PROCEEDINGS

OF THE

26th ANNUAL MEETING

July 29 to August 4, 1990

Mayaguez, Puerto Rico

Published by:

Caribbean Food Crops Society

with the cooperation of the USDA-ARS-TARS

Mayaguez, Puerto Rico

GENEBANKS AND THEIR FUTURE ROLE IN CROP IMPROVEMENT

H.L. Shands

USDA-ARS-National Program Leader for Germplasm
Beltsville, Maryland 20705

ABSTRACT

The traditional roles of genebanks and breeders in crop improvement programs have been strongly breeder-oriented in commodity collections curated by breeders. Genebanks housing a diversity of crop species have generally been curatorially oriented with little support or effort in plant development programs. With the recognition of the importance of genebanks in conserving valuable genetic resources, the demand for more than just curation of the materials has increased to include the assessment of the material for the user community. Relocation of the National Small Grains Collection from Beltsville to Aberdeen, Idaho, has placed the collection with scientists taking selected material from raw germplasm to enhanced germplasm which can be used by breeders nationwide. This is a new model for the potential of genebanks where extensive evaluation and enhancement activities are taking place and the germplasm released to public and private breeders. Where a weakness in the total public breeding program effort has reduced the number of scientists transferring genes from wild and weedy relatives into usable genetic material, this may offer an opportunity to renew this aspect of the breeding continuum. As molecular technologies enable scientists to have a clearer understanding of the diversity pools from which the raw germplasm has been derived, there is opportunity to build genepools for heterotic diversity to be instrumental in increasing crop productivity. Much of this work could be incorporated into the evaluation and enhancement programs located at the genebanks of the National Plant Germplasm System.

INTRODUCTION

Over the past decade, genebanks have received increased attention in science, in the press, and in public discussion for several reasons. First, the need to care for valuable plant genetic resources as a component of the planet's eroding biological diversity sets them up as a visible entity. In the past, some of the same institutions whose scientists were espousing concern about the demise of the global resources failed to support conservation activities of ex-situ collections within their physical domain. In addition, a few scientists who maintained collections were sometimes lax about securing and documenting valuable stocks in long term preservation. But, with the increasing attention given to genetic resources and with more financial support available, many critical tasks are now getting accomplished in all facets of the preservation, evaluation, and documentation effort.

A second reason for increased attention to plant genetic resources concerns ownership and intellectual property rights. Plant scientists have historically facilitated exchanges of genetic resources and, particularly, those plant improvements released in the form of new varieties and improved germplasm. The Plant Patent Act of 1930 (PPA) and Plant Variety Protection Act of 1970 (PVPA) have provided legal protection and thereby incentives for increased development work of varieties by private industry. As a result of these laws, the private sector has increased its effort in breeding. The private sector has had variable success with non-hybrid crops. In spite of the weakness in the PVPA which allows farmers to sell to neighbors, companies marketing soybean seeds have done reasonably well. Simultaneously, companies developing and attempting to market wheat seed have failed, first with hybridized wheat because of biological complications, but more recently with bred conventional types primarily because of the broad farmers' exemption in the PVPA. The difference between the soybean and wheat cases may well reside in differences in the seed multiplication rate as well as in the seed keeping quality requirements since it is somewhat more difficult for individual farmers to offer quality soybean seed for sale to a neighbor.

Plant breeding program efforts in the public sector have seen a reduction in emphasis over the recent past (Kalton et al., 1989) as a result of two evolutionary changes. Those changes are the increase in private sector plant breeding and the increase in public sector biotechnology programs. Public institutions were under pressure from private industry to reduce competitive plant breeding programs and those public institutions often shifted those funds to a biotechnology effort while operating with a static budget. Although there is now a recognition of the complementarity of the plant biotechnology and the breeding efforts, new funding is unavailable to reconstitute the lost breeding positions. Most of the institutions have found that the two efforts are inseparable in terms of developing the final breeding product.

The breeder has always been an important conduit to acquisition of new germplasm for breeding programs. When breeders visit others' programs, nationally or internationally, there is often a friendly exchange of materials of interest to both parties. As a consequence, many breeders have built up successful small collections of useful material, generally of rather advanced or elite breeding lines as well as sources of unique genes. Breeders who have depended on related plant species to supply new sources of disease or insect resistance, also have accumulated considerable diverse material. Currently there is strong participation by public and private sector breeders in evaluation programs for the germplasm at the genebanks. Few private sector breeders have regularly utilized the central genebanks except under unusual circumstances and have clearly stayed away from raw (undeveloped), unevaluated, and undescribed germplasm. Their preference is to work with elite germplasm for which current performance data demonstrate its utility as a potential parent line. Data assembled by the USDA-ARS show that overall utilization of genebank materials by private company breeders is low, on the average of 6-7 percent of the distributions. At the same time, Kalton shows that the number of private breeders is of a similar magnitude as for public breeders (Table 1) but heaviest with the corn and soybean programs.

Table 1. Data showing the decreased emphasis in public sector and increased emphasis in private sector breeding programs for selected crops.

Selected Crops(s)	Scientists Public Sector Wilkes (1989)		Scientists Private Sector Kalton(1990)		Scientists Total (combined)	
	1980	1987	1982	1989	1980-2	1987-9
Corn	68	55	155	257	223	312
Soybean	42	45	36	60	78	105
Grain sorghum	18	16	22	23	40	39
Alfalfa/forage legumes	43	32	23	28	66	60
Forage grasses	36	30	2	2	38	32
Wheat	59	63	23	25	82	88
Rice	11	11	7	9	18	20
Other sm. grains	39	31	7	6	46	37
Sugar beet			14	22		
Cotton	42	35	17	11	59	46
Vegetables	27	25	96	108	123	133

Recently, James (1990) has pointed out the vulnerability of breeder collections held at public institutions in the U.S. to being lost when a breeder retires or leaves the program (Table 2). He found that some 16 percent of the programs were due to be closed and that an additional 59 percent were in the "unknown" category as to their future. These results should raise a red flag to the public and to the dependent industry. There is little security afforded by the present mechanism of tracking these collections to determine what will happen to the programs or to the genetic materials in the future. What materials will be submitted to the genebank for public safekeeping? Crop Advisory Committees and curators have jointly made a serious attempt to address these needs and now share a responsibility to prioritize, care for, and accession these materials.

Table 2. Data demonstrating the vulnerability of public sector breeding programs for various crops. (From James, 1990)

Category	No. programs	Percent	No. FTE	Percent
Will be closed	28	5.4	7.2	2.5
Probably will be closed	57	11.0	19.8	7.0
Probably will be continued	102	20.0	52.4	18.5
Will be continued	192	36.9	145.3	51.3
Unknown	141	58.5	58.5	20.7
Totals:	520	100.0	283.2	100.0

Genebanks have been characterized as museums, even morgues (Goodman, 1990). Some criteria, including the genetic integrity of the material and authenticity of the data, have been listed by Shands (1990) for the genebanks to concern themselves with in delivering useful material to the user. Undoubtedly, perfect genebank models do not exist at present but elements of successful genebanks can be readily found. First, since breeders do not seek undescribed and unevaluated genetic materials to introduce into their programs, and since they prefer not to regress to the lower performance level of raw germplasm, useful material must be identified and value-added efforts must be introduced at or in cooperation with the genebank. Although the conservation effort is extremely important, the ultimate value of genebanks is in their use. Failure to recognize that factor and take positive action for remedy has led to a lack of a solid constituency and inadequate clientele support for the genebanks.

Successful breeding programs in the U.S. have rarely been conducted by a single person. Most institutions have a team consisting of one or more breeder-geneticists along with other support disciplines such as pathology, entomology, biochemistry, and others. Genebanks have done little to provide anything but minimal evaluation data due to limited funding. When research scientists are involved at the genebank, often their work is not focussed on the evaluation needs of the breeder. While their research may be mission-oriented to the needs of the repository conducting a successful preservation program, it may not be useful to the breeder. It may be true as well that the breeder team may be the best equipped to do much of the needed evaluation work --

either because of expertise, geographical location, or other logical factor. In order to have the genebank more responsive to the breeders' needs, Wilkes (1989) suggested locating evaluation breeders at the genebank where the material is examined for its utility to breeding programs. Extensive screening for pest, chemical, and other valuable traits must be undertaken.

But, the evaluation, alone, is insufficient to insure the germplasm is put to use by the breeder, particularly concerning those private breeders depending on finished varieties and under pressure to quickly deliver attractive products to the farmer. The evaluation may be a disease screening or may concern itself with new molecular technologies to tag quantitative trait loci (QTLs) or important qualitative traits.

User-oriented genebanks must logically concern themselves with the extension to pre-breeding efforts. The International Agricultural Research Centers (IARCs) of the CGIAR are potentially a model for these activities. The IARCS are beginning to make better use of their genetic resources units. The location of the Centers provides an excellent opportunity for developing and utilizing the genebanks for those mandated crops on location with breeders, cytogeneticists, pathologists, entomologists, who can see and use the material directly. In the U.S. there are commodity collection genebanks where a great deal of such efforts exist (Table 3). The National Small Grains Collection (NSGC) through its move from Beltsville, Maryland to Aberdeen, Idaho has been uniquely positioned to serve a major role in this manner. It must keep its focus on utility and interaction with breeding program needs across the country. The cytogeneticist and breeder transferring genes from the wild relatives to cultivated types to introduce specific pest resistant or quality traits are doing an essential task. In the genebanks holding general collections (multiple commodities), this element is lacking and the National Plant Germplasm System has an opportunity and an obligation to provide a most valuable service. Transferring genes from wild and weedy relatives into usable genetic material may offer an opportunity to renew an aspect lost to the breeding continuum during the past decade. The future role of the National Plant Germplasm System genebank may well be to demonstrate its capability to deliver useful enhancements to public and private sector breeders in the U.S. and other countries around the world.

Table 3. Some of USDA commodity genebanks with ARS evaluation or prebreeding scientists working on site with Collection., 1990.

Crop	Location	Crop	Location
Barley	Aberdeen, ID	Oat	Aberdeen, ID
Citrus	Orlando, FL	Pecan	Brownwood, TX
Cotton	College Stn, TX	Potato	Sturgeon Bay, WI
Flax	Fargo, ND	Soybean	Urbana, IL
Grass, range	Logan, UT	Soybean	Stoneville, MS
Lettuce	Salinas, CA	Tobacco	Oxford, NC
Maize	Ames, IA	Wheat	Aberdeen, ID

REFERENCES

Goodman, M.M. 1990. Genetic and germ plasm stocks worth conserving. J. Hered. 81:11-16.

James, N.I. 1990. A 1989 Survey of public plant breeding programs in the United States. Diversity 6, No. 2:32-33.

Kalton, R.R., Richardson, P.A. and Frey, N.M. 1989. Inputs in private sector plant breeding and biotechnology research programs in the United States. Diversity 5(4):22-25.

Plucknett, D.R., Smith, N.J.H., Williams, J.T. and Anishetty, N.M. 1988. Genebanks and the World's Food. Princeton University Press. 247 pp.

Shands, H.L. 1990. Plant Genetic Resources Conservation: The role of the gene bank in delivering useful genetic materials to the research scientist. J. Hered. 81:7-10.

Wilkes, H.G. 1989. Germplasm preservation: Objectives and needs. In: Biotic Diversity and Germplasm Preservation, Global Imperatives. Kluwer Academic Publishers. pp. 13-41.