Perspectives on Germplasm

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The value of germplasm has been described in various ways: as the raw material, or the life blood, of plant breeding, as the key to the maintenance of diversity of living forms on earth, as an indicator of the origin of cultivated species. This paper will focus primarily, but not completely, on the first description, that germplasm serves as the source of genes for disease resistance, for environmental adaptation and tolerance, for yield improvement, for appearance and beauty, and other traits that enable plant breeders to bring about the improvement of our crop species and thereby insure the continued productivity of agriculture including horticulture. Of course, the ultimate goal is the availability, of generous supplies of food, feed, fiber, and ornament for the people of the world.

The conversion of the human life style from the hunter-gatherer phase to the more sedentary production of food, or agriculture, is commonly accepted to have taken place about 10 millenia ago. At that time, everything that grew was germplasm, because there were no named cultivars. It was the beginning. In modern times, we tend to think of germplasm as consisting of landraces and wild forms introduced into the mainstream of breeding and production and that cultivars are the settled forms that are to be changed by the introduction of genes from new, not quite ready for prime time, forms. But, in fact, germplasm is still everything that grows. Our sources of genetic variation are domestic, modern, and heirloom cultivars, cultivars and landraces from somewhere else, genetic stocks, and wild relatives, both near and distant. We also should add to that list the accumulating stocks of DNA in various libraries.

This paper is divided roughly into three parts. The first is historical, to chronicle some of the notable events of the past, to assess their significance, and to set the stage for the activities of the present and of the future. The second part is a discussion of the important aspects of modern germplasm activity: collection, storage, evaluation, application, and distribution. The third part is an assessment of modern trends in germplasm acquisition and plant breeding and how they may impact upon the future.

EARLY HISTORY OF AGRICULTURE AND GERMPLASM

The very early years of the beginnings of agriculture are understandably difficult to chronicle. How, and why does one become a farmer? Perhaps someone noted that a stand of plants with grains or fruit bore edible materials over and over again. Someone else may have found that seeds could be saved. Others may have discovered that it was easier to stay in one place than to move about constantly. Increasingly sophisticated tools for planting, cultivating, and harvesting would be developed. Structures for seed storage, and methods for confining animals for domestication would follow. The perception that some plants performed better than others would lead to selection and the development of the first identifiable varieties. These would also become desirable for trading and therefore the movement of early germplasm from one location to another would be the rudimentary beginning of germplasm exploration and acquisition.

Documented collection trips came later. One of the earliest known is a collecting trip sent by Queen Hatshepsut of Egypt to an almost legendary place called Punt to collect incense trees for the royal gardens. This occurred about 1500 BC (Fig. 1). Thutmose III, Pharoah after Hatshepsut, sent a collecting trip to Syria, in about 1450 BC, which brought back seeds, fruit, and plants of various species (Fig. 2).

Over the ensuing centuries, plants and animals were transported from place to place. For example, lettuce (*Lactuca sativa*) probably originated in the Middle East and traveled to Egypt, where it was first recorded in tomb paintings during the Fourth Dynasty of the Old Kingdom, about 2500 BC (Fig. 3) (Keimer, 1924; Harlan, 1986). It moved around the Mediterranean Basin and was recorded in Persia (550 BC) and Greece (430 BC). It was recorded in Rome (164 AD), where it became very popular. There were several named varieties of different types. It was

Fig. 1. Temple wall drawing of two ships of Queen Hatshepsut's fleet showing incense trees being loaded on board.

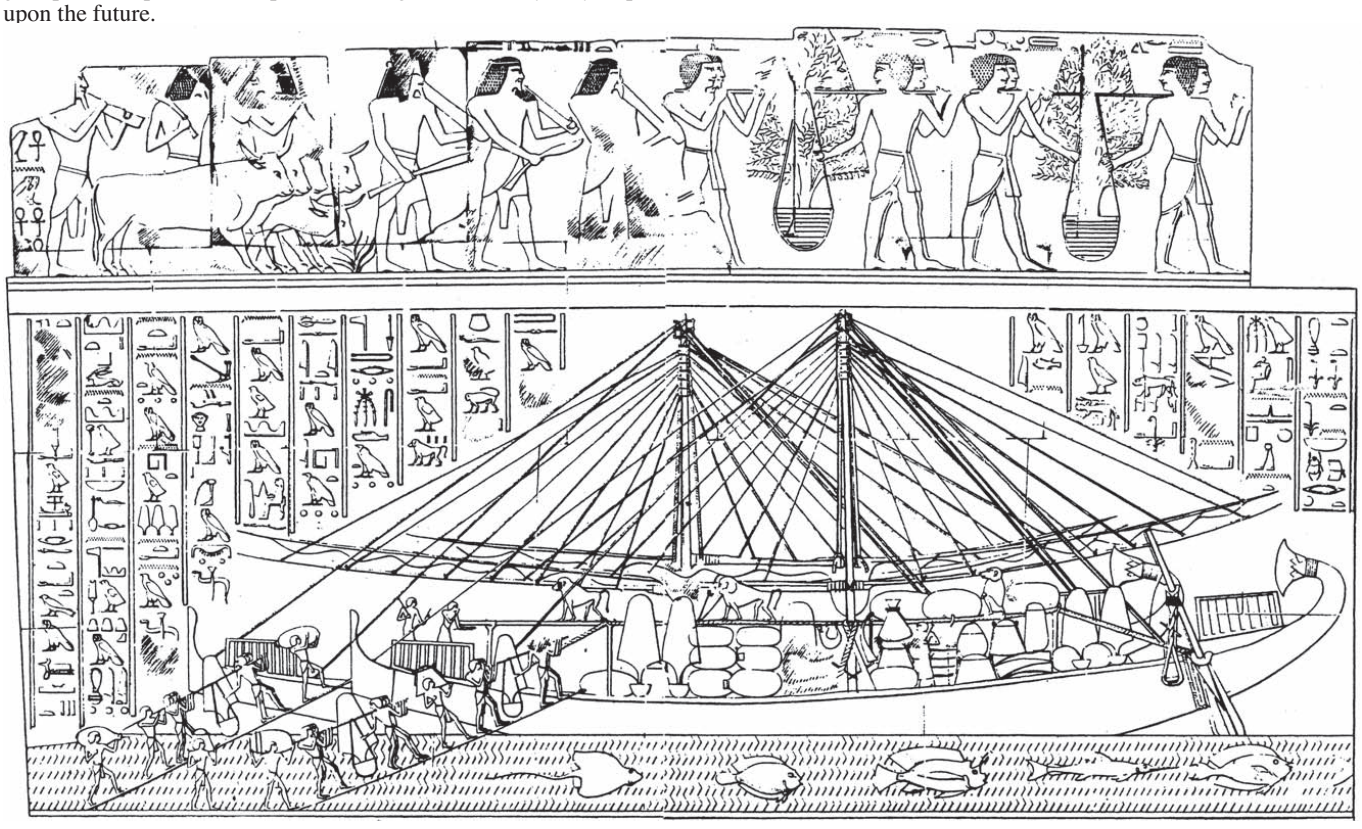

Fig. 2. Temple wall drawing of seeds and plants from Syria, obtained by Thothmes III during an expedition about 1450 BC.

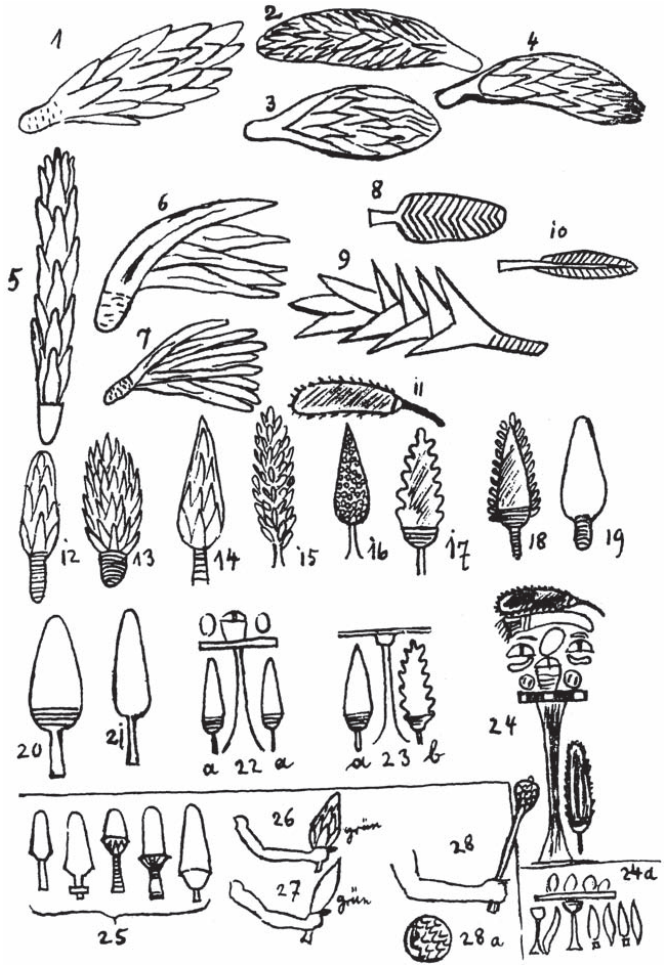

Fig. 3. Depictions of lettuce plants from various Egyptian tomb paintings, beginning about 4th Dynasty with realistic drawings (**top**) to later dynasties with increasingly stylized drawings (**bottom**).

apparently taken to Avignon, France in the early 14th century by the first of nine Popes that resided in that city. It probably came to the New World as early as the second voyage of Columbus in 1494 (Sturtevant, 1972, Ryder, 1999).

In the 17th and 18th centuries, there was great germplasm activity worldwide, including the collection of plants in diverse places, carrying of seeds and plants to newly settled areas, and establishment of exotic species in botanical and horticultural gardens. Collection in East Asia began in the mid 18th century, but it was not until the forced opening of China and Japan in the mid 19th century that the trickle of mostly herbaceous and woody ornamental species to Western countries became a flood. Many noted collectors, including Robert Fortune, Phillip von Siebold, Charles Rogers Hall, E.H. Wilson, and Charles S. Sargent collected in Asia, and brought to Western Europe and the U.S. many ornamental trees and shrubs (Spongberg, 1993).

SYSTEMIZATION OF GERMPLASM ACTIVITIES

In the 19th century, the various aspects of germplasm discovery, collection, and use became more and more systemized as governments assumed responsibility, once having recognized the commercial and scientific value of the world's plant populations. In the United States, in 1819, American consuls overseas were asked to collect seed of potentially useful plants and send them home. The U.S. Patent Commissioner administered plant introduction activities from 1836 to 1862, when the United States Department of Agriculture (USDA) was established and took charge. Finally, in 1898, the Plant Introduction Office was established.

GERMPLASM IN THE 20TH CENTURY

The concepts and the purview of germplasm broadened in the 20th century. Previously, the identification, collection, and placement of new plants were the main activities of those involved. These activities of course continued, with a great deal of exploration for about forty years until curtailed by World War II.

The heyday of the plant explorer was in the early part of the 20th century. Two of the most famous in the U.S. were David Fairchild and Frank N. Meyer. Fairchild was appointed, in 1898, to head the newly created Section of Foreign Seed and Plant Introduction of the USDA. He spent 37 years traveling the world and brought back a number of plants that became economically important, including mango, alfalfa, nectarine, date, horseradish, bamboo, and flowering cherry. One of Fairchild's first acts was to hire Meyer as a plant explorer. Meyer collected extensively in China and was renowned for his long trips on foot.

Other changes were also occurring: 1) increasing systemization of germplasm conservation—collection, storage, evaluation, distribution, and use, 2) the increasing importance of the research aspects of germplasm, with interest in the geographical distribution and evolutionary origins of plant species, the genetic basis for collection and storage decisions, and the basis for longevity in storage; and 3) in more recent years, the political ramifications of collection in one location and use in another and the place of germplasm in the thicket of intellectual property rights.

THE LEGACY OF N. I. VAVILOV

Perhaps the greatest impetus to the advancement of germplasm on all fronts, scientific as well as discovery, was given by Nikolai I. Vavilov. I find no difficulty in comparing his accomplishments and vision to those of Charles Darwin. Darwin's theory of the origin of species was formed during his voyage of discovery on the Beagle and matured after his return to England. Vavilov also traveled, to collect plants in China, Afghanistan, Abyssinia (Ethiopia), Central America, and South America, in a series of journeys from 1923 to 1931. He visited 60 countries, as well as all parts of the former Soviet Union, collected thousands of plants, observed the distribution of species, and developed his theories of the law of homologous series and of the centers of origin of cultivated plants (Vavilov, 1951). He formalized the reasons that collected plants were important to advance plant breeding. At the same time, he recognized the importance of local varieties, which we now call landraces, as sources of variation. He formulated a basis for plant introduction, from his understanding that the species of the world are not distributed uniformly. He