Seeds for Our Future

The U.S. National Plant Germplasm System

United States Department of Agriculture

Agricultural Research Service

Program Aid 1470

As the in-house research arm of the U.S. Department of Agriculture, the Agricultural Research Service has a mission to:

Provide access to agricultural information and develop new knowledge and technology needed to solve technical agricultural problems of broad scope and high national priority to ensure adequate availability of high-quality, safe food and other agricultural products, to meet the nutritional needs of the American consumer, to sustain a viable and competitive food and agricultural economy, and to maintain a quality environment and natural resource base.

Cover: Some of the many economically important field and horticultural crops whose germplasm is collected, preserved, and distributed by the National Plant Germplasm System. (K6036-12)

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In 1970, a disease called Southern corn leaf blight swept through cornfield after cornfield from the southeastern United States into the Great Plains. This epidemic cost farmers 15 percent of the corn crop that year (about 700 million bushels). It happened because nearly all the corn being planted was genetically susceptible to the fungus that caused the blight. To prevent similar epidemics from recurring in later years, seed companies and breeders reverted to hybrids that lacked the susceptibility but otherwise had the desirable genetic makeup of the affected corn.

The 1970 epidemic reminded us of how vulnerable modern agriculture has become. It reminded us of the mid-19th century Irish potato famine, which happened for similar reasons and cost not just money, but hundreds of thousands of lives. It reminded us that since our vast agricultural resources are the foundation of our prosperity, seeds and plants are a national treasure. And it was partly responsible for formalization of the National Plant Germplasm System.

What Plant Germplasm Is

Plant germplasm is living tissue from which new plants can be grown. This can be a seed, or it can be another plant part—a leaf, a piece of stem, or pollen, for example, or even just a few cells that can be cultured into a whole plant. Plant germplasm contains the genetic information for the plant's hereditary makeup.

What the National Plant Germplasm System Is

The National Plant Germplasm System is a network of organizations and people dedicated to preserving the genetic diversity of crop plants. The national system collects plant germplasm from all over the world, including the United States. Curators and other scientists preserve, evaluate, and catalog this germplasm and distribute it to people with a valid use. Members of the National Plant Germplasm System include Federal, State, and private organizations and research units. Coordinating the system is the Agricultural Research Service (ARS), principal research agency of the U.S. Department of Agriculture.

Support and funding comes from Federal appropriations and State contributions that include land, lab and office space, scientists who carry out various research programs, and other employees who perform many technical and support services. Private industry underwrites selected projects and develops and transfers germplasm in the form of hybrids and varieties from the public system to farmers and other consumers.

Strawberries are a native North American crop. (K7180-1)

We need a *national* system to avoid unnecessary duplication and to coordinate funding and information. At the same time, the national system is geographically dispersed because of environmental variations that affect where plants grow. Having many storage sites also avoids the dangers of losing all our germplasm reserves if one location is destroyed.

PI (Plant Introduction) No. 1 is a cabbage variety introduced from Russia in 1898. The National Plant Germplasm System has some 450,000 PI's, and about 10,000 new ones are entered into the system each year. Among the 450,000 items in the national system are antique varieties, once popular but now surpassed by newer ones, and heirlooms, varieties passed down in families like a grandfather's gold watch from generation to generation.

Genetic Diversity

America's abundant and inexpensive supply of food and fiber is based on intensive agriculture. Intensive agriculture benefits from genetic uniformity in crops. But genetic uniformity increases the potential for crop vulnerability to new pests and stresses. Genetic diversity gives us the sustained ability to develop new plant varieties that can resist these pests, diseases, and environmental stresses.

Wild ancestors and relatives of cultivated plants are the keys to genetic diversity. But the amount of land where plants grow wild continues to shrink, and many plant species and varieties are disappearing forever. The National Plant Germplasm System exists to store and catalog germplasm of plants that might otherwise be lost. In the highly populated world of our future, some of these plants may help make the difference between abundance and scarcity.

Origins of the National Plant Germplasm System

Before the national system, there were regional germplasm repositories and various working collections. These have indirect origins in colonial times when settlers brought Old World seeds to the newly emerging North American colonies. Many of the founders of the United States, like George Washington and Thomas Jefferson, were scientific farmers—they studied new ways and experimented with new species and varieties.

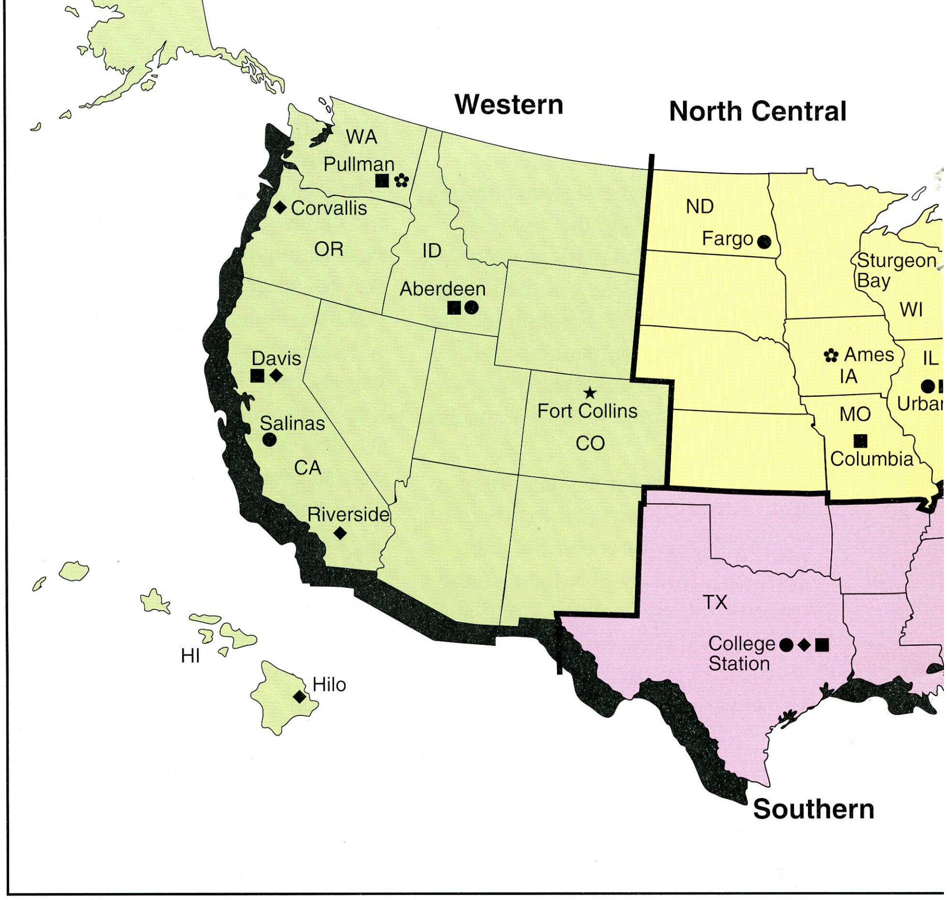
The motivation for these men was partly scientific curiosity, but mostly desire for economic gain—for themselves and for their young country. Then, as now, American farmers were determining the most profitable combinations of crops and growing conditions and trying out new crops that might make more money. This interest in agricultural experimentation among farmers and farmer statesmen led to plant exploration and introduction by members of the U.S. diplomatic corps in the Nation's early years. From their ambassadorial posts around the world, many sent home new plant species and varieties.

When he was Pennsylvania's ambassador to England from 1764 to 1775, Benjamin Franklin often sent home seeds and cuttings to be tried out in the colonies. Likewise, Thomas Jefferson was always on the lookout for plant varieties that would improve the economic return from his farming enterprises.

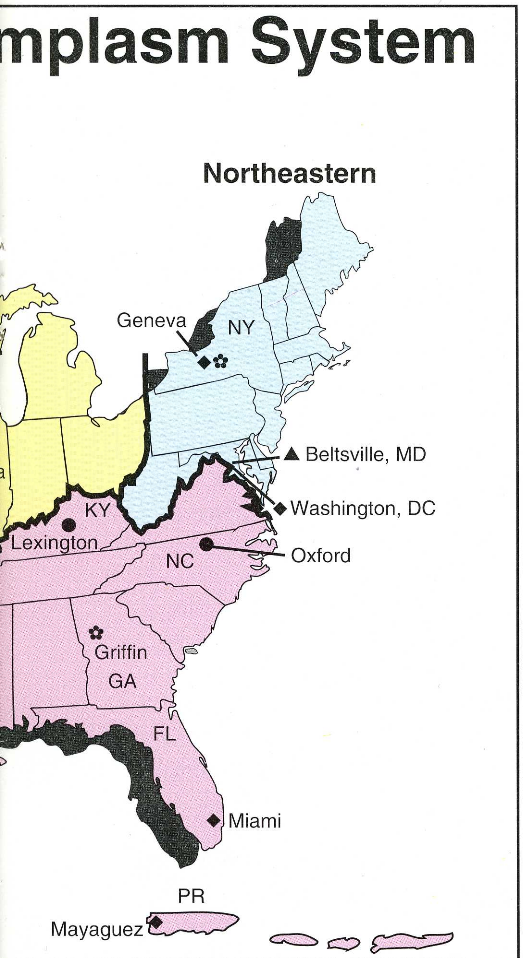
Early plant exploration was an amateur occupation. Even after Abraham Lincoln created the U.S. Department of Agriculture in 1862, there was little systematic collection and cataloging. Professional plant exploration and controlled introduction began officially in 1898 when USDA established the Section of Seed and Plant Introduction. Plant introductions became the basis of crop improvement, and plant breeders and other researchers used them to breed new varieties for stress and pest resistance and for higher yields.

Breeders became the curators for these introductions and maintained them as best they could. Little was known about the conditions needed for stored germplasm to retain its ability to germinate and grow. And collections were maintained somewhat haphazardly until after 1946 when Congress mandated establishment of the National Potato Introduction Station and the Regional Plant Introduction Stations.

The National Plant Ger



- ✿ Regional Plant Introduction Station
- ● Crop-specific seed collection
- ■ Crop-specific genetic stocks collection
- ◆ National Clonal Germplasm Repository
- ★ National Seed Storage Laboratory, Fort Collins, Colorado
- ✚ National Potato Introduction Station, Sturgeon Bay, Wisconsin
- ▲ National Germplasm Resources Laboratory, National Plant Germplasm Quarantine Center, Beltsville, Maryland



Among crops native to the United States are sunflowers, cranberries, blueberries, strawberries, pecans, various minor fruits and nuts, range and forage grasses (but not cereals), and many tree species.

Components of the National Plant Germplasm System

People often liken germplasm collections to banks—repositories of treasured seed. The Nation's only long-term seed storage facility is the **National Seed Storage Laboratory** at Fort Collins, Colorado. Here, our base collection serves as a savings bank by maintaining backup seed samples of the germplasm contained in the working collections. Also, when possible, it keeps seed for plants that are normally propagated from cuttings. (See map for locations of all collections in the system.)

ARS grape specialists bred the varieties shown here from germplasm in the collections. (K3682-9)

The National Clonal Germplasm Repository at Geneva, New York, stores and distributes apple germplasm from among 2,500 varieties. (K3706-1)

Four **Regional Plant Introduction Stations** maintain working collections of seeds. A working collection distributes germplasm to meet the day-to-day needs of research scientists—a kind of gene bank checking account. The regional stations store thousands of plant species and varieties; other working collections across the country concentrate on only one crop or type of crops such as potatoes or small grains. Finally, since many fruit, nut, and landscape varieties lose their varietal identity when they're stored as seed, this germplasm is preserved as living plants at the **National Clonal Germplasm Repositories.**

Each collection has a curator and staff responsible for its maintenance.

Papaya growing at the National Clonal Germplasm Repository at Hilo, Hawaii. Many tropical crops are stored at Hilo and at Mayaguez, Puerto Rico, and Miami, Florida. (K3504-14)

Also part of the national system is the **National Germplasm Resources Laboratory** at Beltsville, Maryland, which supports the entire national system. It is the hub for plant exploration activities and a clearinghouse for exchange of plant germplasm with foreign countries. This ARS lab catalogs all incoming accessions, assigns PI (plant introduction) identification numbers, and distributes germplasm to the various collections in the system. It also assists the Crop Germplasm Committees and maintains the GRIN (Germplasm Resources Information Network) computer database described on p. 9. And, with USDA's Animal and Plant Health Inspection Service, the Germplasm Resources Laboratory jointly manages the **National Plant Germplasm Quarantine Center** at Beltsville, Maryland. The center inspects and tests plant introductions and certifies that they are free of pests that could cause economically significant damage to U.S. crops.

Private companies often donate small collections to the system—for example, pineapples from Del Monte; corn from Pioneer, Ciba-Geigy, Cargill, and Northrup King; and oats from Northrup King.

Apricot trees, like many fruitbearing trees, are both landscape and horticultural crop plants. The National Plant Germplasm System collects and distributes germplasm for both purposes. (K2545-17)

Just a few of the possible variations in tomatoes. (K3707-1)

Plant explorers have often been depicted as intrepid botanists tramping through South American jungles to find a rare medicinal species that cures some previously incurable disease. This picture isn't far removed from the truth. The agricultural plant explorer is more likely to be searching for potato relatives, but he or she may be tramping through high South American plateaus to find them—or, for instance, in North Africa for wild wheat, southwest Asia for alfalfa, and Minnesota for cranberries. ARS employs plant explorer/botanists who spend several months a year in the field. They also plan future expeditions and coordinate funding and technical assistance for explorers from State experiment stations, and universities.

Crop Germplasm Committees counsel the National Plant Germplasm System on specific crops. Committees exist for most economically important food, fiber, industrial, and ornamental crops. In addition to providing guidance, the specialists who make up each committee help set priorities about acquisitions, maintenance, evaluation, and enhancements needed for a specific crop. The tomato committee is a typical example. It includes prominent tomato breeders, pathologists, geneticists, and entomologists drawn from Federal agencies, State universities, and private seed and food-processing companies. Committee members are world authorities on tomato research and production.

What the Collections Contain

Many special collections of particular species still exist outside the national system. Mindful that these might become lost, the collection curators, Crop Germplasm Committees, and other concerned people conduct special collection outreach programs to identify and rescue as many of these as possible. Among the collections acquired through this program: the Brink maize genetic stocks from Wisconsin, a Crookham sweet corn collection from Idaho, the Whitaker cucurbit (cucumbers and gourds) collection, and the Marx pea collection from New York.

The collections include domestic and foreign plants, wild and weedy relatives of crop species, cultivars and inbred parental lines (varieties created through planned breeding programs), elite breeding lines, some rare and endangered species, and genetic stocks. (See list on p. 15 for commonly cultivated species and where they're stored.)

Genetic stocks include induced and natural mutations, cytological (cellular) stocks of genetic oddities and variations on normal chromosomes, marker genes, polyploids, and pest-resistant stocks.

GRIN, the Germplasm Resources Information Network, is the system's computer database. It contains information on all genetic resources preserved by the National Plant Germplasm System. Through **GRIN**, scientists learn about characteristics of specific germplasm and where it's located. ARS maintains the GRIN database at its research center in Beltsville, Maryland, near Washington, D.C., for scientists and other users cooperating in the national system. All sites in the national system interact with the GRIN database regularly, entering data, conducting searches, recording seed orders, and so on.

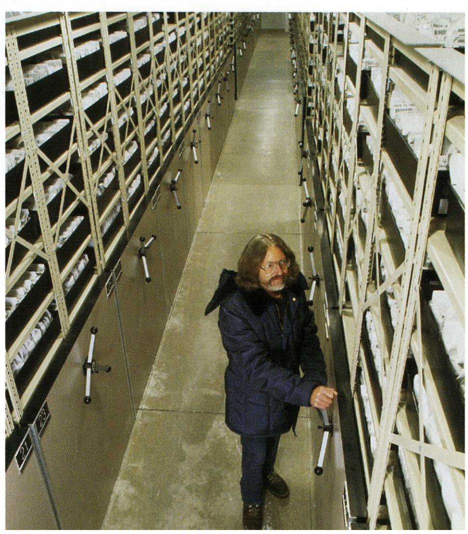
Chief needs for rice breeders are disease and insect resistance and certain quality traits. (K2960-7)

How Germplasm Is Stored

Old World settlers brought such crops as wheat, rye, oats, barley, soybeans, apples, oranges, peaches, melons, cabbage, lettuce, onions, cotton, flax, walnuts, almonds, alfalfa, and red clover. A few crops—such as grapes, cotton, and hops—have wild relatives in the Americas and in Eurasia/Africa.

Depending on species, dry seeds can last from a few years to centuries. Seeds are dried to optimum moisture content, evaluated for quality, and sealed in moisture-proof containers. Then they are stored at below freezing (-20°C) for long-term preservation. For short-term storage, seeds are dried and placed in non-sealed containers at 5°C. But some

Seeds of many different plant varieties being packaged for storage. (K1657-15)



Seed vault at the National Seed Storage Laboratory at Fort Collins, Colorado. (K5586-15) species have short-lived seeds that are difficult to store. For these seeds, other methods are needed.

Researchers at the National Seed Storage Laboratory are developing new ways to store germplasm. Cryopreservation (a type of freezing) in or over liquid nitrogen at –196˚C is the most highly developed of these new techniques. The lab is now storing seeds routinely in liquid nitrogen.

ARS scientists are also experimenting with biotechnology to test, grow, and preserve plant germplasm. Tissue culture techniques are well advanced for many species, and scientists are evaluating these techniques for those species that can't be stored as seed. Tissue culture is a cloning method—growing a whole plant from a small plant part in an artificial medium in a controlled, disease-free environ-

Cryogenic preservation of seeds at Fort Collins. (K5577-02)

American farmers grow many different varieties of wheat. Collectors and breeders are mainly looking for disease and insect resistance. (K1441-16)

ment. It's easier said than done, because techniques may be specific to one crop; solving problems for one crop doesn't solve them for all.

Besides research on seed longevity, scientists are also looking for ways to produce disease-free germplasm for storage and to keep stored seeds free of insects and mites. Much ongoing research evaluates the germplasm we already have in the system and helps pinpoint what germplasm we need. This is detective work: The botanical sleuths identify what genes are missing—drought resistance in wheat, for instance—and track them down through plant exploration and foreign exchange.

Germplasm Evaluation

Federal, State, and private sector scientists evaluate germplasm by screening for resistance to pests, diseases, and environmental stress; for quality factors such as color and flavor; and for other desirable traits. Research takes place in field, greenhouse, and laboratory. Results are available through the GRIN database.

Most of the familiar New World crops came north with the Indians from Mexico and Central and South America. These crops include corn, beans, potatoes, peanuts, tobacco, squash, pumpkin, peppers, and tomatoes.

Okra germination tests to make sure that seeds are still viable. (K1663-2)

Germplasm Repositories

A typical gene bank will have specially controlled refrigerated vaults to store the seeds in cans, jars, trays, envelopes, and other containers. Besides labs, offices, and the vaults and other storage facilities, many sites will also have greenhouses, screenhouses (where fruit crops are protected from disease carriers), and outdoor growing areas—orchards, fields, and plots. These specially built facilities are sometimes on university campuses, sometimes at ARS labs.

Cotton germplasm being evaluated in the flowering stage. U.S. farmers are growing 85 varieties but need improved resistance against insects such as the boll weevil and pink bollworm. (K1401-13)

Germplasm Users

The National Plant Germplasm System is devoted to the free and unrestricted exchange ofgerm-plasm with all nations and permits access to U.S. collections by any person with a valid use. Normally, this means plant researchers and breeders. Other users have included medical researchers and educators.

Germplasm users in other countries have the same privileges as those in the United States. This policy has grown out of the belief that germplasm, like the oceans and air, is a world heritage to be freely shared for the benefit of all humanity.

Altogether, the various collections in the National Plant Germplasm System ship over 150,000 items (packages of seeds and other plant materials) to users in the United States and in over 100 foreign countries each year.

For further information, write:

National Plant Germplasm System
Agricultural Research Service,
U.S. Department of Agriculture
Room 115, Bldg. 005, BARC-West
Beltsville, MD 20705
USA

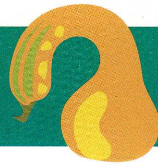
Selected List of Species (by Common Name) and Where They Are Stored in the National Plant Germplasm System

Locations:

Aberdeen, Idaho
Ames, Iowa
College Station, Texas
Corvallis, Oregon
Davis, California
Fargo, North Dakota
Fort Collins, Colorado
Geneva, New York
Griffin, Georgia
Hilo, Hawaii
Lexington, Kentucky
Mayaguez, Puerto Rico
Miami, Florida
Oxford, North Carolina
Pullman, Washington
Riverside, California
Salinas, California
Sturgeon Bay, Wisconsin
Urbana, Illinois
Washington, D.C.

Species	Location
aegilops	Aberdeen
alfalfa	Pullman
almonds	Davis
amaranth	Ames
apples	Geneva
apricots	Davis
artichokes	Geneva
artichokes, Jerusalem	Ames
asparagus	Ames
avocados	Miami
bamboo	Mayaguez
bananas	Mayaguez
barley	Aberdeen
barley genetic stocks	Aberdeen
beans	Pullman
beans, castor	Griffin
beets	Pullman
bentgrass	Ames
bermudagrass	Griffin
birdsfoot trefoil	Geneva
blackberries	Corvallis
blackeyed peas	Griffin
blueberries	Corvallis
bluegrass	Pullman
boysenberries	Corvallis
brazilnuts	Mayaguez
broccoli	Geneva
brome	Pullman
brussels-sprouts	Geneva
buckwheat	Geneva
cabbage	Geneva
cabbage, Chinese	Geneva
canarygrass	Pullman
cantaloupes	Ames
carambola	Hilo, Miami
carrots	Ames

Species	Location
cashews	Mayaguez
cassava	Mayaguez
cauliflower	Geneva
celery	Geneva
cherries	Davis, Geneva
chestnuts	College Station
chickpeas	Pullman
chicory	Ames
chives	Pullman
citrus	Riverside
clover	Griffin, Lexington, Pullman
clover, sweet	Ames
collards	Ames
coriander	Ames
corn	Ames
cotton	College Station
cotton genetic stocks	College Station
crabapple	Geneva
crambe	Ames
cranberries	Corvallis
cucumbers	Ames
currants	Corvallis
dates	Riverside
dill	Ames
dogwoods	Ames, Washington
eggplant	Griffin
endive	Ames, Salinas
fescue	Pullman
figs	Davis
filberts	Corvallis
flax	Fargo



Species	Location
garlic	Pullman
gooseberries	Corvallis
gourds	Ames, Griffin
grapefruit	Riverside
grapes	
cool season	Geneva
warm season	Davis
grasses	
forage, range	Griffin, Pullman
gamagrass	Miami
guar	Griffin
guava	Hilo
hazelnuts	Corvallis
hickory	College Statioin
holly	Washington
honeydew melon	Ames
hops	Corvallis
horseradish	Ames
kale	Ames
kenaf	Griffin
kiwifruit	Davis
kohlrabi	Ames
kumquats	Riverside
landscape, ornamental plants	Ames, Corvallis, Geneva, Miami, Washington
leeks	Pullman
legumes, forage	Griffin, Pullman
lemons	Riverside
lentils	Pullman
lespedeza	Griffin
lettuce	Pullman, Salinas
limes	Riverside

Species	Location
luffa	Griffin
lupine	Pullman
lychee	Hilo
macadamia	Hilo
magnolias	Washington
maize	Ames
maize genetic stocks	Urbana
mandarin oranges	Riverside
mangoes	Miami
maple	Washington
milkvetch	Pullman
mint	Corvallis
mungbeans	Griffin
muskmelon	Ames
mustard, mustard greens	Ames
nectarines	Davis
oaks	Washington
oats	Aberdeen
okra	Griffin
olives	Davis
onions	Geneva, Pullman
oranges	Riverside
orchardgrass	Pullman
pak choi	Pullman
papaya	Hilo
parsley	Ames
parsnips	Ames
passionfruit	Hilo, Miami
pawpaw	Corvallis
peas	Pullman
pea genetic stocks	Pullman
peaches	Davis
peanuts	Griffin

Species	Location
pearl millet	Griffin
pears	Corvallis
pecans	College Station
pennisetum	Griffin
peppers	Griffin
persimmons	Davis
pigeonpeas	Griffin
pilis	Hilo
pineapple	Hilo
pistachios	Davis
plantains	Mayaguez
plumcots	Davis
plums	Davis
pomegranates	Davis
potatoes	Sturgeon Bay
pumpkins	Ames, Geneva, Griffin
radishes	Geneva
rambutans	Hilo
raspberries	Corvallis
rhododendrons	Washington
rice	Aberdeen
rutabaga	Ames
rye	Aberdeen
ryegrass	Pullman
safflower	Pullman
sainfoin	Pullman
serradella	Griffin
sesame	Griffin
shallots	Geneva
sorghum	Griffin
sorghum genetic stocks	College Station
soybeans	Urbana
soybean genetic stocks	Ames, Urbana
spinach	Ames
squash	Ames, Geneva, Griffin

Species	Location
strawberries	Corvallis
sugarbeets	Pullman
sugarcane	Miami
sunflowers	Ames
sweetpotatoes	Griffin
tangerines	Riverside
taniers	Mayaguez
teff	Pullman
tobacco	Oxford
tomatoes	Geneva
tomato genetic stocks	Davis
triticale	Aberdeen
tropical plants	Hilo, Mayaguez, Miami
turnips	Ames
vetch	Pullman
walnuts	Davis
water chestnuts	Griffin
watermelon	Griffin
wheat	Aberdeen
wheat genetic stocks	Columbia
wheatgrass	Pullman
wildrye	Pullman
wingbeans	Griffin
yams	Mayaguez
zoysia grass	Griffin
zucchini	Ames

The National Seed Storage Laboratory at Fort Collins and the Regional Plant Introduction Stations at Ames, Griffin, Geneva, and Pullman all contain many species in addition to those listed here.