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Germplasm Resources at the North Central Plant Introduction Station

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NAS. 1975. *Underexploited tropical plants with promising economic value.* National Academy of Sciences. Washington, DC.

Plucknett, D. L., N. J. Smith, J. T. Williams. N. M. Anishetty. 1987. *Genebanks and the world's food.* Princeton Univer. Press. Princeton, New Jersey.

Purseglove, J. W. 1976. Millets. p. 91–93. In: N. W. Simmonds, (ed.) *Evolution of crop plants.* Longman Group Limited. New York.

Ritchie, R. L. (ed.). 1979. *New agricultural crops. AAAS Selected Symposium 38.* Westview Press, Colorado.

Sloten, D. H. van and M. Holle. 1988. Temperate fruit genetic resources and the IBPGR. *HortScience.* 23:73–74.

Simmonds, N. W. 1976. Quinoa and relatives. p. 29–30. In: N. W. Simmonds, (ed.) *Evolution of crop plants.* Longman Group Limited. New York.

Smith, P. M. Minor crops. p. 301–324. In: N. W. Simmonds, (ed.) *Evolution of crop plants.* Longman Group Limited. New York.

Stone, O. M. 1982. The elimination of four viruses from *Ullucus tuberosus* by meristem-tip culture and chemotherapy. *Ann. Appl. Biol.* 101:79–83.

Williams, J. T. 1989. Plant germplasm preservation: A global perspective In: *Beltsville Symposium in Agricultural Research. XIII. Biotic Diversity and Germplasm Preservation-Global Imperatives.* May 9–11, 1988. (In review).

ADVANCES IN NEW CROPS. Edited by J. Janick & J.E. Simon. 1990. Timber Press, Portland, Oregon.

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INTRODUCTION

History

The introduction of potentially useful plant species into the United States dates back to the early 19th century when embassies were asked to collect and import these materials. A more organized effort was established when the Section of Seed and Plant Introduction was formed in 1898 within the USDA. No provisions were made, however, to store these materials adequately and much was lost (Wilson et al. 1985).

Forty-eight years later, the four Regional Plant Introduction Stations were established under the Research and Marketing Act of 1946. The North Central Regional Plant Introduction Station (NCRPIS) at Ames, Iowa, which was the first station established, began operation in 1948. The three other regional stations were established at Pullman, Washington; Geneva, New York; and Griffin, Georgia (White et al. 1989). NCRPIS was established as Regional Research Project NC-7, entitled "Introduction, Multiplication, Evaluation, Preservation, Cataloging, and Utilization of Plant Germplasm" (Wilson et al. 1985).

Mission

The NC-7 project title describes the mission of NCRPIS, which has the responsibility for the preservation, maintenance and distribution of 1080 species in its present working collection. When an accession is received, that accession is increased, stored, and made available without charge to any requesting scientist or bona fide research agency. The NCRPIS collection includes more than 23,800 accessions. Accessions are evaluated for morphological and physiological characteristics and those data are made available to the user through the National Plant Germplasm System's (NPGS) database, the Germplasm Resources Information Network (GRIN) (Perry et al. 1988). In addition, the NCRPIS Research Unit assists in evaluation of accessions, in new crop development, and in studies related to maintenance of the collection.

Facilities

NCRPIS is located on land provided by Iowa State University. The Station includes farm offices, laboratory space, greenhouses, seed processing space, seed storage, machinery and equipment storage, and a machine shop, as well as land for seed increase and research plots. The professional staff, graduate students, and research technicians are provided offices, research laboratories, and greenhouses on campus.

Staff

Present staff includes both Federal (USDA-ARS) and State employees in several categories:

Administrative Staff: USDA-supported Coordinator and Secretary.

Professional Staff: USDA-supported Research Agronomist, Research Entomologist, and Horticulturist, and State-supported Plant Pathologist.

Curatorial Staff: Five State-supported Curators with responsibilities for the following crops, amaranth and miscellaneous legumes, maize, sunflower, vegetable crops, *Brassica* and grasses.

Support Staff: The Farm Superintendent, two technicians (maintenance and seed), and two clerks; a data processor, and a maize technician, are all State employees. There are USDA-supported Research Technicians for the Agronomist, Entomologist, and Horticulturist, as well as a bee technician. Additional part time or temporary employees (usually students) are hired as necessary. In addition a few graduate students work on germplasm related projects.

Financing

NCRPIS is financed by three agencies. Federal funds account for about 75%, and regional research funds allocated by the directors of the 12 north central states (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin) total 17%. The Iowa Agriculture and Home Economics Experiment Station provides 8% of the support through in kind contributions.

CROPS AT NCRPIS

Major collections

Table 1 lists the genera that account for 85% of the more than 23,800 accessions at NCRPIS. This table also lists the total number of accessions in the present collection, and the number of accessions available for distribution for each genus. The number of available accessions changes from year to year with changes in amount of seed increase, in germination, and demand for seed; as well as new introductions.

Table 1. NCRPIS crop genera, accessions, and available accessions.

Genus	Total Accessions	Available Accessions
Zea	6617	5003
Cucumis	3525	2399
Brassica	3496	1565
Helianthus	3016	897
Amaranthus	2630	721
Beta	1021	462
Panicum	964	775
Setaria	938	867
Cucurbita	816	511
Daucus	625	397
Melilotus	575	485
Cuphea	360	81
Woody ornamentals (511 spp.)	1090	296
Herbaceous ornamentals (154 spp.)	285	102

Other collections

Several major crop collections are kept at other north central locations such as soybeans at the University of Illinois, Urbana-Champaign, potatoes at Sturgeon Bay, Wisconsin, and flax at North Dakota State University, Fargo, North Dakota. Additional genera at NCRPIS are represented by only a few accessions, and include wild relatives of crops, that have shown potential as future crops, or are primarily of botanical interest (Table 2).

Table 2. Genera at NCRPIS with less than 300 accessions/genus.

Genus	No. of Accessions	Genus	No. of Accessions	Genus	No. of Accessions
		Grasses and Field Crops			
Agrostis	193	*Glyceria*	6	*Tetrachne*	1
Apera	6	*Helictotrichon*	9	*Tricholaena*	14
Briza	4	*Nardus*	2	*Tridens*	4
Calamovilfa	3	*Phleum*	2	*Tripsacum*	5
Echinochloa	67	*Schedonnardus*	1	*Urochloa*	1
		Legumes			
Amphicarpa	1	*Dalea*	13	*Petalostemon*	3
Coronilla	91	*Galega*	13	*Tetragonolobus*	20
		Fruits and Vegetables			
Asparagus	144	*Pastinaca*	34	*Sium*	1
Cichorium	193	*Petroselinum*	139	*Spinacia*	264
Ferula	2				
		Oil and Special Crops			
Agastache	21	*Echinops*	2	*Nepeta*	1
Alliaria	1	*Elsholtzia*	1	*Ocimum*	87
Alyssum	1	*Enarthocarpus*	1	*Oenothera*	1
Ammi	2	*Eruca*	149	*Onosma*	1
Anethum	73	*Eryngium*	7	*Origanum*	8
Arctium	1	*Eupatorium*	2	*Orlaya*	2
Berteroa	3	*Euphorbia*	18	*Osteospermum*	1
Bifora	18	*Foeniculum*	12	*Oxalis*	2
Biscutella	1	*Glaucium*	2	*Perilla*	19
Bupleurum	2	*Goldbachia*	1	*Perovskia*	2
Calamintha	1	*Guizotia*	1	*Picris*	4
Camelina	9	*Helenium*	1	*Pimpinella*	17
Cardamine	1	*Hyoscyamus*	1	*Pycnanthemum*	17
Carum	4	*Hyssopus*	1	*Rhaponticum*	4
Caucalis	1	*Iberis*	2	*Rionosciadum*	1
Celosia	6	*Isatis*	2	*Salvia*	6
Centranthes	1	*Lallemantia*	1	*Schlectendalia*	2
Chamaepeuce	1	*Lappula*	2	*Sideritis*	2
Chenopodium	59	*Lapsana*	4	*Sigesbeckia*	1
Christolea	1	*Leonotis*	1	*Sinapis*	20
Cnicus	2	*Lepidium*	69	*Stachys*	1
Coriandrum	46	*Levisticum*	1	*Stenachaenium*	3
Crambe	158	*Limnosciadium*	1	*Symphytum*	4
Cynoglossum	1	*Linum*	9	*Tephrosia*	14
Ducrosia	1	*Lobularia*	1	*Thalictrum*	21
Echinacea	1	*Lunaria*	1	*Thlaspi*	3
		Madia	1	*Trachyspermum*	1
		Monarda	20	*Vaccaria*	8
		Mosla	1	*Vernonia*	15
		Ornamentals			
Abies	1	*Fendlera*	1	*Phellodendron*	6
Acer	64	*Fittonia*	1	*Phlox*	1
Adonis	4	*Fontanesia*	1	*Photinia*	3
Ailanthus	3	*Forestiera*	2	*Physocarpus*	5
Alcea	9	*Forsythia*	3	*Picea*	4
Alchemilla	3	*Fraxinus*	32	*Picris*	1
Alnus	16	*Geranium*	2	*Pinus*	28
Althaea	2	*Ginkgo*	1	*Platanus*	2
Amelanchier	8	*Gleditsia*	2	*Polygonum*	1

Genus	No. of Accessions	Genus	No. of Accessions	Genus	No. of Accessions
Amorpha	12	*Gymnocladus*	2	*Populus*	5
Ampelopsis	4	*Gypsophila*	7	*Potentilla*	13
Anemone	2	*Hamamelis*	1	*Prinsepia*	1
Antirrhinum	1	*Helianthella*	1	*Prunus*	13
Aronia	4	*Helichrysum*	1	*Pterocarya*	2
Artemisia	1	*Hemerocallis*	1	*Pteroceltis*	1
Asimina	2	*Hesperis*	1	*Pterostyrax*	1
Asphodeline	2	*Heteropappus*	1	*Purshia*	1
Asphodelus	1	*Hippophae*	3	*Pyrus*	3
Baileya	1	*Holodiscus*	4	*Quercus*	13
Baptisia	2	*Hovenia*	2	*Rhamnus*	11
Begonia	2	*Hydrangea*	8	*Rhododendron*	12
Berberis	1	*Hypericum*	3	*Rhodotypos*	4
Betula	32	*Ilex*	2	*Rhus*	22
Bryonia	1	*Iliamna*	2	*Ribes*	11
Buckleya	1	*Impatiens*	2	*Robinia*	4
Buxus	1	*Iris*	1	*Rochelia*	1
Calendula	14	*Jamesia*	2	*Rosa*	43
Callicarpa	8	*Juglans*	2	*Rubus*	1
Caltha	1	*Juniperus*	40	*Ruscus*	1
Campanula	5	*Kalmia*	1	*Salix*	45
Campsis	2	*Kalopanax*	1	*Sambucus*	3
Caragana	7	*Kitaibelia*	1	*Sanvitalia*	12
Carpinus	15	*Knautia*	1	*Sapium*	1
Catalpa	1	*Kohleria*	2	*Scilla*	1
Catananche	1	*Kolkwitzia*	1	*Securinega*	1
Ceanothus	7	*Laburnum*	4	*Shepherdia*	3
Celastrus	1	*Lapeirousia*	1	*Sibiraea*	1
Celtis	12	*Larix*	5	*Simsia*	1
Cephalotaxus	2	*Lavatera*	8	*Smilax*	1
Cercis	22	*Ledum*	1	*Sorbus*	29
Cercocarpus	5	*Ligustrum*	26	*Spergula*	1
Chaenomeles	1	*Lilium*	3	*Sphaeralcea*	2
Chamaebatiaria	1	*Lonicera*	13	*Spiraea*	6
Chamaecyparis	1	*Lythrum*	1	*Staphylea*	17
Cheiranthus	2	*Maackia*	1	*Styrax*	1
Chilopsis	1	*Maclura*	4	*Symphoricarpos*	1
Chrysanthemum	85	*Mahonia*	1	*Symplocos*	1
Cistus	1	*Malope*	1	*Syringa*	6
Clematis	4	*Malus*	8	*Tetradymia*	1
Coleus	10	*Malva*	9	*Thuja*	7
Consolida	4	*Malvastrum*	1	*Tilia*	7
Cornus	39	*Menispermum*	1	*Tithonia*	4
Corylopsis	1	*Metasequoia*	1	*Tripterygium*	2
Cotoneaster	20	*Mimulus*	3	*Tulipa*	3
Crataegus	19	*Morus*	1	*Ulmus*	14
Cupressus	7	*Myrica*	1	Undetermined	4
Cytisus	2	*Mytilaria*	1	*Verbena*	1
Daphne	1	*Nyssa*	3	*Viburnum*	27
Delphinium	10	*Onoseris*	1	*Viola*	2
Dianthus	25	*Ostrya*	13	*Weigela*	14
Dipteronia	1	*Oxydendrum*	1	*Wisteria*	1
Duchesnea	3	*Paeonia*	1	× *Sorbocotoneaster*	1
Elaeagnus	5	*Parthenocissus*	1	*Xanthoceras*	2
Eucommia	2	*Passiflora*	1	*Yucca*	8
Euonymus	33	*Paxistima*	1	*Zelkova*	2
Evodia	3	*Peganum*	1	*Zinnia*	32
Exochorda	2	*Penstemon*	41	*Ziziphus*	1
Fallugia	1	*Peperomia*	1		
		Petteria	2		

ACQUISITION

Species are assigned to one of the Regional Plant Introduction Stations (RPIS) after consultation by the Coordinators. Factors such as area of adaptation, current interest in a crop, and number of accessions are considered before a species is assigned to a specific RPIS. These factors have resulted in shifts in assignment over the years.

Accessions are acquired by NCRPIS by several means. These include plant explorations, foreign or domestic, which may be conducted by NCRPIS personnel, or by arrangement with other collectors. Seed can be requested by NCRPIS from other agencies through the Germplasm Services Laboratory (GSL) at Beltsville, Maryland, or by the GSL staff. Direct contact with other researchers and through exchange with other genebanks is another means of acquisition.

All accessions in NPGS are recorded, assigned plant inventory (PI) numbers, and all of their pertinent data recorded into GRIN.

INCREASE AND MAINTENANCE

Every effort is made to maintain the genetic integrity of the original accession after it reaches NCRPIS. Seed increase is usually required before an accession is available for distribution. Additional seed increases are made only after the distribution lot becomes less than a critical quantity (usually 1000 seeds), or germination is reduced to less than 70%. All distribution seed lots are germinated after increase and every five years thereafter. Association of Official Seed Analysis (AOSA) germination rules are used whenever possible (AOSA 1976). All seeds are stored in clear containers in refrigerated storage at 4°C and 35–40% relative humidity.

Pollen control is accomplished for cross pollinated crops by caging increase plots or bagging individual plants. Pollination is accomplished by introducing honey bees, and/or house flies, into the cages of wild sunflower, umbels, cucumber, muskmelon, and many herbaceous ornamentals (Ellis et al. 1981). Other pollinator species, such as bumble bees and leafcutting bees, are used for specialized crops such as *Cuphea.* Crops such as maize, *Cucurbita,* and cultivated sunflower, are isolated by bagging flower parts and hand pollination. Pollen control techniques vary with the species. Seed increase population sizes vary with the species but, whenever possible, they are kept sufficiently large to maintain genetic integrity (Clark 1989 and NCRPIS 1988).

Self-pollinated crops are generally increased without providing isolation. They require smaller population sizes than cross pollinated crops if they are homozygous. Where the degree of outcrossing within an accession is variable or unknown, increases are isolated by cages without pollinators.

Seedlings of most small seeded crops are started in the greenhouse and transplanted to the field. Large seeded crops, such as maize and sunflower, are direct seeded with a tractor drawn planter. Harvest is accomplished by hand, and plant material is dried at 27° to 32°C. Fruits from vine crops are hand harvested, seed is removed from the fruit and dried under similar conditions. Dried seeds are generally threshed by hand or by hammer mill, and then cleaned with desk top clipper cleaners and/or air column separators. Hand picking is sometimes required for final cleaning. After cleaning, seed is inventoried and placed in storage. Seed of each accession is sent to the National Seed Storage Laboratory at Fort Collins, Colorado for inclusion in the base collection.

Some crops or accessions from various crops need to be increased at sites other than NCRPIS. Tropical maize, for example, which has a short day-length requirement for flowering is increased at the USDA Agriculture Research Service Tropical Research Station at Mayaguez, Puerto Rico. This station is also used as a winter nursery for sunflowers.

DISTRIBUTION

Seed of available accessions are distributed to requesting scientists free of charge. For most species, 100 seeds per accession are distributed. The small seed of *Amaranthus, Brassica, Cuphea,* and some grasses are distributed in lots of 200 or less depending upon seed availability. In special cases, such as evaluation requiring larger seed amounts, additional seed can be sent if reserves are adequate. Seed requests can be made by letter, telephone, or computer linked to GRIN. The use of GRIN requires the requester to obtain the proper GRIN access codes and procedures (NCRPIS 1988 and Perry et al. 1988).

In 1987, 19,689 seed lots were distributed worldwide. About half of the 13,473 U.S. requests were from privately supported research projects, and about half of those requests came from the North Central Region. Foreign scientists received 6216 seed lots (NCRPIS 1988). Table 3 shows the number of crop distributions.

EVALUATION

Accessions are evaluated for various traits to increase their usefulness in crop improvement. A list of the more important traits (descriptors) is developed by the Crop Advisory Committees (CAC) responsible for each

Table 3. Number of packets or plants distributed from NCRPIS, July 1987 to July 1988.

Genus	Distribution (no.) Seed packets	Plants
Zea	1806	
Cucumis	5258	
Brassica	2440	
Helianthus	1239	
Amaranthus	199	
Beta	72	
Panicum	96	
Setaria	71	
Cucurbita	137	
Daucus	303	
Melilotus	58	
Cuphea	70	
Woody ornamentals	21	1217
Herbaceous ornamentals	60	1
Other	6944	

crop. When feasible, the U.S. descriptors are kept consistent with those established by the International Board of Plant Genetic Resources (IBPGR). Many of the morphological descriptors are measured by the curator at the time of seed increase.

Much of the evaluation is for pest resistance. The NCRPIS pathologist and entomologist are responsible for some of this work. Since it is not possible for NCRPIS personnel to evaluate all pests that may affect a crop, researchers at other institutions work cooperatively with NCRPIS personnel to evaluate for pests, and morphological and physiological descriptors for which they have expertise. All these data are entered into GRIN.

Special funds have been provided to NCRPIS by USDA-ARS to evaluate certain characters in sunflower and sugar beets. Evaluation for adaptation of woody ornamental species to conditions in the North Central Region is an ongoing project, with 32 active trial sites. (Wilson et al. 1985).

ENHANCEMENT AND RESEARCH

Jones (1983) defined enhancement as transferring useful genes from exotic or wild germplasm into agronomically acceptable backgrounds. Enhancement is being applied at NCRPIS in transferring fruit rot resistance into cucumbers and the domestication of *Cuphea.*

Several problems pertaining to maintenance of germplasm at NCRPIS are being addressed by the Research Unit. Examples of past and current research include: studies of insect pollination in cages of sunflower (Collison and Wilson 1985) and *Cuphea,* studies to determine rearing techniques for insect pests needed for evaluation (Wilson and McClurg 1986), storing and longevity of *Cuphea* seed, storing sunflower pollen (Roath et al. 1988), and adapting wild mint family species to use as bee pasture (Widrlechner 1987).

DATA PROCESSING

The Germplasm Resources Information Network (GRIN) is the information data bank common to the NPGS (Perry et al. 1988). This data bank provides uniform capability for storing and retrieving, passport, inventory, germination, order processing, and descriptor data on all material in the NPGS. These data can be accessed by the user community directly if the user has a computer and a modem along with the proper access codes. In this way, the user can search for the germplasm material of interest and order that material electronically. However, the traditional means of phone and mail requests are still the major means of sending requests for information or securing germplasm. Information on securing access to GRIN can be obtained by writing:

Mr. J. D. Mowder
GRIN Database Manager
USDA-ARS
Bldg. 001, Rm. 130, BARC West
Beltsville, MD 20705
301/344-3318

REFERENCES
AOSA. 1976. *Rules for testing seed.* (Rev. Ed.) Graphic Publ. Co. Lake Mills, Iowa.
Clark, R. L. 1989. Maintenance and storage—seeds. *Plant Breed. Rev.* 7:95–110.
Collison, V. L. and R. L. Wilson. 1985. Comparison of honey bees vs. hand and self pollination for obtaining seed from wild type sunflower in cages. *The Southwest. Entomol.* 10:268–273.
Ellis, M. D., G. S. Jackson, W. H. Skrdla, and H. C. Spencer. 1981. Use of honey bees for controlled interpollination of plant germplasm collections. *HortScience* 16:488–491.
Jones, Q. 1983. Germplasm needs of oilseed crops. *Econ. Bot.* 37:418–422.
NCRPIS. 1988. *NC-7 Operations Handbook.* North Central Regional Plant Introduction Station. Iowa State Univ. Ames.
Perry, M., A. K. Stoner, and J. D. Mowder. 1988. Plant germplasm information management system: Germplasm Resources Information Network. *HortScience* 23:57–60.
Roath, W. W., J. S. Pomeroy, and M. P. Widrlechner. 1988. Effects of sunflower (*Helianthus annuus* L.) pollen storage conditions on pollen viability and progeny *Mdh1* allelic frequency. p. 331–336. In: *Proc. 12th Int. Sunflower Conf.* Novi Sad, Yugoslavia.
White, G. A., H. L. Shands, and G. R. Lovell. 1989. History and operation of the National Plant Germplasm System. *Plant Breed. Rev.* 7:5–56.
Wilson, R. L., R. L. Clark, and M. P. Widrlechner. 1985. A brief history of the North Central Regional Plant Introduction Station and a list of the genera maintained. *Proc. Iowa Acad. Sci.* 92:63–66.
Wilson, R. L. and S. G. McClurg. 1986. Artificial oviposition substrate for infesting sunflower with eggs of the sunflower moth (Lepidoptera:Pyralidae) *J. Econ. Entomol.* 79:545–547.
Widrlechner, M. P. 1987. Mint family as plants for honey bee forage. p. 66–76. In: J. E. Simon and L. Grant (eds.). *Proc. 2nd Nat'l Herb Growing and Marketing Conf.* Purdue Agric. Exp. Sta. Bull. 530, West Lafayette, In.

Genetic Enhancement and Plant Breeding

Donald N. Duvick

INTRODUCTION

Plant breeding, a respected discipline, has been practiced as a distinct profession for about a century. Genetic enhancement is a new term, of uncertain meaning, certainly not describing a distinct profession. What precisely is genetic enhancement? How does it differ from plant breeding? Why should we discuss it at all? The concept of genetic enhancement relates to a fairly new concept: genetic vulnerability. And genetic vulnerability is a direct by-product of successful plant breeding. Let me explain.

GENETIC ENHANCEMENT, A DISCIPLINE

Plant breeding as an art probably pre-dates civilization; it certainly has shown results (cultivated plant varieties) for the past 10,000 years. As a science and a full-time profession, however, plant breeding is largely a 20th century discipline. Its successes, as we all have heard many times over, have given rise to great expanses of a few highly favored cultivars, which in turn have attracted epidemic spread of diseases and pests, uniquely adapted to their ever restricted range of hosts. From experiences with such epidemics, the concept of genetic vulnerability has been developed, along with its corollary, genetic diversity.

Promotion of genetic diversity requires introduction of new, unrelated breeding materials into basic and advanced breeding pools. Resulting new cultivars thus can display a greater diversity of genotypes, and present less opportunity, as grown on the farm, for epidemic disaster.

But to bring greater diversity into the breeding pools means going outside the range of elite adapted local materials. It requires bringing in unadapted and, thus, unproductive cultivars—or even weedy or wild species—that have only a few useful traits, usually tightly linked with a panoply of other undesirable, yield-reducing traits. Such exotic material, when crossed directly with elite adapted lines, uniformly gives unsuccessful breeding results. Useful cultivars rarely or never can be developed from such wide crosses.

But skillful breeders can overcome this problem. They do not try, immediately, to use the unadapted material for production of elite new cultivars. They settle, instead, for selection of intermediates: lines or populations that, while maintaining the good new traits from the exotics, also contain some of the germplasm of the