

The U.S. Plant Introduction System¹

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Plant introduction as a service to mankind is as old as mankind itself. It began when the most primitive form of agriculture took place – when man first learned that he could collect seed of his food plants from the wild and grow them near his home. Thus, he could be assured of a food supply, could grow it more abundantly, and above all, reduce his exposure to danger which was always present when he had to search for food in the wild.

Throughout the development of civilization, man always took his plants with him whenever he moved, and in his travels, he looked for new plants that would either supplement his diet or make it more interesting. The search for new plants, or better sources of known ones, was often an underlying reason for many of his explorations into unknown parts of the world. The quest for spices, for example, is well known, as are the resulting geographic discoveries made.

History of plant introduction in the U.S.

Plant introduction was indirectly involved in the European discovery of the western world and was later destined to play a most important role in the agricultural development of North America. As a system of introducing new plants for trial and crop development, plant introduction in the United States began when the first colonists arrived in the New World. In a primitive form, however, it already existed here because the Indians made use of corn, squash, and other crops, which had their origin in Central or South America. The cultivated sunflower, a heritage from the Indians as a source of food, is one of the few major plants of North American origin now grown extensively in various parts of the world.

The present strong and diversified

agricultural economy of the United States, however, has developed from plants introduced from many countries. All our major crops, like the cereals, many vegetables, most fruits, and many forage crops were introduced. We were dependent on plant introductions of these crops during the early years of our country's development as a source of material for crop improvement; we are presently dependent on them as a source of genes for pest resistance and other desirable crop characteristics; and we will rely on them in the future for traits now unknown to us.

Plant introduction in the early years was many faceted and generally not systematized, but numerous valuable crop varieties were developed during the first 200 years. Much progress was made through efforts of various individuals like Adams, Franklin, Hamilton and others, and agricultural societies flourished. Congressmen obtained seed and distributed hundreds of thousands of packets to their constituents. Federal assistance was initially provided through the U.S. Navy and by foreign consuls. The first federal grant of \$1000 for plant introduction was made in 1839. It was an appropriation from Patent Office funds to aid in collecting and publishing agricultural statistics and for the collection and distribution of seeds. This was one factor that eventually led to the establishment of the U.S. Department of Agriculture in 1862. In the 1850's, supporters of a U.S. Department of Agriculture stressed the great value of plant introduction work to the nation's agriculture to help support their cause. With the establishment of the Office of Foreign Seed and Plant Introduction in 1897, seed of all new plant introductions was channeled through that central office, and an inventory system was established whereby all seed introduced into the United States was numbered with PI (Plant Inventory) numbers and documented as to origin and known value. O. F. Cook established this system in 1898. Seed distribution records were kept. This marked the beginning of the Plant Inventory Publications of the U.S. Department of Agriculture. These continue to be published annually and are available in the libraries of all land grant institutions. Each PI number is assigned only once. Hence, PI No. 1 was assigned in 1898, and the numbers currently being assigned are in the 390 thousands. Also, over 160 actual foreign



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explorations to centers of crop diversity have been undertaken during that time.

This development was the first landmark in the evolution of the plant introduction system as we know it today, but there was one significant weakness. There were no centralized facilities available for permanent maintenance and preservation of the seed once it was introduced and used. Consequently, much valuable germplasm was lost during the first 48 year period of this new system.

Regional approach for centralized germplasm preservation facilities

The passage of the Research and Marketing Act of 1946 is a second landmark in the evolution of the plant introduction system. It provided stimulus and a mechanism for a cooperative program by state and federal agricultural research agencies on a continuing basis. A portion of the Hatch funds going to the State Agricultural Experiment Stations from the federal government was earmarked for use in cooperative regional research. Similarly, a portion of the funds for USDA in-house research was earmarked for cooperative programs with the State Agricultural Experiment Stations. Funds were allotted to the states for research in which two or more state agricultural experiment stations cooperated to solve problems that concern the agriculture of more than one state. These are known as Regional Research funds, and plant introduction work qualified for these funds.

Thus, the concept of a regional state-federal cooperative program with central facilities for seed increase, maintenance, storage, preservation, and distribution was born. The first Regional Plant Introduction Station was established at Ames, Iowa, for the North Central Region in 1948. Within the next 5 years, regional stations were established in the Southern, Western,

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and Northeastern regions. A separate inter-regional station was established at Sturgeon Bay, Wisconsin, for preserving potato introductions. Plant introduction programs supported by federal and state governments had been active for several decades, but this marked the beginning of our current long-term, cooperative state/federal program to introduce, preserve, evaluate, catalogue, and distribute plant germplasm.

The federal effort toward the regional program includes cooperation and administration of the four Regional Plant Introduction Stations, the Inter-regional Station for the introduction and maintenance of potatoes, the introduction and exchange of plant material, and the inspection of plant stocks upon arrival in the United States. The Agricultural Research Service also administers the National Seed Storage Laboratory at Fort Collins, Colorado, and three U.S. Plant Introduction stations located at Glenn Dale, Maryland; Savannah, Georgia; and Miami, Florida. Plant quarantine and ornamental breeding work is carried on at the Glenn Dale Station, pulp and fiber crop breeding at Savannah, and tropical and subtropical ornamental plant maintenance and breeding at Miami. This paper, however, will concern the regional and inter-regional programs and the National Seed Storage Laboratory.

The four regional projects seek to preserve germplasm needed by plant scientists in their research now and in the future. They have very similar titles: "The Introduction, Multiplication, Preservation and Evaluation of New Plants for Industrial and Agricultural Utilization". The stated objectives are:

a. To cooperate and participate in a coordinated program of foreign and domestic plant exploration and the introduction of germplasm potentially valuable for agricultural and industrial uses in each region by:

- 1) Determining the germplasm needs of scientists in each region.
- 2) Recommending that the ARS, USDA conduct foreign and domestic explorations for, or otherwise obtain, needed material.
- 3) Receiving within the regions all introductions of plant genera for which each regional project is assigned primary responsibility, and other plants of interest.

b. To multiply, evaluate, and maintain introduced materials assigned to Regional Plant Introduction Stations and to provide accessions to the National Seed Storage Laboratory for long-term conservation.

c. To distribute introduced plant materials within the region and cooperatively to other regions, to maintain records of their use and potential value, to publish research results, and to publish, update, and distribute catalogs of seed available for distribution.

Such research provides information on chemical, physical, genetic, agronomic, horticultural, disease and insect resistance, and conservation and beautification characteristics of introductions that are potentially valuable for improving existing crops or developing new crops in the United States.

For convenience in coordinating the national cooperative program, the U.S. is divided into 4 regions – Northeastern, North Central, Western, and Southern – each with a state-federal cooperative project (Fig. 1). These four regions correspond with those delineated by the 4 Regional Associations of State Experiment Station Directors and with the 4 Agricultural Research Service regions.

Each regional and interregional project is identified by a letter-number designation, by which it is best known, and is headquartered at a Regional Plant Introduction Station. These designations and corresponding station locations are:

NE-9 – Northeastern Regional Plant Introduction Station, Geneva, New York

NC-7 – North Central Regional Plant Introduction Station, Ames, Iowa

S-9 – Southern Regional Plant Introduction Station, Experiment, Georgia

W-6 – Western Regional Plant Introduction Station, Pullman, Washington

IR-1 – Interregional Potato Station, Sturgeon Bay, Wisconsin

Puerto Rico is affiliated with the Southern Region, Hawaii, formerly with the Western Region but now with the Southern Region, and Alaska with the North Central Region.

Regional technical committee

A coordinator supervises the activities of each Regional Station, and with the aid of a Regional Technical Committee, coordinates evaluations of plant introductions within the region. The technical committee is made up of one representative (horticulturist or agronomist) from each participating state agricultural experiment station in the region, and each of the following U.S. Department of Agriculture agencies 1) Agricultural Research Service, 2) Cooperative State Research Service, 3) Soil Conservation Service, and 4) Forest Service. In the Western Region, the Bureau of Land Management of the U.S. Department of Interior is also represented. Each regional technical committee develops the project budget request and helps guide the course of its respective project. Individual committee members help serve as liaison for the project at their home stations.

The Technical Committee for the North Central Region has established six crop advisory subcommittees to provide technical assistance on matters pertaining to specific crops. These subcommittees represent the following crop groups: vegetables, fruits, ornamentals, forages, grains, and industrial crops.

Subcommittee membership consists of a representative from each of the 13 states in the region and from any USDA agency wishing to participate, but the chairman is usually a Technical Committee member.

By agreement between the ARS, Germplasm Resources Laboratory and the coordinators of the 4 regional projects, a system of crop-maintenance responsibility for preservation and maintenance of new plant germplasm has

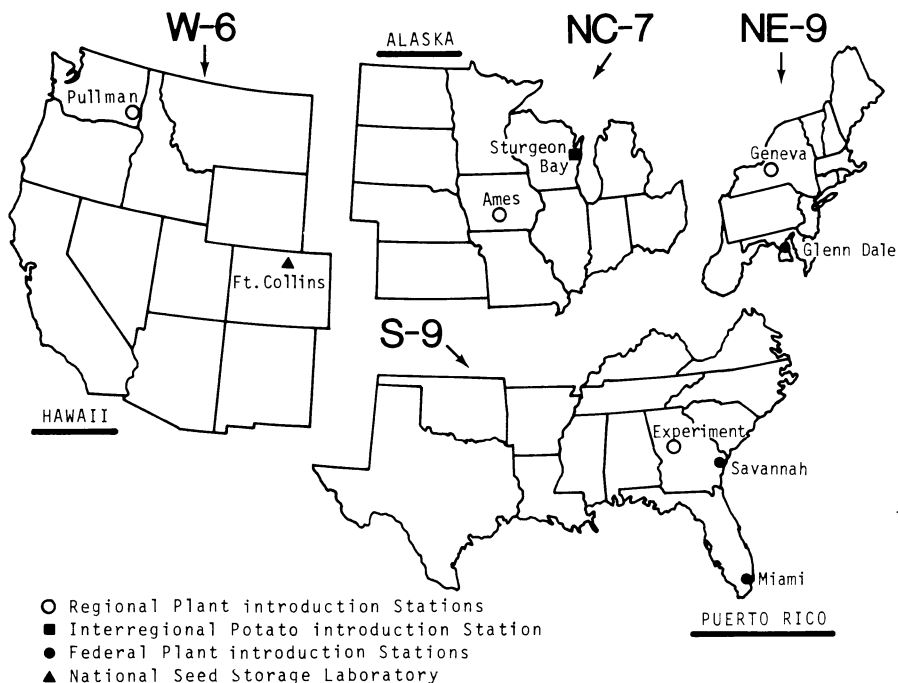


Fig. 1. Major stations for the evaluation and maintenance of germplasm and boundaries of the four regional projects.

been established whereby each crop species in the plant introduction program is assigned to one of the 4 regional stations for preservation. As an example, the Western Region has primary responsibility for maintaining bean introductions; the Southern Region for warm season grasses; the North Central Region for corn; and the Northeastern Region for peas. New introductions are directed after clearance by the USDA Inspection Station, Washington, D.C. to the appropriate regional station according to the crop priority assignment.

Regional Plant Introduction Stations are operated by multidisciplinary research teams directed by a coordinator, usually an agronomist, horticulturist, or plant pathologist. Other staff members would include an agronomist, entomologist, horticulturist, and plant pathologist, depending upon the coordinator's title or role. The professional staff members are employed by the ARS. In addition, there are farm, laboratory, and seed technicians, clerical and farm workers, employed with funds allocated to the Regional Project and are usually state employees.

An informal type of cooperation exists between the regional stations and private industry. In recent years, there has been an increase in the number of plant breeders in private industry, and they have availed themselves of the services and seed from the regional stations and, in return, have provided evaluation reports on the materials used in breeding programs and in newly released cultivars.

National seed storage laboratory

Through an act of Congress in 1956, funds were appropriated for the construction of a National Seed Storage Laboratory at Fort Collins, Colorado to help preserve germplasm, both introduced and domestic. Construction was begun in 1957, and the Laboratory was ready for operation in 1958.

The storage rooms in use are maintained at 40°F with a relative humidity of about 32%, but three rooms can be cooled to 10°F whenever the need arises. There is space in the Laboratory to accommodate 500,000 lots of agronomic, horticultural and specialty crop seed.

An attempt has been made to collect seeds of old, obsolete varieties when available. In addition, as new varieties are released by federal or state agencies, or by commercial breeders, an invitation is extended to the developer to deposit seed. Other stored seeds include open pollinated lines, inbred lines, genetic stocks, discontinued breeding lines, differential hosts for pathogens, varieties for indexing viruses and for physiological studies, and reserve seeds of plant

introductions.

The Laboratory is responsible for the preservation of a broader scope of germplasm than the regional stations, which are concerned primarily with preserving seed of foreign plant introductions. The regional stations, however, are the source of daily working stocks of seed while that from the Laboratory is distributed only when there is no remaining source available to the requestee or when a national emergency requires access to our national seed reserves.

If viability drops during storage in the Laboratory, stocks will be rejuvenated under contract in an area where the crop is adapted and in such a manner that the new seed will retain the genetic characteristics of the original seed. The regional stations, however, make most of their own seed increases. Extra or reserve quantities of seed of plant introductions are sent by the regional stations to the Laboratory for safekeeping.

Acquiring and handling plant introductions

As conducted, plant introduction is largely concerned with acquiring plant germplasm to meet the present or anticipated needs of specific research programs. Requests for the introduction of plant material usually come from national, regional, or state levels, as well as from private research organizations engaged in plant breeding programs.

Requests are channeled via the regional stations to the ARS Germplasm Resources Laboratory, Plant Genetics and Germplasm Institute, Beltsville, Maryland. This laboratory is responsible for the exchange of seed with foreign countries and for coordinating (not funding) foreign plant explorations. Therefore, if seed is needed from a foreign source, or if special foreign exploration for germplasm seems desirable, contact the coordinator of the regional station serving your region. He will advise and assist in obtaining your germplasm needs. We recommend, however, that available germplasm in our collections be screened first. If the desired trait cannot be found in existing collections, then we should strive to introduce new material.

Generally, collections of foreign germplasm should be able to provide breeders with some or all of the following materials:

- a. Cultivars
 - 1) Advanced cultivars
 - 2) Primitive cultivars
 - 3) Lines with special applications in genetics, physiology, pathology, entomology, and chemistry.
- b. Wild progenitors of crops
- c. Wild or semidomesticated species of actual or potential use as new crops

Whether material is obtained by exploration, exchange, gift, or purchase, it invariably goes first to the Plant Inspection Station, Washington, D.C. Here it is inspected for diseases and insects, fumigated, if necessary, with methyl bromide, assigned a PI number, documented, and sent to the regional station having priority for the crop or to the individual requesting it. Some crops such as rice, sugarcane, cotton and potatoes are subject to strict quarantine regulations. Clonal stocks of many fruits are also subject to propagation in quarantine facilities. Diseased seed samples may be discarded. Before distribution, the seed is examined by a seed taxonomist to verify its identity.

Usually, if seed samples are large enough, small amounts of seed from introduced samples destined for individuals are withdrawn and sent to the appropriate regional station for preservation. If samples are too small to permit this, then special arrangements are made between the coordinator and recipient of the seed to assure its preservation. This procedure is important to assure that incoming germplasm is preserved.

Fig. 2 is a flow chart that shows the normal routing of incoming plant material. After leaving the Inspection Station, routing is determined by the nature and condition of the material. Double arrows indicate routes taken by the majority of introductions. An introduction may be detained or even rejected for many and various reasons at any point and may not reach the ultimate goal of commercial clearance. Material likely to possess genes useable in future plant breeding programs goes into long-term storage.

Plant breeders who wish to send seed to a correspondent abroad usually take advantage of the Inspection Services and forward their seed via that facility. Thus, the Inspection Station is used for movement of seed in both directions.

Preservation and maintenance of seed collections

The amount of incoming seed received at the regional stations is usually quite small and must be increased before it can be distributed. Methods of increase are used that will preserve the genotype of the original incoming seed insofar as possible. Cross pollination is prevented, wherever practical, by using controlled pollination techniques. This can be done more easily with some crops than with others. At NC-7, we use the sib pollination method for increasing cucumbers, pumpkins, corn, and sunflowers. Onions, carrots, and parsley are grown in cages with bees used for pollinators. Other cross-pollinated crops are grown under open-pollination because no practical techniques are

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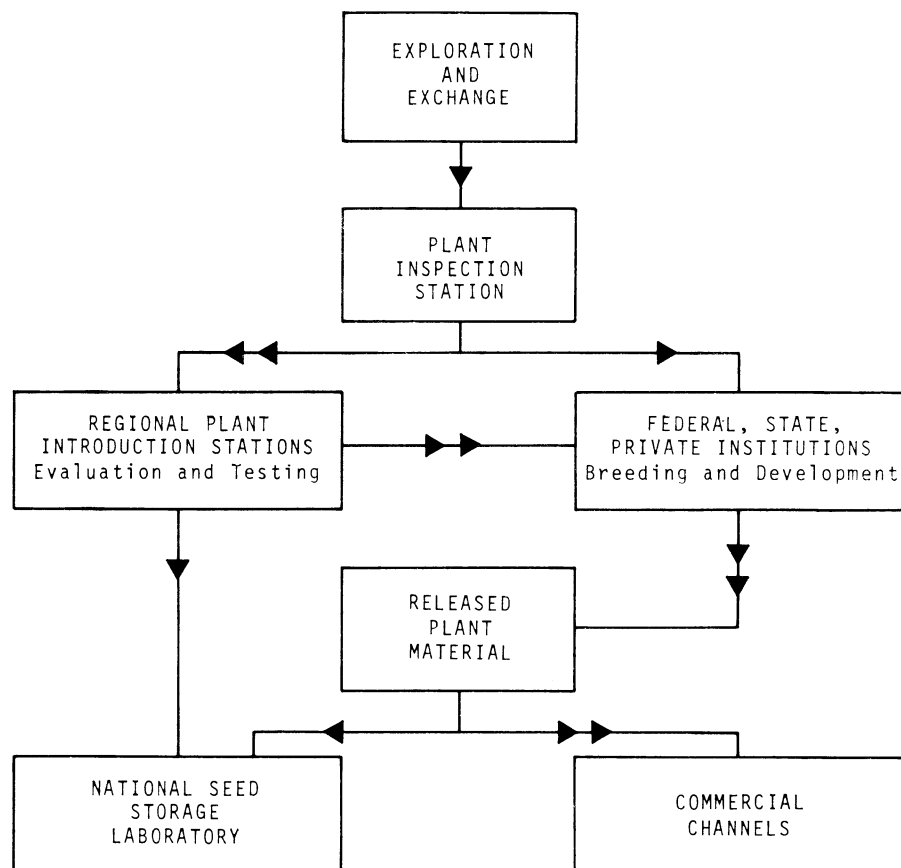


Fig. 2. Normal routing of plant introductions after entering the U.S. (courtesy of H. H. Fisher, 1969).

presently known for controlling the pollination of a large number of accessions of a given crop grown at the same time. Some crops, like garden tomatoes and peas, are highly self-pollinated, so there is considerably less chance of cross pollination in these crops.

At Ames, about 3200 accessions of all crops are grown each year, and more than one-third, or about 1200, are vegetables. More than 300 tomatoes alone are grown.

As mentioned, all incoming seed is inspected at the Inspection Station for external signs of diseases such as spores, rust pustules on the glumes, and other visible evidence. Seedborne diseases, however, cannot be detected in this way, so it becomes the function of the Regional Plant Pathologists to observe plants derived from original seed for such diseases. This is done in the greenhouse on seedling plants and in the field on direct seedlings or on established plants. The plant introduction stations are especially vulnerable to the accidental introduction of seedborne diseases, so this function of the plant pathologists is extremely essential.

Usually, original seed is not distributed unless adequate assurance is obtained from the recipient that the resulting plants will be grown under the observation of a qualified scientist.

Only relatively small quantities of seed of each accession are produced. Usually plant scientists need only a few seeds for their work, so making large-scale increases of individual accessions is not necessary. Further limitations are imposed by the relatively large number of accessions of many crop genera that must be grown each year. The maximum amount of seed of individual accessions preserved in storage varies among regions, but, for example, at NC-7, we store a maximum of one pint of tomato seed, one quart of cucumber seed, and two quarts of pumpkin seed of each individual introduction. It is evident that the maximum amounts are dictated, in part, by seed size. The uniformity of container size also facilitates handling in the seed storage room. Only small experimental quantities of seed are distributed, usually 100 to 200 seeds.

Conditions for seed storage are about the same at all regional stations. At Ames, seed is stored in glass jars in a room kept at 42°F and 40% relative humidity. Under these conditions, it will remain viable for many years, although some crop seed inherently stores better than others. Corn is known to have germinated well, 80 to 100%, after 20 years of storage. Tomato seed stores well, too. Lettuce and onion seed is relatively short lived even under these

storage conditions, and must be increased more frequently than others.

This low-temperature storage provides an added bonus in that it prevents insect activity and eliminates the need for insecticides, which are a hazard to the health of seedroom personnel who fill seed orders. The threshold of insect activity is about 50°F.

A long-term accomplishment of the regional programs on which the use of germplasm depends is the assembling of working stocks of plant introductions according to crop priorities assigned to regions. Despite recognized gaps, nowhere else in the world is there so great an array of genetic diversity available to plant breeders. Plant introductions held by the regions, according to genera and number of accessions, are as follows:

Region	Genera	Accessions*
NE-9, Geneva, N.Y.	150	18,000
NC-7, Ames, Iowa	135	17,000
S-9, Experiment, Ga.	247	25,000
W-6, Pullman, Wash.	278	18,000
IR-1, Sturgeon Bay, Wisconsin	Solanum	3,500

*Based on 1970 inventories. Collections in all regions have increased in size considerably in the past 4 years.

Some of the largest individual collections at Ames are tomatoes—3700; corn—2500; alfalfa—1000; cucumbers—600.

Seed distribution

Each year there is considerable seed distribution activity at each regional station. Outstanding introductions are used repeatedly. As a consequence, plant introductions tracing back to early eras of plant exploration are used as frequently and are as carefully conserved as more recent ones.

The regional programs distribute seed and other materials as follows:

Region	Annual Distribution*
NE-9	4,500
NC-7	10,000
S-9	9,500
W-6	7,250
IR-1	3,000

*Based on seed and other orders filled averaged over the 5-year period, 1967-1971.

New stocks are made available for distribution as rapidly as possible. At Ames, more packets of tomato seed are distributed than any other crop, followed by corn, alfalfa, cucumbers, and pumpkins.

Catalogs, or seed lists, of available material of all crops are distributed to all interested workers. These catalogs are amended at intervals to provide a current list of available stocks and pertinent information about each.

Catalog information is being transferred into the automatic data processing system so that the catalogs can be printed out by computer. Further service can be provided by automatically searching collections for desired plant traits.

These catalogs are distributed regionally and interregionally to plant scientists. Crops workers are encouraged to request any materials they need from or through their regional coordinator. They should also avail themselves of the services provided by automatic data processing when in search for desired traits in any crop in the system by contacting their regional coordinator.

Seed of plant introductions is available at no cost, but performance reports from the users are requested. Reports are made in various ways: 1) by direct correspondence; 2) through state progress reports made by technical committee representatives; and 3) by special accession performance reports solicited by the Coordinator. Frequently, information on advanced evaluations of plant introductions is published in various journals. All these reporting procedures accomplish the same purpose — to inform the Regional Station about the value of the plant introductions used and to state if they were used in breeding lines, released varieties, or for other purposes.

From these reports, it is possible for the regional stations to maintain records on the valuable traits in plant introductions and to periodically summarize them. These summaries are distributed as an aid to other plant scientists for selecting material that might be helpful in their own plant breeding programs.

It is interesting to note that out of our collection of 600 introductions of cucumbers, 125 have been reported as having resistance to one or more diseases and (or) insects. Half are reported to have multiple resistance; i.e., resistance to two or more diseases and insects. One introduction, PI 197087, has resistance to eight.

In the tomato collection of 3700 introductions, 250 have multiple resistance. Multiple resistance to 8 to 12 pests is common, and one accession has resistance to 13.

When publishing about plant introductions, we request two things of the author: 1) to give credit to plant introduction by using PI numbers for identifying material and listing the source; and 2) to verify the accuracy of PI numbers, nomenclature, and country of origin by sending a copy of the manuscript to the Coordinator serving his region. Publication of an incorrect PI number can become very troublesome. Usually, regional stations do not distribute seed under anything but PI numbers. If, in an unusual case, they do so, the PI numbers always take precedence over any other number that may also be used.

Seed exchange with foreign countries

Plant breeders in foreign countries avail themselves of the seed collections maintained at the regional stations and the National Seed Storage Laboratory.

These requests for seed are coordinated by the Principal Plant Introduction Officer of the Germplasm Resources Laboratory. The movement of seed out of the United States passes through the Plant Inspection Station in Washington, D.C., as does all incoming seed. Phytosanitary certificates are attached before the seed leaves the country.

Excellent plant exchange relationships exist with plant breeders in Canada. They frequently use seed from our collections and reciprocate by donating seed that might be useful to us. Further, they provide reports on introductions in the same way as U.S. plant breeders. We keep them on our mailing lists to receive copies of reports and publications, including summaries of valuable plant introductions.

Preservation of asexually propagated stocks

Up to this point, we have considered only the preservation of germplasm in the form of seed. Seed is relatively easy to propagate and store and requires little space for long-term storage. Consequently, the primary effort for germplasm preservation has been in the form of seed.

For many years, the preservation of asexually propagated stocks has been discussed, but no practical solution or adequate resources could be found for providing effective long-term preservation. Within the past two years, considerable interest was regenerated for preservation of clonally propagated fruit and nut crop germplasm. A meeting was held by the ARS Plant Germplasm Coordinating Committee in Geneva, New York in 1974 to consider this subject. Suggestions were made as to the amount of land, facilities, and financial support that would be needed to maintain certain collections. The NC-7 Technical Committee recommended that the Regional Station programs be expanded to include preservation of clonally propagated fruit and nut stocks and that funding be provided to designated holders of fruit and nut collections of fruit germplasm for preservation of stocks. Further, it was recommended that the National Plant Germplasm Committee coordinate the designation of repositories and that crop commodity committees be appointed to advise the national committee. This recommendation will be forwarded to the National Plant Germplasm Committee for consideration.

Recent developments in organization

In 1972, the Agricultural Research Service was reorganized and changed from a national to a regional basis with four geographic regions that coincide with the present Regional Plant Introduction program boundaries. This reorganization severed the national program of plant introduction that had been

in effect since 1898, recently administered by the New Crops Research Branch of the former Crops Research Division. However, plant introduction work within ARS was considered to function more effectively on a national basis, so a national plan of operation was developed and approved. This national plan is administered by an in-house committee called the ARS Plant Germplasm Coordinating Committee. Its members consist of the four regional coordinators, two members of the National Program Staff, the Principal Plant Introduction Officer, the Director of the National Seed Storage Laboratory, and four plant scientists, one from each region. This committee meets as often as necessary to consider the needs of plant introduction and to make recommendations to the Administrator of ARS concerning these needs for plant introduction activities.

Since their establishment, the 4 regional plant introduction programs, the interregional projects for potatoes and fruits, and the National Seed Storage Laboratory were coordinated by an umbrella committee called the National Coordinating Committee. This committee met every two years and handled problems common to all plant introduction facilities. In 1974, this committee was terminated and replaced by a committee called the National Plant Germplasm Committee. This new committee has fewer members and will meet as often as necessary to consider matters referred to it, but in a broader concept as related to germplasm preservation and genetic vulnerability. Membership consists of the four regional administrative advisers, four regional coordinators, two members of the National Program staff, a representative from private industry, through the National Council of Commercial Plant Breeders.

The efforts of these committees are being directed toward the heart of problems concerning preservation and conservation of plant germplasm resources and genetic vulnerability. Much work lies ahead in these areas, but progress is being made. Meanwhile, every effort is being made by the regional stations and the National Seed Storage Laboratory to preserve and maintain germplasm presently in our collections for use by plant breeders now and in the future.

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