scientists to understand better the nature of genetic diversity in rice. In the future, they will also help produce new varieties and make the conservation of rice genetic resources more efficient.

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