

Plant Introductions and Quarantine: The Need for Both

International movement of plants or their parts—seeds, tubers, bulbs, and cuttings, referred to as germplasm—is widely practiced as a means of diversifying a country's crops and their genetic base. Many people are not aware that most of the important food and fiber crops, so widely distributed around the world today, actually evolved in a rather restricted geographical area (3,8). Food crops native to the United States include sunflowers, cranberries, blueberries, brambles, and some types of grapes. Even the major ingredients of so-called American apple and cherry pies originated elsewhere. We think of corn as native because the Indians taught its culture to the arriving colonists, yet it originated in Mexico or southward.

The need for new germplasm in the United States and in most countries is as great as ever. In fact, concern has been expressed for at least 100 years about the reduction in genetic variability in the gene centers of crop species (12). This reduction has accelerated in recent years as preferred types have become more widely grown. There are still large gaps in the genetic diversity of some crops, and sources of resistance to many diseases, insects, and environmental stresses are not yet available to breeders. Efforts to collect, maintain, and evaluate more diverse germplasm resources have been increasing. A corresponding increase in the several-year average rate of 7,500 new introductions per year is already evident.

A Haphazard Beginning

When Europeans began settling the United States they brought crop seeds with them. This haphazard form of plant introduction continued well into the nineteenth century. Plant introduction became a partially funded project in 1829 when the U.S. Congress appropriated \$1,000 to import rare plants and seeds (3). From 1836 to 1862 the U.S. Patent Commissioner was responsible for introducing plant germplasm. When the U.S. Department of Agriculture was established in 1862, a Commissioner of Agriculture was appointed to collect, test,

and distribute potentially valuable plant germplasm. Finally, in 1898 a Section of Seed and Plant Introduction was established within the USDA. This specialized responsibility has continued with only minor changes in the system of operation (12,14).

A permanent and detailed record of germplasm that has subsequently entered the U.S. plant germplasm program has been published and is available in the libraries of most state agricultural colleges. This multivolume inventory, beginning with Plant Introduction (PI) No. 1 assigned to cabbage seed from the USSR in 1898, includes information on the source and characteristics of the more than 465,000 plant germplasm accessions imported to the United States.

Little or no attention was paid to the inadvertent importation of pests and diseases by most countries through the nineteenth century (9). This apparent apathy existed in spite of some devastating diseases in various parts of the world. For example, some 40,000 persons died in France as a result of ergot poison that spread in rye fields; famines occurred in parts of Asia that were blamed on plant diseases; and nearly 2.5 million people starved in Ireland during the potato late blight epidemic of the 1840s. Many other examples could be given of diseases caused by viruses, bacteria, mycoplasmas, nematodes, and insects that greatly affected economies or resulted in many deaths (6).

When foreign pests are carelessly introduced to new areas of the world, serious losses can result. The Dutch elm fungus, the chestnut blight fungus, the European corn borer, and the Japanese beetle are examples of pests that caused extensive damage after becoming established in the United States. Hundreds of equally destructive pests and disease agents are still "at work" in various parts of the world. Fortunately, some of these pests occur in rather restricted regions. Among the most threatening are Philippine downy mildew of corn, bacterial leaf blight of rice in Asia, African cassava mosaic virus, pangola grass stunt virus, coconut lethal yellowing mycoplasma, and potato rust fungus (13). The Animal and Plant Health Inspection Service (APHIS) of the USDA considers some of the most

damaging foreign pathogens to be fungi that attack forest trees (14); these include species of *Rosellinia*, *Helicobasidium*, *Cronartium*, *Poria*, and *Melampsora*.

Fundamental Premises

Quarantines are one means of keeping pests or diseases under control. They are usually government-enacted laws designed to regulate the entry of imported objects that might carry pests. Nearly all countries regulate the importation of plant materials. Governments also stipulate that specified genera prohibited to the commercial or lay public may be imported for scientific purposes under appropriate safeguards. This is the case in the United States.

Certain premises are fundamental to plant quarantine measures (9):

1. The measures should be based on sound biological principles.

2. They should not be used for the hindrance of trade.

3. Quarantines must derive from adequate law and authority.

4. Quarantines should be modified as conditions change or more facts become available.

5. The objective of preventing introduction and spread must be considered reasonable to achieve.

6. Both professional workers and the general public must cooperate on an international scale.

7. Those responsible for quarantine measures must be well informed.

8. Quarantines are only one facet of domestic pest management programs, and careful integration of measures is needed to achieve maximum effect.

Three Quarantine Acts

Among the earliest quarantine laws were those of Germany (1873) and the United Kingdom, both intended to prevent the introduction of the Colorado potato beetle from the United States. The first federal plant quarantine law in the United States was enacted in 1912 after the white pine blister rust, the chestnut blight fungus, and the citrus canker bacterium (subsequently eliminated at a cost of \$53 million) became established in this country. Known as the Plant Quarantine Act, it authorized government activities

to control the introduction of exotic pests and provided authority for domestic quarantines to prevent the spread of plant pests new to the United States (11). Unfortunately, additional catastrophic disease and insect agents entered the country in spite of this early, apparently inadequate quarantine law. Among them were the potato wart fungus in 1918 (since eradicated), the wheat flag smut fungus, the Dutch elm fungus, and the Japanese beetle.

Another major act was the Organic Act of 1944. It provides for pest management strategies, either independently or in cooperation with states, farmer associations, and even individuals. This act authorizes survey and control programs against endemic as well as exotic pests. It also gives authority for issuing phytosanitary certificates in accordance with the requirements of importing states and foreign countries.

A final major act was the Federal Plant Pest Act of 1957. It authorizes emergency actions to prevent the introduction or interstate movement of plant pests that were not subject to the act of 1912. The 1957 act's broad definition of pests includes all insects, slugs, nematodes, fungi, other parasitic plants, viruses, and other organisms that can damage any plant or any processed products of plants. The act makes provisions for the movement of plant pests into or through the United States for scientific study.

Many quarantine regulations have been enacted as a result of these three acts. With subsequent amendments and expansions, we now operate under a series of complex, detailed, and comprehensive plant quarantine laws that appear to cover every conceivable situation. These quarantine regulations are found in the code of Federal Regulations under Title 7 (Agriculture), Chapter III (APHIS), and include some 250 pages of fine print. Chapter III, consisting of parts 301 to 370, deals with such diverse subjects as domestic and foreign quarantine notices, restricted entry orders, Mexican border regulations, territorial quarantines, importation of honeybees, and regulations on soil, stone, and garbage (1). Other subjects include interstate movement of articles, importation of plant products by mail, inspections, paperwork procedures, noxious weed regulations, and freedom-of-information considerations. Certain other countries operate under equally complex plant quarantines.

Three Quarantine Categories

Nearly all plant materials that enter the United States for scientific or educational purposes fall into one of three quarantine categories (4,14): 1) restricted, 2) postentry, and 3) prohibited. Most plant species are in the first (least restrictive) category. Species are placed in one of the other categories when APHIS determines

that additional precautions should be taken to safeguard U.S. crops. A more restrictive classification is not made until after a public hearing during which potentially affected persons, research groups, and businesses may be heard.

Restricted. Genera in this category can be readily imported by anyone with few, if any, restrictions on how or where the material can be grown or used. For some, a permit is required before the importer may have the material. On arrival, all restricted material is subject to inspection (Fig. 1) and possible chemical treatment (Fig. 2). For example, chemical treatment and a permit are the conditions of entry for seeds of soybean and garden bean from Africa and Australia because of soybean rust. Restricted category items tend to be seeds (barley, oats, various vegetables, alfalfa, clover, grasses) or vegetative parts of exotic low-risk genera. Such items intended for the U.S. germplasm program are inspected, assigned a PI (plant introduction) number, and immediately forwarded to the appropriate germplasm curator and to the importer.

Postentry. This intermediate quarantine category includes about 100 genera of vegetatively propagated woody ornamentals, fruit and nut crops, and herbaceous flowering plants. These species imported from certain countries present a higher risk of damage to U.S. crops than plants or seeds in the restricted category because of the diseases or pests they may carry. Consequently, after inspection and treatment, these plants must be grown under close observation. They may be grown at any of the plant introduction stations, at a state agricultural experiment station, at a private

research facility, or in one's private yard. In all cases, written permission must be obtained from the federal quarantine office before receiving the material. The permit specifies the restrictions on use and propagation of the plants. The material must be accessible to inspection for about 2 years; if no pest is found, the germplasm may be released from quarantine. This procedure allows the importer to obtain foreign germplasm rather quickly and to begin certain experiments under phytosanitary conditions without the wait he must endure for prohibited genera. In recent years, some 600 U.S. scientists and private citizens have held postentry permits on one or more genera.

Prohibited. Species in this category tend to have a high incidence of latent viral infections, to carry new races of fungi or bacteria, or to originate from an area with a widespread serious disease or pest not known to occur on the crop in the United States. Since such conditions pose a serious threat to U.S. agriculture, specific requirements must be met before the species can be imported.

Seeds. About 90% of all food crops grown in the world are propagated by seed (10). Nine crops—wheat, rice, corn, barley, sorghum, sugar beet, beans, soybeans, and peanuts—represent by far the greater part of world food production, and all are attacked by devastating seedborne diseases. Seeds of all species can harbor any of hundreds of surface-contaminating microorganisms (7). Many seedborne diseases cannot be recognized by examining the seed; only by examining the plants they produce can one be certain that seeds are free from bacteria and fungi. Seeds of about 200 genera of economic crops can become infected by 100 or so viruses (2,10). Generally, seeds of field crops, vegetables, and flowers, which are essentially herbaceous, may be imported without a permit from APHIS. But there are exceptions. Some of the major prohibited crop seeds are corn, sorghum, cotton, rice, and wheat. Restrictions vary depending on the source countries. For example, corn importations from Central and South America are subject only to inspection, whereas all importations from Africa and Asia are prohibited. Qualified scientists can obtain permits for these and other prohibited crop seeds.

Vegetative propagules. This group includes cuttings, budwood, or plants of most tree fruits (including apples, pears, peaches, and plums), grapes, potato, sweet potato, and some ornamental species. These materials are inspected on arrival and established and held under quarantine at the Plant Introduction Station, Glenn Dale, Maryland. The potato and sweet potato introductions may remain in quarantine for 18–30 months, whereas most of the tree fruits require 4–6 years. Citrus must be



Fig. 1. Newly arrived germlasm is inspected for pests by APHIS personnel.

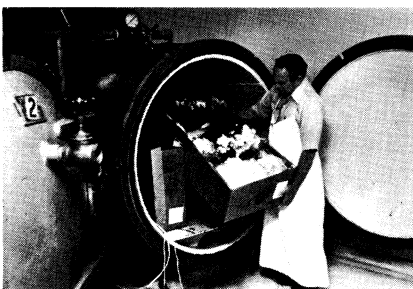


Fig. 2. Newly arrived plants are fumigated to destroy pests or diseases found during inspection.

observed for a time at Glenn Dale before being sent to a special facility in either California or Florida for completion of the quarantine period. Grape introductions are handled under permits at three locations. After quarantined items at Glenn Dale are released, they are documented and distributed to the germplasm curator and to interested scientists and nurseries.

Some of the prohibited major crops, involved countries or areas of the world, and pest threats are shown in Table 1.

Processing at the PI Station

All new germplasm is observed for pests and pathogens, especially for those of quarantine significance, ie, those listed in the regulations and/or not known to occur in the United States. Most prohibited plants remain in quarantine for at least 2 years, while others remain for as long as 6 years. They are held in specially-constructed greenhouses or screenhouses. Inspectors make regular examinations of plants in all greenhouses. Any pest or pathogen found is identified by specialists and destroyed.

The frequency of finding insect, fungal, bacterial, and other nonviral pests on introductions is low because: 1) the foreign collector of the germplasm usually selects healthy-looking plant parts; 2) the shipment is small, usually two to four fruit tree scions, two or three potato tubers, or a few small cuttings of ornamental plants; and 3) items are often dipped or fumigated to kill surface-infesting organisms.

Detecting and identifying internal, latent pathogens, such as viruses, viroids, some mycoplasmas, and spiroplasmas, require a much greater effort. Depending on the genus, one or more of the following procedures are used: 1) electron microscopy; 2) serology; 3) mechanical transmission to virus-sensitive herbaceous indicators; 4) graft transmission to varieties known to be particularly sensitive to one or more viruses that could be present in the introduction; and 5) graft transmission to other plants of the same species to determine whether a "viruslike" symptom is transmissible.

The percentage of plant introductions infected with viruses or mycoplasmas varies according to the crop, ranging from 2% for cacao to 68% for apples. Certain genera, such as apples, potatoes, and grapes, are often infected with two or three pathogens (5,14).

Each year a list of PIs that have been released from quarantine is distributed to plant breeders throughout the United States. Recipients indicate which new introductions they wish to include in their research programs and return a standard form.

Importing Plants or Germplasm

Any U.S. resident wanting foreign plants or germplasm may pursue one of

Table 1. Some major prohibited crops^a

Crop	World sources	Pest
Seeds		
Cotton	All	Pink bollworm, viruses, various diseases
Wheat	Asia, eastern Europe, Australia	Flag smut
Sorghum and millets	Africa, Asia, Brazil	Smuts
Rice	All	Smuts, viruses, various diseases
Corn	Africa, Asia	Downy mildew, witchweed
Lentils	South America	Rust
Vegetative propagules		
Apples, cherries, peaches, pears, plums (including ornamental types)	All except a few countries with special certification	Viruses
Citrus	All	Viruses
Potato (sweet and Irish)	All except Canada	Viruses
Bamboo	All	Diseases
Chrysanthemums	Many	White rust

^aList is intended to show examples of better-known species prohibited from some areas of the world and is not inclusive; species closely related to listed crops may also be prohibited from same areas.

two courses of action, depending on the quarantine category of the item (determined by the genus and country of origin). Program Aid 1163 on "Guidelines for Importing Plant Germplasm" provides useful information.

For all but the prohibited genera, plant breeders and private citizens should write to: Permit Section, Plant Protection and Quarantine, APHIS, FCB, Hyattsville, MD 20782. If the item falls in the least restrictive quarantine category, a permit is issued to the requester, who then arranges to import it. After inspection on arrival, the item may be grown and distributed as the importer desires. If the item falls in the intermediate, or postentry, category, the importer is sent appropriate forms to be completed. After state and federal approval, which assumes adequate precautions to prevent the escape of foreign pests, an import permit is issued, and the importer makes arrangements to import the plants. On entering the United States via the Plant Germplasm Quarantine Center at Beltsville, plants or seeds are considered for inclusion in the national germplasm system, and the requester may be asked to share them with plant breeders. Quarantine personnel inspect the growing plants during the first 2 years after arrival; if no insects or diseases are found, the plants are released from quarantine. Germplasm in the prohibited category can also be obtained via this procedure.

Persons who desire to import germplasm in the prohibited category for educational or research purposes may pursue a second course of action that has the advantage of federal personnel making most of the effort. Scientists may write to: Plant Introduction Office (PIO), Germplasm Resources Laboratory, USDA Agricultural Research Center-West, Beltsville, MD 20705, naming the

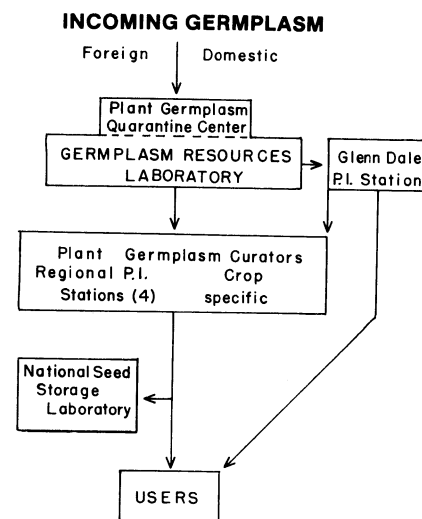


Fig. 3. Flow of plant germplasm after entering the United States.

cultivars desired and, if possible, the source person or institution. The PIO informs the requester of the plant's quarantine category and asks the foreign source person for the item. In the meantime, the requester may apply for a permit from the quarantine office.

Germplasm Flow and Collections

The material is inspected on arrival at the Plant Germplasm Quarantine Center. A restricted item is sent to the scientist, and a postentry item is sent to the scientist after the permit and a growing agreement are completed. A prohibited item is sent either to the Glenn Dale Plant Introduction and Quarantine Station or to a specific permit holder (Fig. 3). If the required virus indexing test results are negative, the item is released to plant breeders, nursery companies, arboreta, and the appropriate germplasm reposi-

tories, as well as to the original importer.

The majority of seed introductions arrive as a result of contacts initiated by the PIO, germplasm curators, and USDA-sponsored germplasm collection trips made to broaden the base of genetic diversity of our crops. It is not unusual for 50 to 200 or more accessions of a given species to arrive in a single shipment. Most seed accessions are sent to one of

four regional plant introduction stations (Table 2), which are operated under a state/federal cooperative arrangement, or to crop-specific curators. Plants from seeds or vegetative propagules are evaluated for specific traits, propagated to desired volume, and distributed on request to plant scientists in the United States and abroad. All items are placed in germplasm collections. For information

about research programs and germplasm collections of these stations, plant researchers may write to the individual stations.

Acknowledgments

We thank F. Cooper of the Permit Section, APHIS; M. J. O'Brien, plant pathologist; and R. H. Lawson, virologist, for reviewing this manuscript. Figures 1 and 2 were provided by the APHIS Information Office, Washington, DC.

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Table 2. Some of the crop germplasm collections processed, evaluated, and distributed from the four regional plant introduction stations*

Experiment, GA	Ames, IA	Geneva, NY	Pullman, WA
Cantaloup	Alfalfa	Broccoli	Bean
Castorbean	Asparagus	Brussels sprouts	Bluegrass
Clover (annual)	Beet	Buckwheat	Cabbage
Cowpea	Bromegrass	Cauliflower	Chickpea
Eggplant	Carrot	Celeriac	Fescue
Guar	Corn	Celery	Garlic, shallot, etc.
Millet	Cucumber	Clover (perennial)	Lentil
Peanut	Foxtail millet	Ground-cherry	Lettuce
Pepper	Mustard	Onion	Lupine (perennial)
Sesame	Prosomillet	Pea	Orchardgrass
Sorghum	Pumpkin	Tall oatgrass	Ryegrass
Summer squash	Radish	Timothy	Chickpea
Turnip	Spinach	Trefoil	Sainfoin
Watermelon	Sweetclover	Winter squash	Wheatgrass

*Crop germplasm collections maintained at other locations include: soybean at Urbana, IL, and Stoneville, MS; cotton at Stoneville, MS, College Station, TX, and Phoenix, AZ; flax at Fargo, ND; and small grains (wheat, barley, oats, rye, triticale) and rice at Beltsville, MD.



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