Public Sector Plant Breeding Resources in the US: Study Results for the year 2001

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INTRODUCTION

In 1994 Kenneth J. Frey conducted a survey of plant breeders working in the public and private sectors in the United States[1]. Frey's survey provided the first comprehensive look at where plant breeders were employed, what crops they were working on, and what type of breeding they were doing. The study generated a great deal of discussion about the future of plant breeding. The information reported here is an attempt to update the 1994 data on plant breeding in the United States. The study was conducted under the direction of Greg Traxler, Auburn University. The survey instrument is included in appendix 1. For this study, Dr. Traxler received grants from the Cooperative State Research, Education, and Extension Service (CSREES) and the Economic Research Service (ERS), USDA. The authors wish to thank the many public- and private-sector organizations who gave their time to provide the data for this study.

The intent of the survey was to construct a data base on scientists working as of 2001 on plant breeding research (PBR), gene pool enhancement (GE), cultivar development (CD), and plant biotechnology development (BIO) for field, forage, horticultural, and special crops in the US. The questionnaire was sent to ARS/USDA, to state agricultural experiment stations (SAES), and to private sector plant breeding and biotechnology companies. Each institution was requested to estimate the number of Scientist Years (SYs) that their organization devoted to PBR, GE, CD, and BIO in each crop for which they had a research and development program. This data can be compared to the 1994 Frey data. It is hoped that it will be useful in considering national strategies for gene pool enhancement and cultivar development.

The questionnaire was organized into five sections:

- Part A requested general information about the organization.
- Part B requested information on Science Person Years (SYs) devoted to plant breeding research, germplasm enhancement, cultivar development, and biotechnology for individual crops.
- Part C requested more detailed information on plant biotechnology-related research and development (R&D) activities.
- Part D requested information on the scale of each breeding research program, and about means employed to protect, acquire and use intellectual property.
- Part E requested information on costs per SY devoted to plant breeding research, germplasm enhancement, cultivar development, and biotechnology for individual crops.

This report presents the public sector information from parts A and B.

METHODS AND MATERIALS

The survey questionnaire was based on the one used by Frey. The first section of the questionnaire requested data for 2001 on the number of scientist years (SYs) devoted to PBR, GE, CD and BIO by crop from each employer (see questionnaire for definitions of SY and plant breeding activities). Also requested was whether an employer's input had changed over the 5-year period 1990-94. These data were used to estimate net gains or losses in SYs by employer category.

Data on ARS/USDA input into plant breeding research and technology were obtained from the National Program Staff/ARS. The questionnaire also was sent to the USDA Plant Materials Centers (PMC) that select species and accessions of plants for land conservation purposes. Data on state public plant breeding were provided by 76 institutions, including SAES, universities not associated with an SAES, experiment stations in territories administered by the U.S. government, and 1890s colleges. Of these, 22 reported that they had no plant breeding activity.

The private sector address list was compiled by Ken Frey using the 1994 addresses, updated using the current membership lists of the American Seed Trade Association (ASTA) and the National Council of Commercial Plant Breeders (NCCPB), company names provided by the chairs of Commodity Germplasm Committees, and state seed trade associations. A total of 401 questionnaires were sent to private companies. Of these, 69 were returned as undeliverable. A total of 162 companies verified that they engage in plant breeding.

Comparing 1994 and 2001 survey results

Plant breeding has undergone several important changes since the 1994 survey. The first of these changes has been the widespread incorporation of plant biotechnology techniques into plant breeding programs. Transgenic varieties had not yet been commercially planted at the time of the previous survey. In fact, the 1994 survey

instructed respondents that they were not to include scientists conducting “basic research on plant molecular biology.” Secondly, the structure of the plant breeding industry has been dramatically restructured during the past decade. The private sector has been transformed by mergers, acquisitions and new alliances. These changes have in turn influenced the direction of the scientific effort in the public sector.

These two influences created challenges for the 2001 survey. The growing use of methods of biotechnology such as plant transformation, genetic markers, and genetic diagnostics meant that plant breeders using these techniques could not be excluded from the survey. Respondents were asked to categorize their efforts into four research areas: Plant Breeding Research, Germplasm Enhancement, Variety Development, Biotechnology Research and Development. Frey included only the first three categories. This introduces a difficulty in comparing the 2001 results to those of the 1994 Frey survey. Although the same general definition of PBR, GE and CD research was provided to respondents in both surveys, there is certain to be some variation among respondents in interpretation. Given the evolving understanding of the term biotechnology itself, some differences in the categorization of research activities across survey years may have occurred. Because of this difficulty, one cannot be sure whether Frey’s 1994 SY totals should be compared to the 2001 totals from just the first three categories, from all four categories--or from the first three and part of the fourth, as is most likely.

A more serious problem for comparing the surveys is the low response rate from the private sector in the 2001 survey. There are likely a number of explanations for this, the most important of which may be the increased concern for privacy in the industry. Many of the firms receiving surveys have changed ownership in recent years and may have been reluctant to provide information. The low response rate makes it impossible to compare the total number of plant breeders between survey years, but does provide other useful information. This report focuses on information from the public sector. Private sector results will be deferred to a future publication.

RESULTS

A total of 419.7 plant breeders were employed by the SAES in 2001 (Table 1). This is a decline of 108 breeders, or 21% since the 1994 survey. Cereals, followed by grain legumes, were the largest crop categories in both years, but significant changes in the ranking of the remaining categories occurred. Ornamentals was the only crop category with significant growth. Seven categories (forage, leafy, bulbous & stem vegetable, fruit vegetables, medicinal, spice, & special crops, root & tuber, and temperate fruit & nut) experienced declines of 30% or more.

The total number of USDA/ARS plant breeders increased by 41, or 23%. The overall increase reflects significant adjustments among crop categories, with an equal number categories experiencing declines as experiencing increases. Twenty-seven SYs were added to cereals research, and nearly 20 SYs were added to ornamentals research. Combined SAES and ARS data shows an overall decline of 10% in public sector SYs.

Ornamentals was the only category to show a significant increase from 1994, with 13 of 18 crop categories showing declines in the number of SYs.

Table 2 compares the number of plant breeders employed by the USDA Plant Materials Centers (PMCs). There was a decline of 6 SYs (17%) between 1994 and 2001. Plant breeding activity shifted strongly toward shrubs and trees, while grasses and legumes declined.

Table 3 details the distribution of R&D activities of SAES, USDA (including ARS & PMCs) and private sector breeders[2]. Although the private sector survey response does not allow us to report on the total number of industry scientists with confidence, the sample of responses is felt to be representative of the activities of industry with regards to research focus. SAES and industry have the same ranking of research activities – CD is the largest single area, followed by BIO, PBR and GE. Industry devotes nearly half of their plant breeding resources to CD, and CD and BIO account for 80% of industry SYs. SAES breeders are more equally spread. It is important to note though, that industry has far more breeders than the SAESs do in all categories. So while industry clearly focuses on the applied research, their numbers are so great that they provide critical quantities of basic and strategic crop improvement research. GE had by far the lowest number of combined SYs, with neither SAES nor industry. GE is a role that naturally falls to USDA/ARS. Although the exact breakdown among PBR, GE and CD is not available, they do relatively little CD. The USDA breakdown among PBR, GE and CD was 12%, 48% and 40% in 1994.

Plant Breeding SYs by crop group

Tables 4-10 present SAES and ARS/USDA SYs for 2001 and 1994 by crop group. The ARS/USDA totals in these tables do not include PMC personnel.

Cereal crops are presented in Table 4. SYs declined in seven of the ten crops in SAES, while all crops with active ARS/USDA programs showed increases of at least 50%. Wheat is the largest SAES cereal crop, and the largest combined public sector crop. The total number of ARS/USDA SYs in cereal crops increased by 82% between 1994 – 2001. Corn has the second highest number of combined public sector SYs. Wheat and corn together account for nearly two-thirds of public sector cereal breeding SYs.

Public sector activity in fruit vegetable crops (Table 5) declined significantly between 1994 and 2001. The number of SYs declined by 50% in the SAES, by 9% in ARS/USDA and by 43% for the combined public sector. Only one fruit vegetable crop, tomato, had more than five public sector breeders in 2001. ARS/ USDA had more than one SY in only two fruit vegetable crops.

SAES SYs declined by 33% or more in six of eight grain legume crops (Table 6). Soybean is by far the largest activity, accounting for about 75% of SYs in both SAES and ARS/USDA. Total ARS/USDA grain legume crop SYs increased by 55%. The number of SAES fiber crop SYs was nearly constant, but declined slightly in ARS/USDA

(Table 7). SAES have small amounts of activity in a large array of forage crops (Table 8). SAES and ARS/USDA had nearly equal numbers of total SYs and had a combined 25% decrease in the total public sector SYs. Alfalfa, at 28% of total public sector SYs was the largest single forage crop. Peanut has the largest number of SAES and ARS/USDA plant breeders among oilseed crops, accounting for two-thirds of total public sector SYs (Table 9). Only blueberries, peaches and strawberries have more than 5 public sector SYs among temperate fruit and nut crops (table 10). Because of the small numbers of SYs in any individual crop, a number of crops show large percentage changes in SYs. Overall, SYS in SAES declined by 32% and in ARS/USDA by 19%.

Table 11 lists the twenty crops that have the most combined SAES and ARS/USDA plant breeders. Four major row crops have the largest number of SYs, jointly accounting for more than one-third of public sector SYs. Overall, the twenty crops listed account for nearly two-thirds of SYs. Fifteen of the crops had fewer SYs in 2001 than in 1994, but there was a decline of just 12% of the total SYs for the twenty listed crops.

[1] Frey, K. *National plant breeding study - I: Human and financial resources devoted to plant breeding research and development in the United States in 1994* (Special Rep. No. 98), Iowa: Iowa Agricultural and Home Economics Experiment Station, 1996. Available on the ERS web site, at http://www.ers.usda.gov/data/plantbreeding/

[1] USDA did not provide a breakdown on their research focus among PBR, GE and BIO.

APPENDIX: Survey Instrument

National Study On Plant Breeding

Definitions:

- ***Science Person Year (SY):*** Work done by a person who has responsibility for designing, planning, administering (managing) and conducting (a) plant breeding research, (b) germplasm enhancement, (c) variety development and (d) biotechnology R&D in one (1) year (i.e. 2,080 hours). ***DO NOT include technicians, farm and clerical workers, computer specialists, post doc, grad student, etc.***

- ***Plant Breeding Research:*** Research on the genetics of plants and methodologies of plant breeding and biotechnology usually done to provide fundamental information useful for making plant breeding more efficient and productive.

- ***Germplasm Enhancement:*** Any activity that includes (a) the transfer of useful genes from unadapted lines of the same species, related species and genera, or any plant, animal, or microbe species transfer by sexual or asexual technology into plant populations that are useful for developing new crop varieties and (b) increasing the frequencies of desirable genes in crop gene pools that will be used for developing parents or varieties.

- ***Variety Development:*** Any activity of crossing, transformation, and/or selection (including biotechniques) among plants that has the direct purpose of releasing a crop variety.

- ***Biotechnology Research and development (R&D):*** Activities related to the scientific manipulation of living organisms, especially at the molecular genetic level, to produce new crop varieties or to improve crop breeding practice, including: molecular manipulation of genes, transformation, selection with molecular genetic markers, cell biology and diagnostic techniques, and genomics (see question **C-2** on the survey form for a more complete list of activities). ***DO NOT include basic research on plant molecular biology.***

- ***Cost per Science Person Year:*** Total annual cost incurred in plant breeding research, germplasm enhancement, cultivar development, or biotechnology divided by the number of SYs devoted the respective activity. Total cost should include salaries and benefits of the research staff, cost of materials, and all other costs associated with the research and dissemination activities.

PART A: General Information about Your Organization

*Please use fiscal year **2000** as the base time period for reporting answers to the questions.*

A-1 Please circle the item that best describes your organization.

1=USDA
2=SAES
3=Private
4=Other (Please explain)_____

A-2a How many years has your organization been involved in plant breeding research, germplasm enhancement, and/or variety development? _____

A-2b How many years has your organization been involved in biotechnology R&D? _____

PART B: Report of Crop Breeding Science Person Years by Crop

B-1 In 2001, how many Science Person Years did your organization devote to each crop?

Crop Name	Plant Breeding Research	Germplasm Enhancement	Cultivar Development	Biotechnology R&D
Use one line for each crop (refer to reference crops list)				
Example: Wheat	*2.3*	*0.5*	*4.2*	*1.5*

B-2 Compared to three years ago, what is the percentage change in Science Person Years (SYs) (+ for increase, – for decrease) that your organization devotes to plant breeding research, germplasm enhancement, variety development, and biotechnology R&D?

	Plant Breeding	Germplasm Enhancement	Variety Development	Biotechnology R&D
Percentage increase or decrease in SYs during last 3 years				