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Origin and Dissemination of *Prunus* Crops:

Peach, Cherry, Apricot, Plum and Almond

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Origin and Dissemination of *Prunus* Crops
Peach, Cherry, Apricot, Plum, Almond

Edited by
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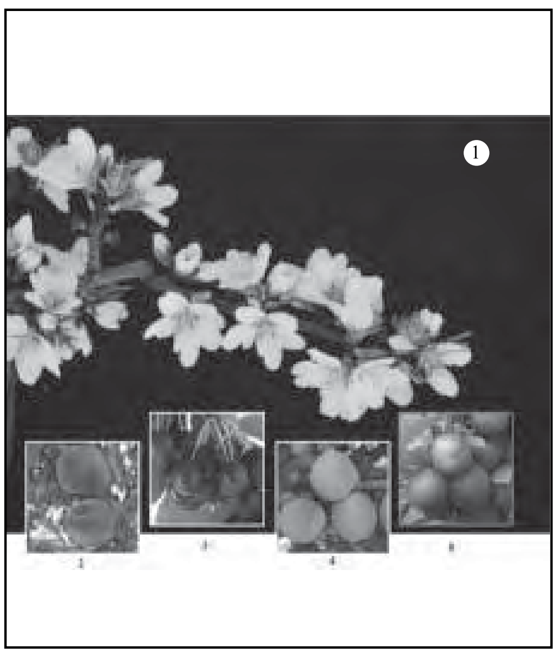
Photographs on the front cover:
1. 'Kester' almond flowers. (Source: Thomas M. Gradziel)
2. Venture' peach. (Source: Vineland Research and Development Center, Ontario, Canada)
3. 'Sweetheart' sweet cherry, (Source: Frank Kappel)
4. 44-2005-1 apricot (Source: Bayram Murat Asma)
5. 'Vampire' plum (Source: Vineland Research and Development Center, Ontario, Canada)



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Miklos Faust
(1927-2008)

Preface

Species of *Prunus* that include peach, cherry, apricot, plum, and almond, the most important nut worldwide, have long been considered as gifts of summer (Hummer and Janick, 2009). Their exquisite flavors and gorgeous appearance have made them much admired throughout the centuries and they have been lauded in poetry, song, and art (Palter 2002). In addition stone fruits represent important and valuable fruit crops throughout the temperate and subtropical world, for fresh and processed products. These tree crops originated in Europe, Central Asia, and China (Janick 2005) and were disseminated worldwide to become universally admired to become part of the cultures of the lands that adopted them. The history of their origins and migrations has become part of the romance of horticulture. This complex and wonderful saga led the great pomologist Miklos Faust (1927–1998) to initiate a series of individual articles published in *Horticultural Reviews* on the origin and dissemination of peach (1995), cherry (1997), apricot (1998), and plum (1999). Recently, Thomas M. Gradziel (2011) completed the series with the treatment of almond.

These five reviews are here reunited in one volume of *Scripta Horticulturae*, under the joint sponsorship of the International Society for Horticultural Science, the American Pomological Society, and the Fruit Breeding Working Group of the American Society for Horticultural Science. These groups have shared the cost of publication. The articles have been reformatted but are essentially the same as first published. We believe they will form a historic resource for pomologists and others interested in the history of stone fruits and the history of horticulture.

However this volume also serves another function, to honor the celebrated career of Miklos Faust, a true giant of a man, who inspired the admiration of so many scientists and students around the world. His memory is also enshrined in a travel award that was endowed by his wonderful wife Maria that has supported young pomologists to attend meetings of the three societies. The following tribute to Miklos draws heavily on a dedicatory essay written by Richard H. Zimmerman (1983) for volume 5 of *Horticultural Reviews*.

Miklos Faust was born on December 25, 1927, in Hungary. He left Hungary after the revolution there and arrived in the U.S. in 1957 with academic training, work, and managerial experience in horticulture but with little knowledge of English. He soon began work at Rutgers University, in New Brunswick, New Jersey, earning his M.S. degree while at the same time he was fast learning English. Following several years in research with the United Fruit Company, part of which was in Central America, he completed his Ph.D. at Cornell University, in Ithaca New York. In 1966, he began work with the U.S. Department of Agriculture at Beltsville, Maryland, where he became an ebullient spokesman for the Department's research programs and progress and became Head of the Fruit Laboratory.

Miklos Faust's contributions to fruit research soon established him as an international leader in pomology. His research interests were diverse, ranging from packaging bananas for long distance shipment to the role of calcium in tree fruit nutrition and fruit disorders, from the biochemistry of anthocyanin development in apple skin to improve apple color, the production of dwarf fruit trees by breeding and selection for highly productive orchards, from the role of cyanide-resistant respiration in early flowering fruit tree species to the effect of drought stress on nutrient uptake by apple trees and the methods to alleviate the stress through nutrient foliar sprays, as well as alleviating it through controlling stomata movements and plant water use-efficiency. Also, he made significant contributions into our understanding of dormancy and bud break in fruit trees by examining changes in lipids in membranes, water status of dormant and breaking buds as well as the role of antioxidants in breaking dormancy. He was one of the first to realize the implication of polyamines in horticulture. His thorough understanding of commercial production practices and needs provided a solid base from which he explored these diverse problems in his research. He was a prolific author on a wide range of topics and contributed nine articles to *Horticultural Reviews*.

Miklos Faust was a man of wide ranging interests but above all he was creative, unorthodox, and open minded, and had courage to explore the unknown and challenge current dogma. He was a continual source of ideas on all manner of topics relating to his own research, that of his Fruit Laboratory colleagues, and the many scientists with whom he collaborated here and abroad. He loved working with his many students. The depth of his knowledge on a wide range of subjects made his ideas and suggestions always stimulating and interesting. Life with Miklos was never dull! The result was that he motivated others to investigate many new lines of research.

One of Miklos Faust's major contributions was to foster the exchange of ideas by prompting foreign scientists to visit and work at laboratories in the United States. They came to his laboratory from many countries such as Hungary, The People's Republic of China, Poland, Italy, Israel, Romania, South Africa and many others. He carried out extensive travels to foreign laboratories, and encouraged scientists with whom he worked to do the same, thus greatly facilitating international cooperation and understanding. He was influential in organizing conferences, and motivated others as well. These exchanges provided valuable opportunities for dialog on scientific subjects that led to long-term continuing cooperative efforts among the scientists involved. He was incredibly generous with sharing his ideas, time, and even private resources to facilitate the progress of science, better understanding among people and to get things done. He once mentioned that there are too many ideas to waste and because it was impossible for him to follow them all he was happy to share them freely. His co-workers, collaborators and students never returned from discussions with Miklos empty-handed. They were charged with new ideas, energy, and enthusiasm to pursue new lines of research.

Miklos has always been a man of direct action who accomplished a prodigious amount of work in a surprisingly short time, whether it be writing a review or organizing a conference. He proved to be brilliant at finding innovative ways to get things done and "cut red tape," yet he knew how to work within the system using the necessary formalized procedures to accomplish worthwhile goals.

Miklos Faust published the results of his scientific studies in 159 technical papers, monographs, reviews and book chapters. He singly-authored the book *Physiology of Temperate-Zone*

Fruit Trees, which remains a classic in its category.

The result of Miklos' professional endeavors brought him recognitions that are too numerous to mention so only selected examples follow: Fellow of ASHS; twice recognized for the excellence in research by ASHS; Special Recognition from the Minister of Agriculture of Hungary for his contributions to revitalize Hungarian Agriculture; an Honorary Doctor of Sciences Degree from the Horticulture and Food Science University of Budapest, Hungary; Commandant-Cross of the Hungarian Republic's Order of Merit, the highest honor for scientific achievements in Hungary, bestowed on him by the President of Hungary; Friendship Award from the People's Republic of China for his work as a consultant of the World Bank and the FAO. Miklos Faust also was very active in scientific professional organizations, serving among others as President, International Horticultural Society for Plant Nutrition and Plant Nutrition Colloquium, Vice President for the International Division and President for the North Eastern Division of ASHS.

When not engaged in the many facets of his research career and administrative duties, Miklos enjoyed a relaxing sail on the Chesapeake Bay, cooking a Hungarian specialty such as palacsinta, attending the opera or symphony, studying history, or working in his garden. He was a truly Renaissance man. His four articles in this volume demonstrate his wide interests in history, humanity, and horticulture. He passed away too early on June 6, 1998. Miklos is still missed and will never be forgotten by his many friends, students, colleagues, and admirers.

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Origin and Dissemination of Peach 1

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I. INTRODUCTION

Peach is one the most variable of all tree fruit species. There are several types of peaches, which differ in their fruit (beaked, round, extremely flat shaped; white, red, or yellow fleshed; melting or nonmelting flesh; clingstone or freestone; hairy or smooth skin), in seed (sweet or bitter), in their flower (large, medium, or small; single or double; red, pink, white, or mixed; and single or grouped on spurs), in the growth habit of the tree (columnar, upright, spreading, spur type, short internode dwarf, evergreen), in leaves (narrow, wide, red or green, with reniform or globose glands on the petioles, or eglandular), in buds (hairy or smooth), in requirement for various environmental factors (short or long chilling requirement, extreme hardiness, or late blooming), and resistance to various diseases. How this variability came about is intriguing. Historical and notable facts about the long-standing fascination by humans for peaches, the origin of peaches, and their dissemination throughout the world included in this review to help provide answers to this question. Accounts on various aspects of the history of peach have been presented by Hehn (1911), Hedrick (1917), Li (1984), Roach (1985), Wang Yu-Lin (1985), Myers et al. (1989), and Scorza and Okie (1992), in addition to the historical works of De Candolle (1855) and Leroy (1879).

II. CLASSIFICATION

A. Botanical

The present scientific name of peach is *Prunus persico* (1.) Batsch. The generic name, *Prunus,* is from the Latin for *plums.* The specific name *persico* was given this species because the Romans believed that peaches originated in Persia and this belief persisted throughout the eighteenth and nineteenth centuries. Among botanists there had been a controversy as to whether all stone fruits should be one genus, or this group of plants should be split into several genera. Occasionally, even peaches were divided into more than one species.

Remarks of Hedrick (1917) set the stage for this section of botanical classification:

> *Prunus persico* is variously divided by botanists and pomologists. Quite commonly two botanical varieties of edible peaches split off, as shown in the synonymy, to separate the nectarine and the flat peaches from the pubescent and globular peaches. But these sub-species originating over and over in the case of nectarine as bud or seed mutation and the flat peaches probably having originated as a mutation, are not more distinct from the parent species than the red fleshed sorts, the snowball peaches, the Yellow Transvaals from South Africa, the nippled peach, the cleft peach, the beaked peach, the winter peaches from China; in fact, are not more different from other peaches than a clingstone from a freestone, a yellow flesh from a white flesh, a large flowered from a small flowered sort. All

constitute merely pomological groups which more and more, are becoming interminably confused by hybridization.

The earliest scientific designation of peach was made by Linné (Carolus Linnaeus, 1707-1778) in 1753, who classified peach in the Rosaceae, under the Prunoideae subfamily and named it *Amygdolus persico* L. Linne's classification was based on the fact that among the stone fruits both almond and peach had hirsute fruit and the flowers and tree structures were similar. Subsequently, many botanists developed their own strategy of classification. Within 15 years of the original classification, in 1768, Phillip Miller (1691-1771), an English botanist, renamed it *Persico vulgaris* Mill. Joseph Antonie Risso (1777-1845) categorized peaches based on the consideration that there are two types of peaches: clingstones, *Persico vulgaris* Risso, and freestones, *Persico domestico* Risso. In 1801, August Johann Georg Batsch (1761-1802) changed the name again to *Prunus persico,* which we still use today. In 1812, Jonathan Stokes (1755-1831) accepted the name *Prunus persico,* and two German botanists, Phillip Franz Siebold (1796-1866) and Joseph Gerhard Zuccarini (1797-1848), affirmed this name as *Prunus persico* Sieb. & Zucc.

In 1820, Thomas Andrew Knight, an English horticulturist, considered that almond and peach constituted a single species and under cultivation almond could ultimately turn into a peach. He used the fact that almond × peach hybrids had somewhat intermediate fruit as a proof for his theory. Others had accepted the theory, and a writer, who is identified by Hedrick (1917) as John Lindley (1799-1865), pictured the descent in *The Gardener's Chronicle* as follows:

"1. Almond became more fleshy-Bad clingstone.
2. Bad clingstone became more fleshy-Good clingstone.
3. Good clingstone became more fleshy-Our soft peaches.
4. Soft peaches sported, receding toward the original fleshy type and lost its wool-Nectarine."

In 1863, another authority, Thomas Rivers, stated that peaches left to a state of nature degenerated into thick-fleshed almonds. In 1867, Elie Abel Carriere (1816-1896), a French botanist, supported Knight's idea and in his book of *Varietes de pêchers* cited more intermediate forms between peach and almond than either Knight or Lindsley had contemplated. In 1868, Darwin considered Knight's supposition and supported the idea that the peach acquired its characters at a relatively late period.

An opponent of this theory was Alphonse Louis Pierre Pyramus de Candolle (1806-1893), who placed the geographic origin of almond in western Asia, especially in southwestern Asia, where it was cultivated for many centuries before the peach was known in that region. In contrast, almond was unknown in China before the Christian era, whereas the peach had been cultivated there at least 2000 years. Based on this geobotanical evidence, De Candolle (1855) rejected the theory that peach originated from almond.

It is notable that even though Knight was incorrect, he was not that far off. Peaches have a double-sigmoid growth curve, with a fast-growing period at the beginning, a resting growth period, and a second fast-growth period. Almonds have the first two periods, however, the second fastgrowth period is missing. This is the reason why the hull (fruit) of the almond is thin, whereas the peach has thick flesh. The geographical reasoning of De Candolle in rejecting Knight's arguments, although correct, was also close. The origin of peach and almond were not that far apart geographically. Peaches are native to the Tarim basin north of the Kunlun mountains, in China (Wang Yu-Lin 1985), whereas almonds are native south of these mountains in Afganistan to northern Pakistan, a mere 200 miles from the Tarim basin on the other side of the mountains. Of course, in his time De Candolle did not consider the Tarim basin as China and may not have known that peaches were native that far west or that almonds were native that far east.

Botanists also had to deal with the various forms of peaches, which included the hairless and the flat forms. The hairless form was first named by Linné as *Amygdolus persico* var. *nucipersico* L. Moritz Balthazar Borkhausen (1760-1806) called it *Prunus nucipersico* in 1790. In 1811, William T. Aiton (1766-1849), an English botanist, renamed the hairless peach *Amygdolus nectorino* by retaining the original genus name but coining a new species name. He was the one who first used "nectarina," which has remained the name of this type of fruit. In 1805, Augustin Pyramus de Candolle (1778-1841) used a new species name and called it *Prunus loevis.* In 1832 the name was changed to *Amygdolus Nucipersico* by Heinrich Gottlieb Ludvig Reichenbach (1793-1879). In 1852, Albert Dietrich (1795-1856) combined the previous names and called the nectarine *Amygdolus loevis.* Leopold Ludvig Dippel (1827-1914), a German botanist, reduced the standing of the nectarine to a subspecies level again and called it *Prunus persica* var. *nucipersica.* Apparently, Camillo Karl Schneider (1876-1951), an Austrian botanist, reaffirmed this classification as *Prunus persica* var. *nucipersica* Schneid. Johann Maximowitz (1827-1891) retained the subspecies level with a slightly different name and called the nectarine *Prunus persica* var. *nectarina,* and Asa Gray (1810-1888) named it *Prunus persica var.laevis.* The flat peach has been classified by Decaisne (1809-1882) as *Prunus platycarpa,* but in 1901 L. H. Bailey thought that it was only a form of peaches and reduced its standing as *Prunus persica* var. *platycarpa* (Fig. 1).

Throughout the years it has become obvious that the peach-and perhaps the entire subgenus *Amygdalus*-is extremely variable and new intermediate species between the almond and the peach have been discovered. E. A. Carriere (1816-1896) described *Persica davidiana* Carr., which was reclassified as a subspecies by Karl Johann Maximowitz *(1827-1891)* as *Prunus persicavar. davidiana Maxim.* and by A. Franchet (1834-1900) as *Prunus davidiana* Franch. (Fig. 2). Bernhard Adalbert Emil Koehne (1848-1918), a German botanist, characterized *Prunus mira* Koehne, a relative of peach with completely smooth stone; Alfred Rehder (1863-1944), an American botanist, described Persica *kansuensis* (Rehd.) Kov. et Kost.; and Vincenz Franz Kosteletzky, a Bohemian botanist, and his co-workers thought that *Persica ferganensis* (Kost. et Riab.) Kov. et Kost. was a distinct species. Then it was discovered that even in *P. mira* the entire range of peach characters can be found combined with completely smooth stone and a long tree life, which can exceed 1000 years (Wang Yu-Lin 1985).

Fig. 1. *Prunus persico* var. *plotycorpo* (Adapted from Trans. Hart. Soc. London 4:512; 1822.)

Fig. 2. *Prunus davidiana* clearly showing the flech that cannot enlarge, and because of this the fruit of this species is not useful for human consumption. (Adapted from Hedrick 1917)

The controversy about the scientific name of the peach has continued until very recently. L. H. Bailey (1927) used *Prunus* as the genus name for all stone fruits: plum, cherry, peach, nectarine, apricot, and almond. He lists 82 species in this genus and groups them into four subgenera:

I. *Prunophora:* plums, prunes and apricots. Leaves are convolute in the bud (rolled up, showing well as the leaves emerge from the bud).
II. *Amygdalus:* almonds and peaches. Leaves are conduplicate (trough shaped, folded lengthwise along the midrib) in the bud. Fruit normally hairy, floral cup is spread.
III. *Cerasus:* cherries.
IV. *Padus:* cherries with racemose inflorescences.

Even after all these name changes, Andras Terpo, a Hungarian botanist specializing in fruit-producing plants (Terpo 1974), went back to the old name of *Persica vulgaris* Mill. with a synonym *[Prunus persica* (L.) Batsch] stating that the taxonomy of peach, as in all other fruit-producing species, is based on the fruit, overlooking all the other physiological variability in the species. Therefore, he set up the following forms using convarietal (cultivated race) and provarietas (cultivated botanical variety) as subgroups:

1. Convarietal: *laevis (nucipersica)* nectarine, fruit is naked
   Provarietal: *aganonucipersica (glabra),* freestone
   Provarietal: *scleronucipersica (nudicarpa),* clingstone
2. Convarietal: *persica(vulgaris, lanuginosa),* fruit is hairy Provarietal: *persica (aganopersica),* freestone
   Provarietal: *scleropersica (duracina),* clingstone
   Provarietal: *compressa (platycarpa),* fruit is flat

Other forms are: *atropurpurea,* leaves are red; *cameliaeflora,* flowers are deep red; *dianthiflora,* flowers are pink; *albo-plena,* flowers are white.

B. Horticultural

In 1887, Gilbert Oderdonk, a special agent of the U.S. Department of Agriculture, published a natural classification of peaches. He put cultivars into four groups, which he called races:

1. Persian race, brought to North America by the early settlers.
2. Northern Chinese group, characterized by large fruit with tender skin and flesh.
3. Southern Chinese group, represented by cultivars that bear small pointed, white-fleshed fruit with sweet flavor and good adaptation to warmer climates.
4. Peento, a warm climate type inclined to be evergreen and bear fruit that is much flattened, white skinned, and sweet.

R. H. Price, a professor at Texas Agricultural College, adopted and greatly extended Oderdonk's observations (Price 1896) and eventually became the authority in horticultural classification of peach in the United States. Hedrick (1917) disagreed with this classification and considered the Oderdonk-Price classification to be inspired by the southern types of peaches and to be too exclusive, excluding types such as the cleft peach 'Emperor of Russia', the nippled peach 'Teton de Venus', the 'Perseque' with its teatlike protuberances, the snow white and red blood cultivars, and not showing physiological characters such as hardiness. Hedrick (1917) considered a natural classification of peaches to show relationships of cultivars impossible.

Dwarf peaches remained as a horticulturally distinguished group and they remained ornamental peaches or breeding material. According to Tukey (1964), in 1846, A. Poiteau of France described a very dwarf form of peach and designated it "Pêcher Nain" *(Persica nana* Poit et Turp.). The description Poiteau gave did not fit *Persica nana* Stokes, used for the dwarf Russian almond. Poiteau's description rather resembles dwarf peaches of today such as "Bonanza," released by D. L. Armstrong. In fact, "Pêcher Nain" was a short internode *Prunus persico.* The pomological literature mentions several short-internode dwarf peaches such as 'Dwarf Champion' described from New Mexico in 1899 and 'Dwarf Cuba' mentioned from Michigan in 1895 (Tukey 1964). Another dwarf peach with double flowers was introduced from China under PI number 41395 in 1915 and was called Swatow from the place of its origin in Yunnan, China. Based on chilling requirements, the short-internode peaches must belong to the south Chinese group, described in Section IIID.

III. CHINA, THE NATIVE CENTER

A. Evidence for the Native Center

Peaches were acquired by the Romans from Persia and this had given rise to the supposition that the peach had originated there. De Candolle (1855), who is still our best authority on the origin of cultivated plants, questioned this. The peach must have been imported to Rome during the period from the second century B.C. to the beginning of the Christian era. De Candolle argued that if peach were a native of Persia, this beautiful fruit would have been taken to Europe much earlier. Xenophon does not mention the peach in 401 B.C. De Candolle (1855) pointed out that Hebrew and Sanskrit people did not mention peach in their writings, whereas they often mentioned olives, quince, grape, and pomegranate, indicating that peach had not been grown in these lands, which are otherwise suitable for peach production. Apparently, the Greek and Roman writers assumed that the peach originated in Persia simply because they received it from Persia. By the end of the nineteenth century few horticulturists believed in the Persian origin.

In 1917, Hedrick (1917) summarized all existing information and concluded that China is the original home of peaches. Chinese writings refer to peach at least 1000 years earlier than the first European literature. Peach along with pear and apricot had been domesticated long before the Zhou archeological period (3300-2500 B.C.) in China (Li 1983) and its cultivation in Japan was apparent in the Yayoi archeological period (2400-1800 B.C.) (Kotani 1972). Ancient books also refer to early cultivation of peach. *Shi-Jing,* a book of songs, written about 1000 B.C., acclaimed the beauty of peach blossoms (Li1984). Confucius (551-479B.C.), who had the latinized name of K'ung Fu-Tzu (K'ung the master) collected poetry in a book called *Shi-king,* in which peach, in common with the plum, pear, jujube, and other fruits, is mentioned several times. According to Hedrick (1917), the translator remarked that all the poems were written before the sixth century B.C. In this series, peaches were mentioned in *The Odes of Chow* (Book I), *The Odes of Wei* (Book IX), and *The Odes of Kwei* (Book XIII).

Slightly more recent Chinese literature also mentions peach. *Er Ya,* the earliest dictionary of terms and names mentioned in the ancient literature, written about 200 B.C., refers to three cultivars of peach, 'Dongtao', 'Hutao', and 'Shantao' (Li 1984). Another book, *Xi Jing* Za *Ji,* translated as *Sketches on the West Capital,* written by Ge Hong during the Western Han dynasty (206 B.C. - 24 A.D.) mentions six additional peach cultivars (Li 1984). Finally, a chapter "On planting peach trees" in the book *Qi Min Yao Shu*, translated *The Important*

Measures to Improvet he Living of the People, written by Jia Si-Xie (533-544), summarizes experiences gained during the past 1500 years in peach culture. The description includes planting, transplanting, storage, and processing (Li 1984).

Vavilov (1951) concluded that the center of origin of plants coincides with the center of diversity. In the case of peach, the species or type diversity is unquestionably the highest in China. Therefore, it seems necessary to review the origin of the peach in China before the movement of each type can traced throughout the world.

The difficulty in establishing the areas where peach may have been native is that the Chinese moved peaches around and no doubt selected them for size. Peach areas in eastern China can be divided into north and south divided roughly by the Yangtze river; western China includes the area of the Tarim basin and the Tibetian highlands. The types of peaches or peach relatives grown in each area are different, but where the actual cultivated peach developed or where it is native is unclear. Hedrick (1917) lists the records of Frank Meyer, plant explorer of the U.S. Department of Agriculture around 1910, concerning peaches he found in China, but it is not possible to determine what degree of improvement occurred in the 3000 years of cultivation to the types he collected.

B. Northeast China

This native peach area includes the area from Lanzhou, Gansu Province to north of the Qin Ling mountains in Shaanxi (Fig. 10.3). Frank Meyer (1915) reported that he had found peaches elevations of about 1300 to 2300 m. Peaches in this area have long internodes, single flower buds, upright branching structure, large flat leaves, and are largely clingstones or semi-clingstones. These trees require high chilling. *P. kansuensis* Skeels, widely grown in this area, is similar to *P. persica* with the exception that its winter buds have no pubescence (Wang Yu-Lin 1985).

C. South China

Two areas for native peach are important here, Jiangsu and Zheiang, north and south of Shanghai, respectively (Fig. 3). This is a warm area with mild winters and a rainfall that exceeds 1000 mm. Here the trees have more lateral branching and require less chilling. The flat peach, Peen-to, which is recognized as *P. persica* var. *platycarpa,* is native in this area as well as the so-called Honey peach, which has an elongated, pointed fruit with a deep suture near the base (Fig. 4). The Honey peach is often white fleshed.

Fig. 3. Native peach areas in China.

D. Northwest China

The native area is from Lanzhou, Gansu Province to the west, including the Tarim basin bordered by the Tien Shan, Pamir, and Karakoram mountains (Fig. 3). Peaches are found in the southern part of the Tarimbasin on the slopes ofthe Kunlun Shan and Nan Shan mountains. The area is arid today with less than 400 mm of rain, but water was more plentiful there as recently as 1500 years ago (Hedin 1906; Stein 1934). Therefore, it is entirely possible that peaches had been more widespread in this area than they are today. The variability of peach is very high in this area. *P. kansuensis* and *P. davidiana* are native on the east side of this area and *P. jerganensis* is native on the west side. It is likely that the nectarine originated in this area.

Fig. 4. Typical southern Chinese peach with beeked fruit. (Adapted from Hedrick 1917)

Nectarines were found in almost every oasis in the Tarim basin around 1900. Most of the peaches are clingstones. Some of the ecotypes ripen very late, with the so-called "storable" peaches originating in this area. Plant explorer Frank N.

Meyer wrote to Hedrick that near the Tibetian frontier, in Gansu, native peaches were small and people did not call them *yeh-tao* or *shan-tao* (wild peach) but *mao-tao,* meaning "hairy peach," signifying their poor quality (Hedrick 1917).

E. High Mountain Area

The high areas of Sichuan, Qinghai and Xizang (Tibet) (Fig. 3) have relatively low-growing small-fruited peaches, among which *P. mira* is recognized because its pits are smooth. *P. mira* trees are located on rather barren slopes at altitudes of about 2400-3500 m.

F. Peach in Chinese Folklore and Mythology

One sign that a plant is native in a certain area is that people living there mention this plant in their mythology and folklore. Peach is strongly entwined in the folklore of the Chinese people.

In Chinese mythology there are eight immortals who are not, strictly speaking, gods but legendary personages who became immortals in Taoist doctrine (Taoism was established by Lao-Tzu about 604-531 B.C.)

The immortals appeared at the banquets given by Lady Wang, the Queen-Mother of the West. The dwelling place of immortals is in the Kunlun mountains in far western China, at the "earth's center." ruled by the Lady Queen of the West. Her nine-story palace, located on the top of the mountain, is built entirely of jade. Magnificent gardens surround the palace, in which grows the Peach-tree of Immortality. The only human beings allowed there are those permitted by the gods, as a reward for their virtues, to eat the marvelous fruit of the Peach-tree of Immortality during their earthly life (Larousse 1959).

The personage of the Queen-Mother of the West also entered into the everyday folklore through Chinese folk paintings. Ancient Chinese paintings are usually divided into two artistic forms. One is mounted on scrolls; *Chine painting* usually refers to this category. The other is exhibited in the markets around the time of the Chinese lunar New Year. Buyers paste the paintings they selected on their gate to enhance the festival. These, called *New Year Pictures,* provide invaluable information on the beliefs of Chinese people. Three examples of such paintings involving peaches follow.

Dongfang Shuo (154-93 B.C.), a man of letters and an official during the reign of Wu Di (140-87 B.C.) in the Han Dynasty is the object of many humorous and satirical tales, one of which is illustrated in Fig. 5. According to this story, on the seventh day of the seventh month, Emperor Wu Di entertained the celestial Queen-Mother of the West in the imperial hall of Chenghua and asked her for an elixir of longevity. The Queen-Mother gave him five peaches but discovered that Dongfang Shuo was peeping into the hall through the window. She told the emperor: "This little chap has stolen my peach three times." Since then, peaches are known as the fruits of longevity. The New Year print of this story symbolizes wishes for a long life (Wang Shucum 1985).

Zhong Kui (Fig. 6) is a legendary character. It is said that Emperor Xuan Zong, who reigned from A.D. 712 to 756 dreamed of a large ghost eating small ghosts. He asked the big ghost who he was. The ghost stated that he failed the imperial military examinations and died with a grudge, determined to annihilate all evil spirits of the world. The emperor woke up and ordered the painter, Wu Daozi, to make a portrait of him. Since then, the common people paste up portraits of Zhong Kui at the New Year to get rid of evil. In the portrait, Zhong Kui holds a tablet in his hand, which signifies that he was successful in the imperial examinations; there is a writing brush, which is a homonym of "must"; and there is a peach, which signifies long life. Together the elements of the painting mean: "You must live long" (Wang Shucum 1985).

The portrait of the Three Stars (Fig. 7) dates from the Ming Dynasty (1368-1644). "Three Stars" refers to the God of Happiness, Fu-hsing; the God of Salaries, Lu-hsing; and the God of Longevity, Shou-hsing. They can reward people with good luck, high salary, and long life. The middle figure, tablet in hand, is the Star of Happiness. The one on the right, a hair binder on his head, is the Star of Salary. The one with a prominent forehead, a long beard, and a peach in his right hand is the Star of Longevity. This is the earliest example of pictures with the Three Stars; similar pictures are still made (Wang Shucum 1985).

The peach blossom is also important in Chinese folklore. Yamei Kin (1914) retells the story of the Peach Blossom Fountain, written by T'ao Yuan Ming between 365 and 427. A lost fisherman finds himself in a creek bordered with many peach trees in full bloom. He comes upon a small mountain in which is a cave which he traverses and enters a new country where there is every sign of prosperity and everyone is courteous; kindliness and contentment prevail.

Fig. 5. Picture of Dongfang Shuo, the person stealing a peach branch from the tree of longevity.

Fig. 6. Painting of Zhong Kuia legendary character. The peach above the head of Zhong Kui signifies long life.

The people wear the garb of the times of the First Emperor, some five centuries previous, and have been lost to the rest of the country. The fisherman returns after a sojourn with them and tells his fellow villagers of this wonderful country and stirs up so much interest that the governor of the province joins in the search, but it is all to no avail. At last the fisherman realizes that he will never see the peach blossom days of his youth with its rosy dreams and ideals that come but once in a lifetime.

Fig. 7. Portrait of the "Three Stars" peach in the hand of the God of Longevity. Shou-hsing also signifies long life.

IV. EURASIA

A. Westward Movement

Sturtevant (Hedrick 1919) remarked that the peach grows quickly from seed, which allowed its rapid dispersal along the ancient communication routes. If its origin was in China, it had to be carried by caravans into Kashmir or Bukhara and Persia. We do not know what time this may have happened. Records of peach production in southwest Asia are relatively recent in origin, stemming from the nineteenth century. Albert Regel (1886-1887), a physician who lived in Turkestan for nine years wrote that "Next to pomegranate, the Asiatics prize peach" (Hedrick 1917). He wrote that in the south, peachs extended to Afghanistan; however, their proper home is northern Persia to the Caucasus. He describes nectarines in this region and remarked that they are equal to the nectarines of Samarkand. Another writer, Eugene Schuyler (1876), writing about the Zarafshan valley (Uzbekistan north of Bukhara) noted that fruit in the gardens was plentiful and that peaches, and especially nectarines, were very good quality. Henry Lansdell (1885) writing about central Asia mentions nectarines in Samarkand and Bukhara. Early travelers record peaches in present-day Iran, Turkey, and the Caucasian mountains, but their descriptions of peaches in the nineteenth century provide little information on how the peach was taken to Persia.

Xenophon traveled through Persia in 401 B.C. and visited the gardens of Cyrus III at Sardis. In addition to Cyrus's garden, he had plenty of opportunities to observe the walled gardens throughout Persia. Although his book *Cyropaedia,* written in 394 B.C., describing the life of Cyrus, is fictional, it includes experiences gained in his travels in the area. He describes many plants but not peaches, suggesting that peach was not in Persia in 400 B.C. In 138 B.C. Zhang Qian was sent as an envoy of the Han Dynasty from Chang'an (the present-day Xian) to the countries geographically west of China and thus opened the Silk Road (Jia and Hua 1990). There is evidence that materials (other than peach) were exchanged between China and Persia during the second century B.C. (Boulnois 1972). The Chinese Emperor Vu-ti and Mithridates II, king of Persia made atreaty that regulated the silk trade coming to the west in 105 B.C. (Timon 1992). After this, regular shipments of silk arrived from the Orient to Persia. The Romans occupied Syria in 70 B.C., the beginning of the Roman-Persian connection. Silk appeared in Rome at about this time. Almonds, which were native in Afganistan, were taken into China probably during the first century B.C. The same caravans may have taken peach in one direction and almond in the other. Thus it is entirely possible that the Romans found peaches in Persia not much after the peach had arrived there with the silk caravans. Peach was also found north of Persia. Archeological evidence from Yerevan, Armenia, includes necklaces made of peach pits found at a central Asian locations but only dated to the end of the first or the beginning of the second millennium (Pjotrovszkij 1959). Regardless of the circumstances that may influenced the coming of peach into Persia, there is no hard evidence for its precise time of arrival. Circumstantial evidence, however, points to the first or second century B.C., not much before the Romans obtained it from Persia.

According to some, the peach reached Europe about 300 years before the Christian era. In 332 B.C., Theophrastus (372-287 B.C.), a Greek writer, mentioned "Persian fruit," or "Persian apples" in *History of Plants,* the earliest surviving botanical treatise. "Persian fruit" has been interpreted to be peach and Dioscorides and Pliny in the first century also used this term to designate peaches. However, Theophratus's "Persian fruit" may also refer to *persea,* a plant grown in Egypt. Evidence that Theophratus's "Persian fruit" was not peach is that Xenophon (434-355 B.C.), a Greek historian, soldier, and a writer in agriculture, did not mention it despite the fact that he spent considerable time in Persia in 401 B.C. and should have been familiar with this excellent fruit if it was present at that time. Maior Cato (235-150 B.C.) described most of our common fruits in 201 B.C. but did not mention the peach, neither did Marcus Terentius Varra (117-27 B.C.), another Roman agricultural writer, in his work *Rerum rusticarum libri tres* in 36 B.C.

Peach in the early literature shows up almost 300 years later. Dioscorides, a Greek physician who lived around A.D. 60 in Alexandria, Egypt, mentions peaches (De Candolle 1855), but he discussed them with reference to their medicinal properties and did not enlighten us about their horticultural characters. Henrico Stephano (1531-1598), in his Latin-Greek dictionary *Theseaurus*

Graecae Linguae, analyzed Dioscorides's work and remarked that Dioscorides wrote about *Persicum malum* (Persian fruit, Le., peach) in section 165 and *Armenicum malum* (Armenian fruit, i.e., apricot) in section 166. The controversial "persea" mentioned by Theophrastos is discussed by Dioscorides in section 188 as an Egyptian plant. Therefore, Theophrastus's remarks may not refer to peach at all, and the early mention of peach should be discounted. In the Roman literature, Vergilius (Virgil, 70-19 B.C.) is the first to mention peaches: "I will search our planted grounds at home for downy peaches and the glossy plum."

There is an another version of the introduction of peach to Italy. Lucius Licinius Lucullus, a Roman general who commanded wars against Mithridates, the powerful Asiatic king, and was the governor of the Roman province of Cilicia in Asia Minor, acquired great wealth during his career. Upon his retirement in 66 B.C., gardens were laid out for him in diverse cities throughout Italy so that Lucullus might change his habitation with the seasons. According to some accounts, Lucullus himself introduced peaches and cherries from Asia Minor (Emboden 1987). He certainly had the connections and may have been exposed to these fruits while stationed in Asia Minor. The time during which Lucullus lived made it possible that he may have imported peaches into Italy.

In Herculaneum, destroyed by the eruption of Vesuvius in A.D. 70, a painting depicting peaches survived (Casella 1950), now located in the Archeological Museum of Naples (picture 8645), which indicates the interest of wealthy Romans in a new luxurious fruit at that time (Fig. 8). The painting is from the house of Sirico (Domus Sirici), a wealthy merchant of Herculaneum. No nectarine painting was found in Pompei or Herculaneum. Peaches were very expensive at that time and only wealthy people such as Sirico could afford them (Comes 1879). There is a wallpainting, also from the first century A.D., in the National Museum of Rome removed from the Villa di Livia from Prima Porta (Roma). The painting shows a large planter with an apple, *Abies pectinata,* and a peach tree. Detail of the peach tree is shown in Fig. 9.

According to other sources, peach apparently came from Persia through Egypt. Although Roach (1985) mentions that in Egypt peaches were used as offerings to the "God of Tranquility" in about 1400 B.C., he does not give any supporting information to authenticate this statement. Pliny the Elder, in *Historia Naturalis,* published after his death in A.D. 79, states in Chapter 13, Book XV, that the peach was imported by the Romans from Persia not long before. He adds that a tree was brought from Egypt to the Isle of Rhodes (Mediterranean Island near Turkey), where it could never be made to produce fruit, and then to Italy (Roach 1985). This seems to underline the belief that the peach came through Egypt.

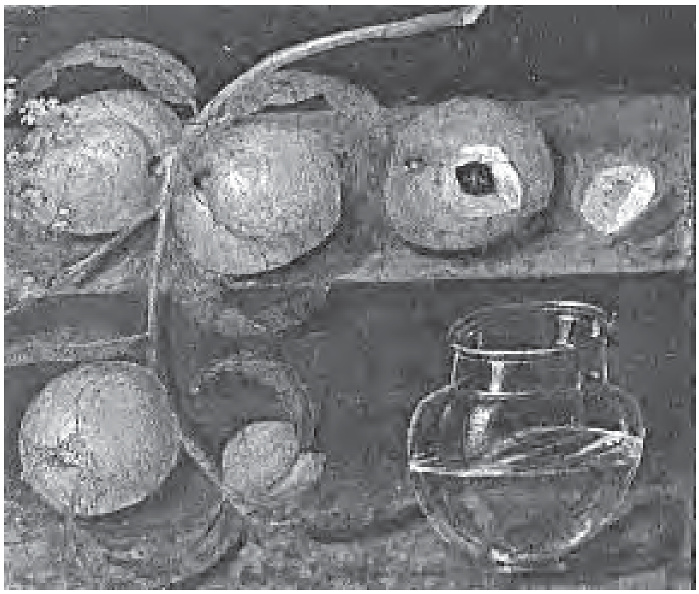

Fig. 8. Painting from the house of Sirico. Herculaneum from A.D. 70. In the painting. peaches are relatively green with yellowish flesh. Part of the flesh of one peach has been removed to show the seed. Leaves affirm that the fruit is peach. Published with the permission of the National museum of Naples.

Fig. 9. Detail showing a peach tree from a wall painting created in the first century and removed from the Villa de Livia, Prima Porta (Roma). Fresco is presently housed at the National Museum of Rome.

In his second section on peach, Chapter 11, in Book XV, Pliny writes about "Persian apples," which are one of the six types of peaches he describes. The others are the *duracinus,* the Gallic, and the Asiatic peaches, named after the countries of their supposed origin, and the *supernatia* and *popularia,* two types of peaches one of which is excellent, the other which grows everywhere. He remarks that "among peaches the palm must be awarded to the *duracinus."* Hedricks (1917) interpreted the word duracinus as nectarine. However, Sturtevant, using De Candolle (1855) and Targioni-Tozzetti (1855) as his sources, speaking about the time of Pliny, concluded that "At this time only five cultivars were known and the nectarine was unknown" (Hedrick 1919). The *duranci,* obviously stemming from *duracinus,* is reserved for clingstones in some languages. The word *durancinus* may originate from the Latin *durum* and *acinus* (translated literally, it means "hard berry"). There is an another version for the origin of this word. According to Wetzstein (quoted by Hehn 1911) the origin of *duranci* is the Arabic word *durakina* which stems from the city *Durak,* which stood where the rivers Tigris and Euphrates join. This version is strenghtened by the fact that Pliny describes a cherry *uva duracina,* which was brought to Italy at the same time from the city of Durak. Yet another possibility for the origin of duranci is the river Durance, located in southern France, called in Latin Druentia. The tributary of this river, near the Rhone, is the location where Gallic peaches may first have been found. Regardless of the origin of duracinum, Gallesio (1839), an Italian pomologist, used it for designating both peaches, as Pesco cotogno (duracino massimo), and nectarines, as Pesco noce (duracino bianco). Therefore, Hedrick's (1917) interpretation of *duracinus* as nectarine appears to be erroneous.

Peach culture must have started simultaneously in France and Italy. Pliny mentioned the peaches of Gaul with those of Rome. Columella in the first century and Palladius in the fourth century both discuss peaches grown in Italy with Gallic origin (Erményi 1978). Hedrick (1917) thought that peach may have been in the area for a long time without written evidence. However, the written record of peach during the beginning of the Christian era is overwhelming and contrasts strongly with its conspicious absence in earlier literature. This raises the question whether there was another route of introduction of peaches to Europe.

In excavations of the first-century ruins at Mincio (northern Italy) and in the region of Poitou (south of Angers), France, archeologists recovered peach seeds (Hehn 1911). Peach seeds were also found in Neuss Germany (near Dusseldorf, western Germany), along the river Rhein dating from the first century A.D. (Erményi 1978). In addition, peach seeds were found in Linz, Pforzeim, Fulda, and Mainz (Werneck 1956). In Hungary at Regöly in a Celtic community from the first century A.D., peach stone fragments were found in a pit together with other kitchen remains (Jerem 1972). The significance of this find is that it was in a Celtic and not a Roman community. There are archeological findings of peach seeds from Czech, Slovak, and Polish communities (Erményi 1978), signifying the Central European distribution of peach beyond the area occupied by the Romans. Archeological findings of peach seed from Gdanszk (Erményi 1978) were probably from dried fruit which was carried there rather than from fruit grown in the area.

According to Werneck (1956), the "Gallic" peaches mentioned by Pliny must have entered into Europe through the Balkans through the route along the Danube from the area of the Black Sea. The archeological evidence is underscored by the fact that from Greece northward extending to France, there are landraces of peaches, usually white, early, and small, that are grown essentially wild in vineyards, hence the name *vineyard peach* (Parnia et al. 1978; Timon 1992). The grooving of the seeds found in Neuss corresponds to the local landrace (Timon 1992), indicating that these landraces are ancient in origin and they may have been there at the time Pliny was writing about Gallic peaches. Closely examining the writings of Columella (first century A.D.), it is obvious that he distinguished three types of peaches: Persian, Asiatic, and Gaul. Columella wrote that "peaches in Persia grow, bearing that country's name, with tiny fruit, are quick to ripen; huge ones by Gaul supplied mature in season due; those Asia yields are slow to grow and wait till winter's cold." Thus Columella's writings would indicate that the Gaul peaches were large and not of the small landrace type.

B. Linguistic Evidence

Usually the name of a product in different languages indicates movement of that product around the world. The name of the peach in various languages is as follows:

1. Names based on "persica": French: *peche;* German: *Pfirsich;* Italian: *pesca;* English: *peach;* Portuguese: *pessego;* Swedish: *persica;* Finnish: *persikka;* Russian: *persic;* Romanian: *piersica;* Indonesian: *persik.*
2. Names based on a word beginning with "br...": Bulgarian: *p(b)raskova;* Serbo-Croat: *breskva;* Polish: *brzoskvinia;* Hungarian: *barack;* French: *brugnon* (small nectarines).
3. Other, unrelated words: Spanish: *melocoton;* Greek: *robakinon,* Turkish: *seftali;* Hebrew: *afarseq;* Persian: peach = *hulu,* nectarine =*shaleel;* Hindi: *aru;* Arabic: *khukh;* Chinese: peach=*tao,* nectarin =yuo *tao;* Japanese: *momo.*

It is obvious that the bulk of western languages use some variation of *persica* for peach. Clearly, the Romans did not use any of the words used by local languages in Asia Minor for their own description of this fruit. It is notable that the Russian name *persic* implies that they learned this fruit through the west rather than directly from central Asia. If the French peaches arrived there independently (Gallic peaches), one would expect them to use a different word to designate peach than that used by the Romans. Whether the *brugnon* (small clingstone nectarines today) was such a word is difficult to determine. According to Leroy (1879) *brugnon* originated from the name of the city Brugnoles (in Roman times, Broniolacum; today, Brignoles) located in Provence, an important center for production of the ancient Gallic peaches. However, the question remains whether Brugnoles evolved from Broniolacum independent of the brugnons grown there, or if the name evolution was influenced by the name of fruit that was already there. Regardless of its origin, *brugnon* was clearly used in the seventeenth century. Both peaches and brugnons were grown in the garden of Versailles *(see* Fig. 9). It is notable that brugnon is closer to the word used in Pannonia (Hungarian-Serbo-Croatian basin) for vineyard peaches than the word used for this fruit (peche) introduced into France by the Romans. This underlines the independent origin of Gallic peaches.

C. Western Europe

France played an important part in the development of peach. In 1879, Andre Leroy (1879) summarized developments during the Middle Ages in France. He quotes several early sources who mentioned peach. Among these are Bishop Fortunat of Portiers (born in 530); the Acta found in the Saint Denis Monastery in 784; Charlemagne from 800; Lupus, Abbot of Ferriers, near Amiens from 860; all of whom discussed peaches in various contexts. There were also other descriptions, without giving recognizable details about the types of peaches that were grown in France. Even Oliver de Serres in his *Theatre de Agriculture,* published in 1604, quoted by Hedrick (1917), names only 12 kinds of peaches with incomplete descriptions. Nevertheless, from his brief section on peach it is clear that peach is no longer grown as a species, but he makes it plain that cultivars received recognition and that there were a considerable number of sorts. The peach became important in seventeenth-century France, at least in the garden of Louise XVI developed by La Quintinye (1626-1688). The number of peach trees planted in the king's garden at Versailles was quite high compared to other walled gardens (Fig. 9). The number of cultivars increased as time progressed. Hedrick (1917), who was interested in cultivar development, collected information regarding the increase of number of cultivars in France: Lectier, agent of the king of Orleans, in cataloging an orchard, lists 27 cultivars in 1628. Merlet, in his *L'Abrégé des bons fruits,* names 38 sorts in 1667. Duhamel du Monceau, in *Traite des arbres fruitiers,* lists 43 peach cultivars in 1768. Calvel names 60 cultivars in 1805, Louis Noisette list 60 sorts in 1839, Leroy names 41 peaches in 1852, but a later edition of his work in 1865 describes 148 peaches. Finally, O. Thomas, in *Guide pratique,* publishes a list of 355 peaches in 1876. Some of these cultivars found the way back to Italy. Bartolomeo Bimbi (1648-1729), an Italian painter, produced a large canvas of still life with 36 peach and 9 apricot cultivars in 1699. Bellini and Pisani (1982) identified these cultivars and among them were 'Primaticia di Francia', 'Francese', and 'Moscadella Francese', clearly indicating French origin. Most peach-producing areas, including Italy, received advanced cultivars from France beginning in the Middle Ages and up to the end of the eighteenth century. Therefore, France can be considered as the second major distribution point for peaches, the first being China. In his *Traité des arbres fruitiers,* Volume II, Duhamel du Monceau remarked that peach has adapted so well to its new environment that only the name *persica* remained exotic.

Peach trees were also rare and expensive in England. In 1275, the gardener of Edward I supplied various fruit trees for planting in the gardens of the Tower of London, including two peach trees which together cost about the same as 100 cherry trees (Ellacombe 1884; Roach 1985). The first mention of peaches in the early English herbals was by Peter Treueris in 1526 in his *Grete Herball.* Although during the time of Edward I (1272-1307) fruits and vegetables were plentiful (Roach 1985), peaches had virtually disappeared during the succeeding centuries. The unsatisfactory production of peach prompted Turner to write in his *Herbal* in 1568 that "the peach is no great tree in England that I could see." As a result of the disappearance of the fruit trees, many trees were imported again during the reign of Henry VIII. Reference to this was made by Harrison (1534-1593), Dean of Windsor, in the *Holinshed Chronicles* in 1586. Tusser (1580) mentioned various types of peaches first in the English literature when he wrote of red and white types. Gerard, in 1597, described four types: the white, the red, the "d'aunt" (or avant), and yellow peaches. The d'aunt peaches had larger fruit than the others, russeted skin, and a pleasantly flavored yellow flesh. Parkinson's *(1629) Paradisi de sole* discussed nectarines first in England, and a later edition of Gerard's *Herball,* revised by Thomas Johnson in 1663, gave more details about cultivars of peach (Fig. 10) including *Nucipersia* or *Nectorins.*

England was cold and all writers, including John Rea (1676), recommended that peaches be planted on the front of the warmest walls or be planted in glass houses (Worlidge 1697). Planting peaches along the walls or in walled gardens in cool climates also turned out to be beneficial in warmer climates. It was customary in the sixteenth and seventeenth centuries in the Italian villas or in the French monasteries to plant peaches in walled in gardens along the shelter of walls. This method was used almost exclusively by noblemen. Gardens of this type could not be found in or around Italian cities until the end of the thirteenth century or the beginning of fourteenth century. The primary information regarding such gardens have come from the first four chapters of the eighth book of *Il Libro della agricultura* by Pietro de Crescenzi (Crescentius 1478). According to Crescenzi, the ideal garden would be built on about 8ha and the interior walls would be decorated with espaliered trees. Orchards were in the most distant part from the villa and we estimate that they did not take up more than 1 ha. Apples, pears, peaches, cherries, and plums would dominate the orchard. Considering the fact that often the espaliered trees were peaches, it is possible that 25 to 35 peach trees were planted in every garden. Unquestionably, peaches were also considered as pleasure fruits and were planted in the Medici villas. One of these gardens was of the villa of Poggio a Caiano, outside Florence, designed by Guliano da San Gallo in 1479 (Fig. 12). Alexander Bracci (ca. 1480) listed the 100 plant species grown in the garden in a verse written to Bernando Bimbo. In the verse he mentions *persico chrysomilla* (yellow clingstone peach) along with other fruit and other trees and plants. Thus the peach penetrated the interest of Italian people as well.

Leonardo Da Vinci (1452-1519) was exposed to the gardens of Medici and became familiar with the germination of peach seeds. He used wide analogies to explain his ideas. Leonardo made a comparison between vascularization of the heart and liver and the germinating peach seed (drawing R.L.19028) (Fig. 13).

He was challenging the views of A. D. Gallen, who maintained that the liver was the primary organ. Leonardo stated that the veins have their origins in the heart as the whole plant has its origin in its thickest part, an example of this is the growth of the peach, which proceeds from its seed (its thickest part), as shown in his drawing (Emboden 1987).

Fig. 10. Illustration of peaches in John Gerard's *Herball* revised and enlarged by T. Johnson in 1633.

Leonardo also reveled in cryptic puns, aphorisms, fables, jests, mottoes, and fantastic tales. It was an activity of much of his mature life. Many of his fables had something to do with fruit trees. *Codex Atlanticus* bears stories of grape, fig, nuts, citron, and other plants. A section (C.A. 76r-a) presents a story of a peach tree. Pervading this tale is the theme of envy and false pride: "The peach tree, being envious of the great quantity of fruit that it saw its neighbor the nut tree bearing, decided to do the same, and loaded itself with its fruit to such an extent that the weight of its fruit threw it down, uprooted and broken, level with the ground."

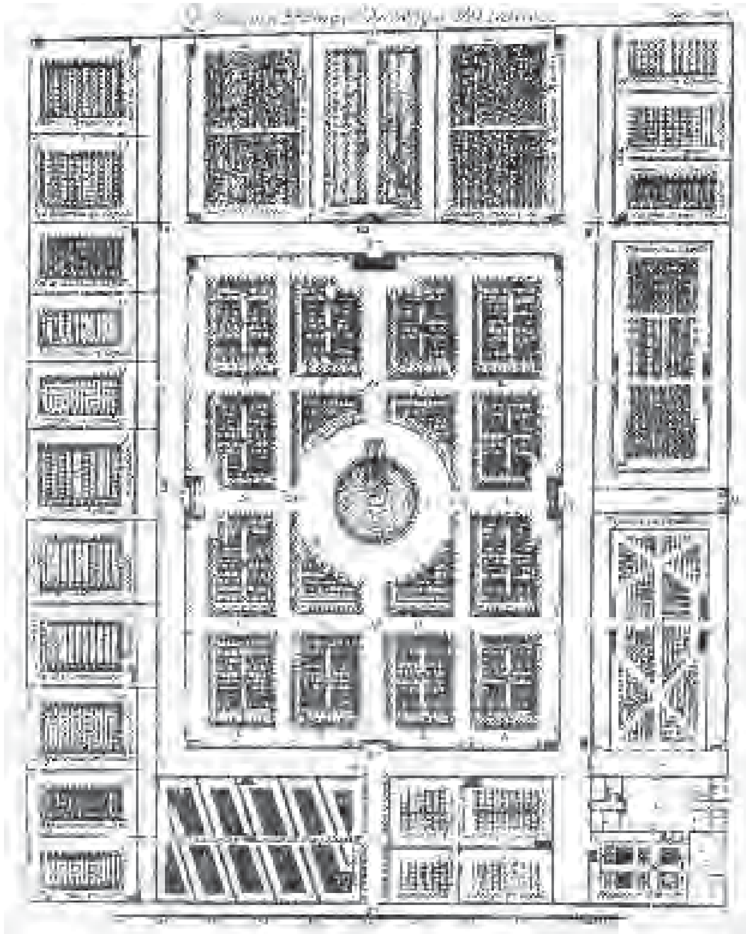

Fig. 11. Original diagram of the king's garden at Versailles, erected for Louis XVI by La Quintinye (1626-1688), in which peaches were a conspicious feature. Blocks were usually filled with fruit and vegetables or flowers. Reading clockwise beginning with the king's entrance (at six o'clock) blocks (5,6,7,8) are diagonal gardens located for favorable sun exposure and contained early peaches and 'White Madelaine' peaches. (9,10) 'Mignone' peaches in espalier. (11) 'Red Madeleine' and 'Bourbin' peaches in espalier. (12) 'Persian' and 'Chevreuse' peaches in espalier. (14) 'Early Violette' peaches in espalier. (15) 'Purple' peaches in espalier. (16) 'Admirable' peaches in espalier. (22) Espaliers mixed with all sorts of good peaches. (24) Brugnones (nectarines) in espalier. (25) Yellow peaches and other peaches in espalier. (35) 'Violette' peaches and several other good peaches in espalier. The espaliers of the main garden (38) were filled with 'Admirable' and 'Nivette' peaches. (Reproduced from Tukey 1964.)

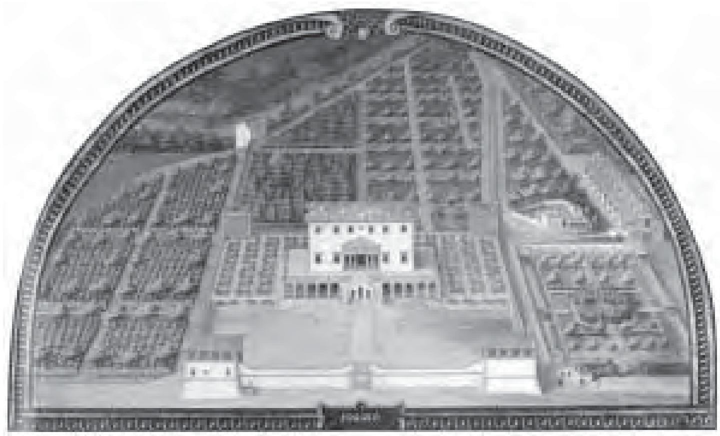

Fig. 12. Villa of Medici, Poggoa Caiano, outside Florence. The walled-in garden shows the Medieval elegant fruit garden, typical of Italy, in which 25 to 35 peach trees were grown.

The only plant motif to be found in the *Last Supper* are the decorations in the lunettes, which are garlands of peaches in fruit about 45 cm high. The work is formal and decorative, but in the opinion of Emboden (1987) it is not an inspired rendering.

Ulysses Aldrovandi (1522-1605), a physician and philosopher, had no particular interest in peaches but created a large herbal and collected woodcuts and watercolors of all living creatures. He made the first encyclopedia of plants and used a peach and a nectarine for illustrating the species which he called among other names *Mali persicialia specis..* and *Nux persico.* His *Iconographia Plantarum* was produced during the second half of the fifteenth century and finally printed as part of his *Dendrologiae* in 1668 (Baldini 1990). Perhaps his illustration of peach and nectarines are the first botanical illustration of this species.

D. Eastern Europe

The peach not only reached western Europe but extended to eastern Europe as well. There is archeological evidence that peach was planted extensively in Hungary and in the Slovak republic (Timon 1992). The earliest finds of peach seeds are from the first and second centuries A.D. from the period when Romans occupied this area. Archeological evidence of a peach orchard, planted in the first half of the thirteenth century on a 2.5-m square, has been discovered on Helemba Island near Esztergom, Hungary, and the species could be authenticated by pollen analysis. The orchard probably was planted by Archbishop Robert, the Archbishop of Esztergom, who came from Liege, Belgium (Kovalowski 1989).

The first written evidence of peach in Hungary comes from a school dictionary from Schlagli. Entry 1534 gives the synonym *persicum* or *barazc* (see the names of peach in Section IVB). Another school dictionary from the Romanian Beszterce under entry 845 describes *barasc, baraczk,* and *barassch,* meaning *psicus, psicum,* or *persicum* 1985).

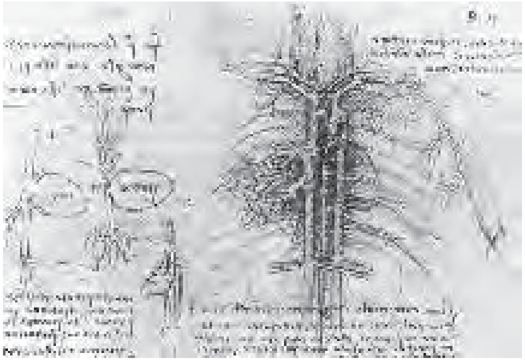

Fig. 13. Leonardo Da Vinci drawing comparing the human vascular system with the one of a germinating peach seed. (From Emboden 1987.)

Probably the Carpatian basin was an important area of peach growing in Central Europe. In 1561, Conrad Gesner described a yellow-fleshed peach from Wroclaw (Poland) garden as a cultivar with Hungarian origin. Caspar Hauhin (1623), in addition to Gesner (1561), considered the red-fleshed peach also to be Hungarian in origin. Even though the red-fleshed peach still exists as a semi wild peach, its origin is not Hungarian. Leroy (1879) describes it as a cultivar of Swiss origin. Mattioli (1554) mentions it as a cultivar with Italian origin, and Merlet (1675) describes its French name. *Sanguinole,* first. That the Carpatian basin was an important peachgrowing area in Central Europe is further signified by the fact that Lippai (1642-1666), the Archbishop of Pozsony (Bratislava, Slovakia), had a large collection of peaches in its walled garden (Fig. 16). Lippai, his brother, a horticulturist, who managed this garden, described in 1667 all types of peaches recognized today (Lippai 1667).

V. THE AMERICAS

A. Entry of Peaches Through Europe

Peaches brought by the Spaniards to America disseminated among the Aztecs in Mexico. Less than 50 years after Cortez conquered Central America, the peach was commonly grown in Mexico. Hedrick (1917) quotes Molina, who wrote a book in 1571 in which he uses Hispano-Aztec compound words such as *xuchipal durazno* for redcolored peach, *cuztic durazno* for yellow peach, and *xocotlmelocoton* for peach fruit in general. From Mexico the peach spread to New Mexico, Arizona, and California. A traveling officer surveying the railroad routes wrote in 1799 that peaches yielded abundantly in the area that is New Mexico today (Hedrick 1917). Apparently, there was a second introduction of peaches by the Spaniards to America. The early cultivation of peach in Florida and along the Savannah River in Georgia indicate that the Spanish had planted peaches at Saint Augustine, Florida in 1565.

Fig. 14. Peach from Aldrovandi's *Iconographia Plantarum* (IV:207). Painting is from the mid sixteenth century. (From Baldini 1990.)

William Hilton, an Englishmen visiting the land 100 years after the Spaniards established themselves at Saint Augustine, recorded the abundance of peaches among other fruits in the countryside in 1664 (Hedrick 1919). A more authorative person, John Bartram, the first American botanist, quoted by Hedrick (1917), often mentions peach in describing his travels through this region in 1765-1766. He noted that the peach was wild and cultivated by the Indians. He found the peach so abundant that he was inclined to believe that it was native to America (Hedrick 1917). Peach growing was also described from Louisiana in 1698 when the French settled that area (Hedrick 1917). John Lawson (1714), a surveyor, reported ample peach production in the Carolinas.

Fig. 15 Nectarine form Aldrovani's Iconographia Plantarum (IV:227); painting is form the mid sixteenth century (From Baldini 1990).

Nuttall (1821) wrote that "the peach of Persia is already naturalized throughout the forests of Arkansa." Kalm (1770) gives a good account of the colonists' method of making peach brandy. Kalm traveled from Trenton to Princeton and found the country full with orchards. Peaches were also planted in New York. Hedrick (1917) mentions several authors who wrote about peaches grown in New York.

Planting of peach seeds was common. The Massachusetts Company in 1629 sent seeds to the colonists to plant peaches (Hedrick 1917). Peter Collison, an English botanist, urged John Bartram to graft nectarines on peach stock in 1736. However, the Prince Nursery of Flushing, Long Island, was probably the first to graft peaches. They offered an assortment of 29 sorts in 1771 (Hedrick 1917). Whereas grafting was introduced relatively late into peach production in the United States, in England 200 years earlier grafting was in use and rootstocks were considered. Heresbach-Googe, in 1578, advised the use of peach, almond, or plum rootstocks. In 1657, Austen (1657) recommended plum suckers or alternatively peach seedlings as rootstock. In 1731, Miller said that some cultivars were not compatible with the plum rootstock. However, Switzer (1724) recommended overcoming such incompatibility by using apricot interstocks (Roach 1985).

Fig. 16. Garden of the Archbishop of Pozsony; drawing is from 1667.

Regardless of propagation method, by 1800 Baltimore became the best market for peaches, and the nearby Chesapeake area a peach belt. This attracted Richard Parkinson (1805), an English farmer and agricultural writer who came to America and rented a farm near Baltimore with a peach orchard. Peaches at this time were grown mostly for brandy. Parkinson found peach growing not very lucrative. He complained that the price of the peaches was so low that it did not pay for his troubles raising them. Peach production had and still has its share of problems.

Peach growing in California started around the mid nineteenth century. General Bidwell mentioned seeing about half an acre of seedling apples and peaches at Fort Ross (Olmo 1976). The first-named cultivars of a number of tree fruits, including peaches, were ordered from a New York nursery in 1849 by W. H. Nash and R.L. Kilburn of Calistoga, Napa County, California. The trees were shipped by boat around Cape Horn and arrived in the spring of 1850. Almost simultaneously the nursery business developed in Sacramento (Olmo 1976). A.

P. Smith arrived in 1848 and established a nursery, called Pomological Gardens at Sacramento and started to produce peaches among other species. Seth Lewelling arrived from Oregon and sold fruit trees including peaches, in the spring of 1851 (Olmo 1976). Peach production increased rapidly and by 1885 the peach became the leading orchard fruit in California.

Severe epidemics such as peach yellows, a virus disease, plagued peach production in the northeastern United States beginning in 1800. Hedrick (1917) has a detailed description of this problem. In 1890 there were 4.5 million peach trees in Delaware. A decade later the number of trees decreased to 2.4 million, and by 1910 there were only 1.1 million trees left. Along with peach yellows, brown rot and borers became more destructive as peach production increased. In 1892, San Jose scale appeared in Virginia. Its rapid spread to other fruit areas led to the adoption of spraying as an orchard practice (Fogle 1974). With better growing techniques peach production increased during the later part of the nineteenth century and the number of trees planted reached its climax in 1910. Thereafter, the number of trees decreased, although the total production increased. The next 60 years resulted in a nine fold increase in productivity (Fig. 17) in the United States (Fogle 1974).

B. Direct Entry of Chinese Peaches

There were a few direct imports of peaches about 1850, and for these imports the names North China and Chinese Cling were both in use. This group of peaches was carefully studied by G. H. Powell at the Delaware Experimental Station. Powell preferred to call these peaches "Chinese Cling" rather than "North China" (Hedrick 1917). The name Chinese Cling (Fig. 18) was engraved into American use and remains so today.

Robert Fortune, an English collector of Chinese plants for the London Horticultural Society, was the first to import Chinese peaches directly. He collected large peaches near Shanghai and forwarded the pits to London in 1844. From the resulting seedling one selection was named 'Shanghai' (Roach 1985). In 1850, Charles Downing also received potted peach trees from the British consul at Shanghai marked 'Chinese Cling' and 'Shanghai'. However, the two trees were identical (Hedrick 1917).

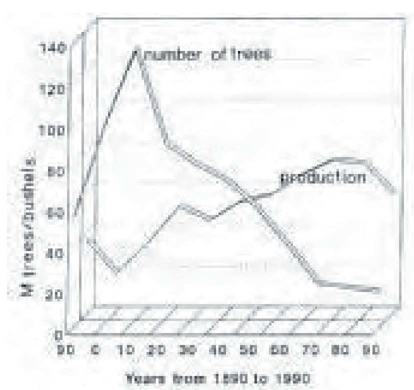

Fig. 17. Number of peach trees in the United States and annual production,1889-1969.

(Adapted from Fogle 1974 and Agricultural Statistic.)

Fig. 18. 'Chinese Cling' (Adapted from Hedrick 1917.)

Downing's peaches were widely distributed and the horticultural magazines gave wide publicity to the Chinese peaches. As a result, several persons imported the 'Chinese Clings' and such peaches were grown in orchards throughout the United States 25 years after the first importation.

In 1857, a Delaware nursery salesman sold peach trees to L. C. Plant, a banker in Macon, Georgia, who had an interest in peach growing. Plant gave the trees to his good friend Colonel Lewis Rumph of Marshallville, Georgia. Rumph grew these trees in the family orchard and with time decided that 'Chinese Cling' was especially good. Colonel Rumph's wife saved seeds of the 'Chinese Cling' and gave them to his grandson Samuel H. Rumph. He planted the seeds on the Rumph farm in 1870 (Myers et al. 1989). The 'Chinese Cling' tree from which the seeds originated stood in the vicinity of an 'Early Crawford' tree. Rumph believed that the seed from which the Elberta peach originated was pollinated by 'Early Crawford'. Myers et al. (1989) provided genetic consideration that this assumption may be correct. The seedling was named 'Elberta' in honor of Rumph's wife, Clara Elberta Rumph and became the most important cultivar of its time worldwide (Hedrick 1917). Myers et al. (1989) describes the naming of 'Elberta' in the following way:

> Samuel H. Rumph married Miss Clara Elberta Moore, a charming lady who entertained numerous friends. During one of Mrs. S. H. Rumph's "spend-a-day" parties, Samuel was showing the guests some of his choice peaches from seedlings along with others and announced each cultivar by name. He at last showed what he considered to be the best peach of all but gave no name. One of the guests, Mrs. L. E. Veal, inquired of the name. Mr. Rump replied, "It has no name. You may name it." With that, Mrs. Veal replied, "Well, let's honor your wife and call it for her. She is perfect and so is the peach. You will never have anything on this

continent to surpass it. 'Elberta' is its name. Thanks for the honor."

Another seed reported to come from the same tree was planted by S. H. Rumph's brother L. A. Rumph, also of Marshallville, Georgia. This seed produced a splendid white-fleshed peach. The flower that produced this seed was believed to be pollinated by 'Oldmixon Free' another cultivar standing nearby. The resulting tree was named 'Belle'. The American Pomological Society listed 'Belle' in its catalog in 1899 as 'Georgia' but changed the name to 'Belle' in 1909. Later its name was popularized and became 'Belle of Georgia' (Hedrick 1917).The impact of Chinese Clings on peach production did not end with 'Elberta'. Soon after the turn ofthe century J. H. Hale, a Connecticut grower, found a tree in a lot of 'EarlyRivers' peaches sent to him by David Baird, of Manaplan, New Jersey and planted on his farm in South Glastonbury, Connecticut. This chance seedling probably originated from an 'Elberta' seed, thus could be considered a second-generation 'Chinese Cling'. This tree was the second outstanding individual coming from the 'Chinese Cling' group. In comparison with 'Elberta', the fruit of this seedling ripened a few days earlier, its fruit was slightly larger and less pubescent, and overall it was very handsome. Mr. Hale, after thorough testing, decided to sell the propagation to Stark Nurseries in 1912 and the new cultivar 'J. H. Hale', was propagated very rapidly and quickly disseminated (Cullinan 1937). Even later, 'Elberta' and 'J. H. Hale' have become the basic cultivars used in peach breeding, which prompted the criticism that the genetic base of peach is very narrow, stemming largely from the 'Chinese Cling' (Hesse 1975; Scorza et al. 1985; Scorza and Okie 1992).

The south Chinese beaked peaches were imported as seeds by J. Caldwell, Newburg, New York. The seeds were sent to him by J. T. Devan, Canton (Guangzhou), China. They were also introduced to Europe by M. Montigny, French Consul of Shanghai, who sent seeds to the Jardin des Plantes, Paris, in 1852 (Hedrick 1917).

Belonging to the Chinese group, 'Peento' was imported to America by William Prince (1766-1842), owner of the Prince Nursery, Flushing, New York, sometime prior to 1828. The trees from Prince importation have been lost. In 1869, Prosper Julius Berkmans (1830-1910), the owner of the Fruitland Nursery, Augusta, Georgia, brought seeds from China, one of which produced a 'Peento' tree (Hedrick 1917).

C. Peach Cultivars Prior to 1930

Commercial peach growing in the United States began early in the nineteenth century. Large orchards were planted in Maryland, Delaware, and New Jersey. Prior to this time, thousands of peach trees, all seedlings, were planted by growers. Many of the cultivars grown in those days were better suited for making brandy than use for fresh consumption. As the commercial industry spread there was a need for better cultivars. During the period of 1850-1900 a large number of cultivars was selected from seedlings as worthy of introduction (Cullinan 1937). There were several private individuals who were on the constant lookout for trees that filled the need and could be introduced as cultivars. These included William Crawford of New Jersey ('Late Crawford' 1815 and 'Early Crawford' 1820), J. Oldmixon ('Oldmixon Free' 1835), L. A. Rumph ('Belle of Georgia' 1870), and S. H. Rumph of Georgia ('Elberta' 1870),1.G.Hubbard of Illinois ('Champion' 1880), J. W. Steubenrauch of Texas ('Carman' 1889), J. H. Hale of Connecticut ('J. H. Hale' 1912), John Halford of California ('Halford' 1921) and an unknown person who introduced the one time earliest cultivar ('Mayflower'), which matured 60 to 65 days before 'Elberta'. In addition to these names, many others are listed by Cullinan (1937). As a result of this activity the number of cultivars greatly increased. In 1917, U. P. Hedrick described 2181 peach cultivars in *Peaches of New York* (Hedrick 1917).

Institutional breeding started in the twentieth century. Controlled crosses to develop new cultivars were started in Illinois and California in 1907; at Geneva, New York in 1910; in New Jersey in 1914; and at the South Haven Horticultural Experimental Station in Michigan in 1924. Beginning in 1925 several new cultivars were introduced by the foregoing stations and by the Ontario Horticultural Experiment Station, which replaced the unsatisfactory types. This early breeding activity also resulted in numerous new cultivars. R. M. Brooks and H. P. Olmo listed an additional 700 cultivars introduced after 1920 in the second edition of *Register of New Fruit and Nut Varieties,* and the list of cultivars has increased to more than 6000 at present (Okie 1993, 1994). Breeding activities and early breeders are listed in Table 1.

Along with the institutional breeders, there were private undertakings in peach breeding. Following passage of the U.S. Patent Law in 1930, several private individuals and companies started peach and nectarine breeding. F. W. Anderson started his breeding work in 1930, Grant Merrill in 1932, and the Armstrong Nursery Company began soon after (Cullinan 1937). They were responsible for many excellent cultivars first grown in California, then throughout the world.

Among the locations where peach breeding was practiced for a long time, the Nikita Botanic Garden, near Yalta, Ukraine, should be mentioned. This botanic garden was established in 1812 for the selection and breeding of various plants, including peach (Ryabov 1969). This is the major location that used *P. mira* and *P. ferganensis* parentage for producing mildew-and leaf curl-resistant cultivars (Shoferistov 1988).

Table 1. Location of early peach breeding in the United States and Canada.

State Institution location	Year work begun	Early workers	Workers in the 1930s
Alabama	1925?		J. C. C. Price
California Agr. Exp. Stn. Davis	1925		W. A. Tufts, G. A. Philps, L. D. Davis, C. O. Hesse
Agr. Exp. Stn. Riverside	1907	E. B. Babcock, C. O. Smith, H. B. Frost	J. W. Lesley
Chaffee Jr. Coll. USDA, Palo Alto	- 1922		G. P. Weldon W. F. Wight, L. A. Thompson
Illinois Agr. Exp. Stn. Urbana	1907	C. S. Crandall W. Dorsey	J. C. Blair, M.
Iowa Agr. Exp. Stn.	1900	S. A. Beach	T. J. Maney Ames
Maryland USDA, Betsville Agr. Exp. Stn. College Park	1931 1929	E. C. Auchter, W. L. Kerr	F. P. Cullinan, J. H. Weinberger A. L. Schrader S. W. Wentworth
Massachusetts Agr. Exp. Stn. Amherst	1918	J. K. Shaw	J. S. Bailey
Michigan Agr. Exp. Stn. South Haven	1924		S. Johnston, V. R Gardner
Minnesota Univ of Min. Excelsior	1919	W. H. Alderman	
Missouri Agr. Exp. Stn. Mountain Grove	1899	J. T. Stinson, P. Ewans, F. W. Foust	P. H. Shephard
New York Agr. Exp. Stn. Geneva	1895	S. A. Beach	U. P. Hedrick, R. Wellington, O. Einset
New Jersey Agr. Exp. Stn. New Brunswick	1914	C. H. Connors	M. A. Blake
Texas Agr. Exp. Stn. College Station	1935		S. H. Yarnell

Virginia			
Agr. Exp. Stn. Blacksburg	1925		F. W. Hofman
Ontario, Canada			
Hort. Exp. Stn. Vineland	1908	A. J. Longsdail F. S. Reives	E. F. Palmer, G. H. Dickson J. R. Haarlem
Summerland	1927		J. E. Britton R. C. Palmer

Source: adapted from Cullinan (1937) and Okie (1994).

D. Peach Cultivars, 1930-1990

The various ecological conditions under which peaches were grown in the United States were recognized early by scientists working with peach improvement. Consequently, improvements came in each ecological area separately and are discussed accordingly.

Freestone, yellow-fleshed peaches were considered the most desirable by the American public. Prior to 1930, the season for freestone peaches was restricted to 3 weeks. Stanley Johnston, working at the South Haven Experimental Station in Michigan, was successful in extending the freestone peach season to 8 weeks, a major advancement its time. He introduced eight cultivars: 'Halehaven' (1932), 'Kalhaven' (1936), 'Redhaven' (1940), 'Fairhaven' (1946), 'Sunhaven' and 'Richhaven' (1955), and 'Glohaven' and 'Cresthaven' (1963). 'Redhaven' was a new level of excellence in peach. It was relatively early (matures 30 days before 'Elberta'), firm, attractive, and of very high quality. It became the most widely distributed cultivar in the world in the 1960s.

There were other improvements of peach cultivars in the eastern United States. M. A. Blake and C. H. Conners started peach cultivar improvement at New Brunswick, New Jersey, in 1914 and Blake continued it until 1947. He introduced greatly improved cultivars such as 'Golden Jubilee' (1926), 'Raritan Rose' (1936) and 'Sunhigh' and 'Triogem' (1938), along with several others. From 1947 to 1981 L. F. Hough and Catherine Bailey continued the program. Along with developing freestone peaches for the mid-Atlantic states, they placed emphasis on developing clingstone processing peaches for the babyfood industry in the east. In 1961 they introduced the 'Babygold' series numbers 5,6,7, 8, and 9. These were firm, non melting flesh peaches with no red around their stone. Throughout the years the New Jersey breeding program introduced 95 cultivars. Blake and Hough imported germplasm from every place they could, and perhaps their cultivars have the widest genetic base among all peach cultivars, although this needs to be examined in detail. For a complete listing of New Jersey introductions see Okie (1994).

By 1974, the 8-week-long ripening sequence Stanley Johnston achieved was greatly extended. Fogle (1974) listed 50 well-adapted cultivars for the eastern United States, with maturity ranging from 61 days before to 37 days after the maturity time of 'Elberta', a period of over 3 months. All but four of these cultivars had yellow flesh. White peaches almost disappeared, either the public preferred yellow-flesh peaches, which showed fewer bruises, or shipping the much softer and brown-rot-prone white peaches was more difficult, and the growers did not plant them. Yet there is a yearning for white peaches and relatively outdated cultivars such as 'Belle' and 'Raritan Rose' are still grown to a limited extent. Recently, firm white peaches have been released by both private and public breeders.

Improvements also came on the southern reaches of the eastern peach production area. Breeding of peaches was initiated by the U.S. Department of Agriculture at Fort Valley, Georgia, in 1937, with J. H. Weinberger in charge until 1954 followed by Victor Prince and from 1980 by W. R. Okie. Weinberger studied the cold requirement of peach cultivars for 11 years using a model proposed by Huchins (Weinberger 1950) and decided that many existing cultivars required cold exposure (chilling) of more than 950 hs at around 6°C, which is more than trees usually received in Georgia. When cold exposure was limited to 880 h during the winter of1948-1949, serious prolonged dormancy problems ensued with the old-type cultivars. He continued to develop lower-chilling-requiring cultivars. Cultivars introduced from this program comprised 45% of peach production of Georgia by 1972 and became important throughout the southern half of the United States. 'Springcrest' and several mutations have been widely planted around the world (Okie and Myers 1991). It has become the most important cultivar since 'Redhaven'. R. Sharpe, carried developing low-chilling-requiring peaches even further and started a breeding program in Gainsville, Florida, to develop cultivars suited for subtropical climates with little or no winter. This program started in 1952, with no commercially satisfactory selection during the first two or three generations, because the poor fruit characteristics of the low-chilling-requiring parent plants (Sharpe and Sherman 1975). Sharpe's first cultivars still required near 500 h of chilling. However by 1961 he was able to introduce 'Flordawon', which needed only 150 chilling hours. The quality of these very low-chilling-requiring cultivars was greatly improved when he released 'Flordabelle' in 1970, a yellow-flesh freestone cultivar that produces fruit 56 to 62 mm in diameter. The program, continued by W. Sherman, has resulted in several low-chilling cultivars, including 'Flordaprince' and others requiring only 150 hours of chilling. 'Flordared', released in 1970, required even less chilling, only 100 h. Developing lowchilling peaches not only extended the southern border of peach production in the United States but allowed peach production in tropical highlands, such as northern Thailand at 1300 m elevation, India, Peru, Brazil and Israel (Sharpe and Sherman 1975). A complete list of 56 introductions from Florida has been published by Okie (1994).

In severe winter climates, cold hardiness is a problem. Winter-hardy peaches were developed at the Horticultural Research Institute of Ontario, Vineland. Peaches were introduced between 1924 and 1981 are generally called the V series because 15 cultivars all start their name with the letter V for "Vineland." The series started with 'Vimy', introduced in 1924, and ended with 'Veeglo', introduced in 1981. Recent introductions from this program have been canning cling peaches. A more modem winter hardy series was developed at the Agriculture Canada Research Station, Harrow, Ontario. From 1968 to the present, R. E. C. Layne introduced 16 cultivars, all names starting with the letter combination "Har" for "Harrow." The first introduced was 'Harbelle' (1968). The Harrow series represent a great advance in producing peaches in areas of cold winters. For a complete list of introduced Canadian cultivars, see Okie (1994).

Winter hardiness became a problem with winter-hardy cultivars developed in Canada when they planted farther south in the mid-Atlantic states, where winter temperatures fluctuate. Winter hardiness is a complex trait. The very winter hardy rootstock 'Siberian C', developed at Harrow Ontario in 1967, predisposes the scion to suffer from spring cold damage in Georgia, even though the cold is far less than it would withstand easily in Canada. This contrast with the cold hardiness of 'Bailey' which is hardy in the fluctuating climate of midwest but not hardy enough in Canada. These experiences made peach researchers realize that the hardiness-dormancy complex is important, and it should be considered in cultivar development.

The California peach-producing area was relatively constant between 1945 and 1965 at about 12,000 to 14,000 ha. The planted area decreased in the late 1960s to about 8000 to 10,000 thousand ha and remained at that level since. The decrease coincided with the increase in nectarine and plum plantings. In 1971, the most important cultivars were still the oldtime favorites: 'Fay Elberta', 'Suncrest', 'Elberta', 'Redhaven', 'Rio Oso Gem', 'Redglobe', and 'Cardinal'. California produces nearly 40% of the U.S. fresh-market peaches. Cultivars that produce shippable fruit are extremely important for the peach industry. Growers continually look for cultivars that have a productive tree, yielding large, firm, and highly colored fruit that is attractive and lacks blemishes especially around the suture. When cultivar improvement is considered, one has to look for the entire range of cultivars because the shipping season is long and several early, midseason, and late cultivars are needed to satisfy demand throughout the season. The period 1960-1975 was important in improving the freestone cultivars of California. Several private breeders, primarily Grant Merrill, and the U.S. Department of Agriculture with John Weinberger at its Fresno station were very active in developing modern peach cultivars. The present 10 most important peach cultivars all developed this time. The cultivars, their developers, the year of their introduction, their contribution to total production, and major fruit characteristics are listed by Johnson and LaRue (1989) and given in Table 2. California cultivars ripen from the third week of May to the fourth week of September. Growers can choose cultivars for the time of maturity they want to market the fruit.

A major change in peach production was the development of highquality nectarines. F. W. Anderson developed nectarine cultivars at Le Grand, California. His cultivars represented considerable advancement over the previous cultivars. Hesse (1975) thought that Anderson's cultivars revolutionalized the nectarine industry. Between 1941 and 1963, he introduced: 'LeGrand' in 1942; 'Late LeGrand' in 1951; 'Sun Grand' in 1950; 'Red Grand'

Table 2. Presently grown freestone cultivars in California.*

Cultivar	Originator	Total production %	Year released	Fruit characteristics
O'Henry	Merrill	16	1970	Freestone, highly colored,
Elegant Lady	Merrill	13	1979	Freestone, well colored
Flavorcrest	Weinberger	8	1974	Freestone, well colored
Springcrest	Prince	7	1969	Semifreestone, early season
June Lady	Merrill	6	1971	Semifreestone, smooth, firm
Redtop	Weinberger	5	1961	Freestone, highly colored
May Crest	Minami	5	1977	Semifreestone, sport of 'Springcrest', early season
Flamecrest	Weinberger	4	1973	Freestone, firm, attractive
Carnival	Merrill	3	1982	Freestone, late season,
Merrill Gemfree	Merrill	3	1955	Freestone, asymmetrical shape, large size but low color

Source: Adapted from Johnson and LaRue 1989.

in 1952; 'Freedom' and 'Grand River' in 1953; 'Grand Haven', 'Star Grand', 'Grandeur', 'Gold Nugget', and 'Golden Grand' in 1954; 'Red River', 'Grandoso', 'Red River', 'Sun Flame', and 'Grand Prize' in 1955; 'Marigold', 'Star Grand II' and 'Golden Free' in 1956; 'Late Red Grand', 'Grandandy', 'Granderli', and 'Royal Grand' in 1957; 'June Grand' and 'September Grand' in 1958; 'Regal Grand' in 1959; 'Red June' in 1961; 'Stark Delicious', 'Stark Redgold', 'Stark EarliBlaze' and 'Stark Sunglo' in 1962; 'Golden Prolific' in 1963. The list does not include all of F. W. Anderson's cultivars.

The major advancements, however, in nectarine production came between the period of 1965 to 1975 when F.W. Anderson, J.H. Weinberger, and C. F. Zaiger introduced the top 10 cultivars still in use today (Johnson and LaRue 1989). The productive USDA program was continued after 1973 by David Ramming, who added several cultivars to the California nectarine production.

As improved cultivars became available, the cultivar composition of the nectarine orchards of California changed. Johnson and LaRue (1989) noted the changes in nectarine production which are given in Table 3.

Parallel to that of peaches, the major nectarine cultivars and those planted on a smaller area form a continuous ripening sequence starting from the second week of May and ending up in the first week of September. There is at least one cultivar ripening in each week during this 16-week period.

Table 3. Composition of nectarine orchards in California between 1960 and 1988.

1960	%	1965	%	1970	%
Late LeGrand	18	Late LeGrand	23	Early Sun Grand	22
LeGrand	17	Early Sun Grand	22	Sun Grand	17
Sun Grand	10	Sun Grand	14	Late LeGrand	15
Early Sun Grand	9	LeGrand	7	LeGrand	7
Early LeGrand	9	Gold King	9	Red Grand	7
Sunrise	7	Red Grand	7	Gold King	7
Red Grand	6	Sunrise	6	Red June	5
Gold King	6	September Grand	3	September Grand	3
John Rivers	2	Star Grand	1	Independence	3
Grand River	2	Regal Grand	1	Regal Grand	2
1975	**%**	**1980**	**%**	**1988**	**%**
Early Sun Grand	13	Fantasia	12	Fantasia	11
Sun Grand	9	May Grand	9	Flamekist	8
May Grand	8	Flamekist	6	May Grand	8
Independence	7	Early Sun Grand	7	Royal Giant	7
Flamekist	6	Flavortop	6	Fairlane	6
Fantasia	6	Fairlane	6	Summer Grand	5
Late LeGrand	6	Autumn Grand	5	Spring Red	5
Autumn Grand	6	Sun Grand	5	Flavortop	5
Armking	5	Independence	5	Red Diamond	5
Red June	4	Firebrite	4	Firebrite	4

Source: Adapted from Johnson and LaRue 1989.

A similar effort was exerted in New Jersey to improve nectarines. L. F. Hough and Catherine Bailey, working at New Brunswick, introduced a series of nectarines named 'Nectared' and numbered from 1 to 10. They were introduced in 1962 and were intended as a series of nectarines with ripening times covering an 8-week period from 6 weeks before to 2 weeks after the ripening time of 'Elberta'. Although these cultivars were well adapted to the humid climate of the eastern United States, they never attained the size or attractive color of their western counterparts achieved and combined with the difficulty of growing nectarines in the eastern United States, they lost popularity.

The success of peaches and nectarines did not go unnoticed abroad. American peach cultivars were tested in Italy, France, Spain, Hungary, and Chile and became popular and planted in all localities. As a result, today, Italy alone produces 20% more fresh market peaches and nectarines than the United States, and about 60% of this production is based on American cultivars. Even new cultivars developed by Italian breeders are mostly first generation hybrids of American cultivars. The situation is similar in France and Spain, with a slightly higher percentage (70%) of production based on American cultivars. Europe outproduces the North American continent, even if we consider our nonmelting, processing peaches, which are not produced in Europe. The production is 3.5 million tons in Europe versus 1.2 million tons in North America. The situation is similar in the other continents, with the exception of Asia. Thus we can say that the world production of peaches and nectarines is based largely on North American cultivars. Movement of peaches to Chile is discussed in Section VI.

E. Rootstocks

One has to mention advances in peach rootstocks. Rootstocks are generally divided into three groups: wild type (feral) peaches such as Tennessee Naturals or Indian Peaches; seedlings of commercial cultivars (usually canning or drying peaches), which in the United States are most often 'Halford' or 'Lovell' and other cultivars in other countries; and rootstocks specially bred for rootstock purposes (Layne 1987). This is the area where advances were important. In 1947, a red-leaf peach was developed for rootstock with the idea that nursery workers can easily notice when the scion bud failed, but use has been limited. The color of the grafted tree should be green, in contrast to the rootstock which is red. From the USDA program in Georgia, 'Nemaguard' was developed in 1959. It became an important rootstock in California and Florida. The primary reason for its acceptance was its vigor and resistance to the root knot nematode *Meloidogyne* sp. Its adverse effect on the hardiness of the scion cultivar, inducing peach tree short life (PTSL), limited its usefulness in the Southeast. Its own lack of hardiness precludes its use in the northern United States. A new rootstock from the USDA-Byron and Clemson University cooperation, designated 'B4520-9', appears to combine scion resistance to PTSL root knot nematode resistance and is widely planted in the southeast. A cold-hardy feral peach, the 'Harrow Blood', was introduced in Harrow, Ontario, in 1967 by G. M. Weaver. A second very hardy rootstock was also introduced from the Harrow, Ontario, program. In 1967 it was named 'Siberian C' by G. M. Weaver, indicating its place of origin. Among all the peach rootstocks, 'Siberian C' is outstanding in its cold tolerance in the north. In Canada it withstood the unique winter of 1971, when soil temperature at the 20 cm depth reached -13.3°C. Peach and nectarine rootstocks are sensitive to iron deficiency when planted in higher-pH soils. Using the species hybridization technique, new rootstocks, 'GF 556' and 'GF 677', were produced and introduced in France in 1978. They are peach-almond hybrids and combine the growth characteristic of peach with the high pH tolerance of almond. They have special importance in Europe, where iron deficiency is common on high-pH soils. Because they are hybrids, they need to be propagated asexually. However, tissue culture techniques are generally available and propagation of the GF hybrids is not a problem.

VI. SOUTHERN HEMISPHERE

In the northern hemisphere peach has found its way to the hot climate of northern Africa. This fruit was commonly grown in Egypt. However, we have very little information on how peach arrived in the southern hemisphere. It is recorded that in 1649 the peach was common in the Azores (Hedrick 1917).

Stander (1983) records that in 1841 there was an attempt to ship dried peaches among other fruit and raisins on the chartered brig *Comet* from Cape Town, South Africa to Australia, and in 1875 there were extensive plantings of peaches in the Cape area. R.A. Davis described peach growing in Transvaal, South Africa in 1905 (quoted by Hedrick 1917). He described an unusual race of peaches that was able to be produced among stone boulders in very poor soil. Apparently, this unusual South African race developed from a chance seedling, the seed of which was thrown from the railroad. This peach was grown extensively as a hedge along homesteads, and it was expected to produce 2 years after the seeds were dropped in the bottom of a furrow. Hedrick (1917) recognized the Transvaal peach as a special ecological race. He remarked that the Spaniards no doubt planted peaches after discovering South America, and as a result peaches grew on both side of the continent. Darvin (quoted by Sturtewant in Hedrick 1919) reported peaches on islands at the mouth of the Parana River, Argentina. Wright (1913) reported nectarine in Argentina, Chile, Bolivia, and Peru under cultivation and as escapes from cultivation. During the turn of the century, large peach orchards existed in New Zealand and in Australia (Hedrick 1917).

There has been a recent movement of peaches into the southern hemisphere. A great increase of production in Chile occurred between 1965 (9700 ha) and 1994 (22,980 ha). Ninety percent of peach production of Chile is within the limits of latitude 32 and 35°. Conditions for peach growing in Chile are similar to those in California and California cultivars predominate. As the cultivar mix changed in California, so did it in Chile. In the 1960s 'Grand' nectarines were important, in the next decade the 'F' lines of nectarines, 'Flavortop', 'Flamekist', 'Fantasia' and 'Fairlane' were planted, and the peach cultivar 'O'Henry' was popular. In the 1980s 'Crest' and 'Lady' predominated in new planting, and the 'Diamond' line of nectarines, along with white peaches started to be popular. During the late 1970s production moved to the north somewhat. Cultivars from the Florida breeding program were planted in the northern valleys of Chile The most important cultivars were 'Flordaking', 'Sundowner', 'Flordagem' and 'Flordaprince'. North American cultivars planted in Chile allowed a production level of 190,000 tons in 1991 (60,00 tons of peaches and 80,000 tons of nectarines for fresh consumption and 50,000 tons of peaches for canning). Because the harvest season in the southern hemisphere begins in January, a large portion of the peaches and nectarines (total of 49%) exported to North America (Y. Moreno 1994, unpubl.)

VII. CONCLUSIONS

Peach has been the favored fruit of nobles for centuries, and today it brings pleasure to many hundreds of millions of people. In Europe and North America the yearly consumption reaches 6 kg per person (15 kg for apple), a significant amount considering all fruits available during summer.

Quality improvements of the fruit allowed long-distance shipping. Today, peaches and nectarines are commonly shipped to distances of 3000 km or longer. This is the reason that California is able to supply New York with peaches and nectarines, or Chile can send fruit all winter long to North America. To do this, the fruit is harvested relatively immature and is not able to develop its full flavor. Cultivars of a new generation are needed that can be harvested at a more mature stage, yet retain transportability.

The increase in productivity was phenomenal from 1910 to 1970, but productivity has leveled since then. Only needed refinements, such as filling the gaps in the ripening sequence or improvements in quality, were possible after 1975. The reason for this is uncertain. The genetic base is definitely a factor that limits the degree of progress. We may also have exhausted the possibilities to improve the fruit further and have to turn our attention to improving the tree. Breeders are already developing new tree types: compact, pillar, or spur.

As a fruit the peach is not much smaller than a pear or apple. Yet it produces less fruit on a land unit basis that the pear or apple may produce. In 1991 in the United States, the average peach production was 16 tons/ha, whereas apples yielded 23 tons/ha (Agr. Stn. 1992). To get a desirable large size fruit, the small fruitlets of peach need to be thinned drastically, which discards most of the crop and reduces production. With all the variability in peach, this character is uniform among all types. The flesh of the almond, *P. davidiana, P. mira,* the vineyard peaches, and the early-maturing cultivars of peach and nectarines all have a limited ability to expand and the fruit remain small. 'Chinese Cling' and its progenitors and the Chinese winter peaches need excessive thinning to attain large size. Improving the ability to keep most of the fruit on the tree and being able to enlarge them looms as a pressing problem of peach production. This apparently has not occurred in 3000 years of natural selection and 80 years of fruit breeding, but for the future of peach production it must be done.

Peach is adaptable to various ecological conditions. It is grown in the humid climate of South China, northern Egypt, and the eastern United States; in the desert climate of California, Spain and Iran; in the cool climatea of northern China and Canada; and subtropical climates without real winter, such as Florida, Mexico and Israel. Hedrick 1917 recognized this flexibility when he wrote: "The peach is an exceedingly flexible fruit, capable of being molded to fit many conditions of environment; and under cultivation, training, feeding and culture in unlike regions, soils and climates, may still be greatly improved and the improvements all intensified and augmented by crossing and selecting."

"Molding" has already been done for quality and productivity. Major improvements occurred from 1870 to 1912 when cultivars such as 'Elberta' and 'J. H. Hale' were developed and almost 100 years later between 1960 and 1975 when high-quality shipping peaches were produced and modern nectarines were introduced. These developments reversed the movement of peach. During the historical times the movement was from east to west. In modern times the movement occurred from west to east and to the south. American cultivars were taken from the United States and Canada to Italy, France, Spain, and Hungary as well as Chile, with limited introductions to China. The peach followed the same pattern that has become a commonplace with many agricultural plants. Germplasm was taken from other lands, brought to North America, and in the hand of North American scientists it has been improved and the high-quality productive material was willingly given back to all nations that wanted to use it. In fact, as far as peach is concerned, the circle has been completed.

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Origin and Dissemination of Cherry 2

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I. INTRODUCTION

Cherry is the common name of several species of the genus *Prunus.* Among cherries, the sweet cherry, sour cherry, flowering ornamental cherry species, and a few other *Prunus* species used as rootstocks for cherries are important. The cherry is revered for its fruit and its blossoms. It is an elegant fruit. Some are eaten fresh, others in the form of soup, tart, pie, candied, or covered with chocolate. Liqueurs or wines are made from cherries called *kirschwasser* in Germany, *maraschino* in Dalmatia, or *cherry kijafa* in Danmark. If we consider that cherries are consumed largely in the country of their production, then the consumption ranges from about 1.5 kg per person in the United States to 6 kg per person in Hungary. All other major cherry-producing countries fall within this range. Even the lowest rate of consumption is quite high for a fruit considered as a gourmet item. Cherries are also a source of beauty, being one of the most spectacular flowering trees. Cultivars with double flowers are adored for their grace. The single-flowered ones, with flowers lasting only for a short time, suggest the transient nature of life. In Japan, cherry flowers have an exalted place in the gardens, in public parks, in villages, and in the countryside.

Although, we value cherries as a gourmet fruit, an outstanding drink, or a source of beauty, we know relatively little about their origin, development, and dissemination during the course of history. The only comprehensive review of the history of cherries was done by Hedrick in 1915. Since then many new archeological and historical facts were uncovered that justify this review on the origin and dissemination of cherry. A brief review was also published by Webster in 1995.

II. CLASSIFICATION OF CULTIVATED CHERRIES

Throughout the years botanists have continually changed the classification of plants, including those belonging to the genus *Prunus.* In 1912, Koehne, the most recent monographer of *Prunus,* described 119 species. L. H. Bailey (1927) remarked that the number of species in the genus *Prunus* is probably around 175, but described only 81 in his *Standard Cyclopedia* of *Horticulture.* Rehder (1958) reduced the number of species even further, recognizing only 71 species. The number of species belonging to the subgenus *Cerasus,* the cherries, is relatively small. For clarity, the classification of genus *Prunus,* simplified after L. H. Bailey (1927) and Rehder (1958), is repeated here.

The four subgenera in *Prunus* are determined basically by how the leaves are rolled up in the bud, if the fruit are hairy or not, and if the flowers are in cymes or in racemes:

A. Leaves are convolute (rolled up) in the bud. I. *Prunophora,* plums, prunes, and apricots.

AA. Leaves are conduplicate (folded lengthwise along the midrib) in the bud.

- B. Fruit is normally hairy, stone is normally furrowed. Flowers appear before the leaves. II. *Amygdalus,* almonds and peaches.

BB. Fruit is normally glabrous or very slightly hairy, stone is smooth. Flowers appear with the leaves: Flowers are in racemes of few flowers, fascicles or cymes.

III. *Cerasus,* cherries. Flowers are in racemes. IV. *Padus,* racemose cherries.

Our concern here is with the subgenus *Cerasus.* This subgenus is further subdivided into sections. The sections and selected species important in horticulture are given below:

Section 1. *Microcerasus* Koehne. Flowers are solitary or in short fewflowered racemes. Leaf axils with 3 buds. *Microcerasus* is considered intermediate between cherries *(Cerasus),* plums *(Prunophora),* and apricots *(Amygdalus).* They can be crossed with cherries and used in breeding programs as sources of stress resistance. Cherries are also graftable on *Microcerasus.*

Prunus pumila 1. (Eastern North America), sand cherry.

Prunus besseyi Bailey (Eastern North America), western sand cherry.

Prunus tomentosa Thunb. Downy Cherry (Northern China and Manchuria, the Himalayas.); sprawling shrub, used mostly as dwarfing rootstock for cherries.

Section 2. *Pseudocerasus* Koehne. As section *Microcerasus* but sepals upright or spreading and buds are solitary. Flowers are in bunches of few-flowered short racemes. A high proportion of the ornamental flowering cherries are derived from the Chinese and Japanese species of this section or from their hybrids.

Prunus serrulata Lindl. (China), Japanese flowering cherry. There are many botanical varieties of this species.

Prunus pseudocerasus Lindl. (China) grown for its fruit, which is similar but smaller than P. *Canescens.* Hybridized with P. *avium* to produce rootstocks, such as 'Colt' for sweet and sour cherries.

Prunus donarium Siebold (Japan), Japanese flowering cherry. Bailey considered it a variant of P. *lannesiana,* but Jefferson and Wein (1984) accepted it as a separate species.

Prunus lannesiana Wilson (Japan), Japanese flowering cherry.

Prunus sieboldii Wittm. (Japan), Japanese flowering cherry.

Section 3. *Eurocerasus* Koehne. Sepals are upright or spreading, buds are solitary. Flowers are usually in sessile umbels with persistent budscales present at base.

Prunus fruticosa Pallas (Europe to Siberia), ground cherry used as edible fruit in limited quantities.

Prunus cerasus L. (Europe, Western Asia), sour cherry. Tree is suckering.

Prunus avium L. ((Europe, Western Asia), sweet cherry. There are many ornamental forms of P. *avium:* var. *pyramidalis* Hort., var. *pendula* Hart., var. *asplenifolia* Kirchn., var. *plena* Hart., var. *salicifolia* Dipp. and others. Tree is not suckering. (Hart. means common usage by horticulturists)

Section 4. *Mahaleb* Koehne *Prunus mahaleb* L. (Europe, Western Asia), mahaleb cherry. Used as rootstocks for cherries.

Several classifiers distinguished P. *canescens* Bois (Central and Western China) in *Eurocerasus* as a separate species. P. *canescens* appears similar to P. *cerasus* but with smaller fruit. Rehder (1958) did not recognize it as a separate species and listed only three species under *Eurocerasus.* Watkins (1981) followed this classification. According to Schmidt (Iezzoni et al. 1992), P. *canescens* behaves as P. *cerasus* in breeding and should not be a separate species. There are several other *Prunus* species, listed by Iezzoni et al. (1992), belonging to the above sections, that are potentially useful in rootstock development or development of cultivars with stress tolerance. They are not considered here because of their limited utilization.

A. Classification of Sweet Cherries

The sweet cherry, *Prunus avium,* was named by Linneaus in 1755. It is commonly called the sweet cherry, Mazzard, or Gean cherry. Although *avium* means birds, De Candolle was the first to use the name bird cherry. Sweet cherries are subdivided by horticulturists into two groups based on the firmness of the flesh of the fruit:

1 *Flesh* is *tender.* This group is known as the Heart cherries, the French Guigne, or the English Gean. The soft-fruited cherries can be subdivided even further into dark-colored cultivars with reddish juice and light-colored cultivars with colorless juice. It is the light-colored group that Linnaeus gave the botanical variety name *Juliana.* Augustin Pyramus De Candolle elevated the Heart cherries to species status and named them *Cerasus Juliana.*

2 *The flesh* is *firm.* These cherries are called Bigarreau in several languages. The name originally referred to the diverse colors of the fruit (Hedrick 1915), stemming from *bigarr(e),* meaning variegated.

Several forms of P. *avium* are used as ornamentals and many latinized common names are used to designate these ornamental variants. One of the major points of controversy was the genus into which sweet cherry was placed. Some used the genus *Prunus* as an inclusive genus name, other used *Cerasus* as a restrictive genus designation. Botanists described variations in flesh firmness and leaf shape and gave each form a name, which led to the development of a large number of synonyms. Linneaus called these variations *Prunus avium duracina.* The first name change came in 1768 when Phillip Miller, an English botanist, changed the name of the sweet cherry to *Cerasus nigra.* In 1790, Friedrich Erhardt, a German botanist, changed the name and split the species into P. *nigricans* and P. *varia.* In 1794, Konrad Moench of Germany called it C. *avium.* In 1796, Moritz Balthasar Borkhausen, a German botanist, used the name C. *varia.* The heart cherries were classified by Linneaus as P. *cerasus* var. *Juliana,* and Augustin Pyramus De Candolie changed the name to C. *Juliana.* In 1805, Heinrich Gottlieb Ludwig Reichenbach, a botanist, introduced P. *Juliana,* and L.H. Bailey returned it to botanical variety status as P. *avium* var. *Juliana.* In 1805, Augustin Pyramus De Candolle also distinguished the Bigarreau cherries and named them C. *duracina.* In 1807, Christian Hendrick Persoon, a German botanist, termed the sweet cherry P. *silvestris,* and in 1812, Nicolaus Thomas Host, a German botanist, designated it C. *intermedia.* In 1927, Robert Sweet, an English botanist, called it C. *macrophylla,* and in 1832, Heinrich Gottlieb Ludwig Reichenbach introduced the name *P. dulcis.* In 1840, Ernst Gottlieb Steudel used the name C. *dulcis.* In 1847, M.J. Roemer designated C. *bigarella* and C. *padilla,* and in 1869, Karl Koch described three horticultural variants: C. *heteropylla,* C. *asplenifolia,* and C. *salicifolia.*

B. Classification of Sour Cherries

The sour cherry, *Prunus cerasus,* was named by Linnaeus in 1753. He thought that the two common groups of sour cherries, those with colorless juice and those with colored juice, were sufficiently different to be botanical varieties and designated them *Prunus cerasus caproniana* and *Prunus cerasus austera,* respectively. Other botanists started to change the name of sour cherry soon after Linneaus classified it. The botanical designation of sour cherries, similarly to sweet cherries, expressed the *Prunus/Cerasus* point of views. Added to the confusion was that, although various types of sour cherries exist, they may or may not deserve to have species status in the opinion of the classifier.

Among sour cherries the commonly recognized types are as follows:

1. Trees are moderate to small in stature, with hanging branches. They develop many suckers, fruit is acidic, with highly colored, staining juice. They are often designated as *aeida, frutescens,* or *collina.*
2. Trees are larger, fruit is light colored, juice is relatively light colored or colorless and nonstaining. They are called the *Amarelles,* from the Latin word for bitter. The English call them Kentish cherries, and the French call them *Ceriser Commun.* They are also designated as *vulgaris, cerasus,* or *caproniana.*
3. Tree is relatively large, fruits are relatively sweet and located on long slender peduncules, juice is dark red. They are the *Morellos* or the *Griottes* of the French. *Morello* means blackish in Italian and *Griotte* is probably derived from *agriotte,* from *aigre,* meaning sharp, in reference to the acidity of the cherries (Hedrick 1915). This type is often designated as *morello, austera,* or *austeza.*
4. Trees are small, branching is upright, fruits are high quality, bitterish, and located on short peduncules. Designated as *marasca. Marasca* is a derivative of amaro or the Latin amarus, meaning bitter.

It is not surprising, that with such variation in fruit, botanical classifiers used many combinations of names. After the original designation by Linnaeus in 1753 as *Prunus cerasus,* the name changed in almost every possible way. In 1768, Phillip Miller, an English botanist, called the sour cherry types *Cerasus vulgaris* and C. *hortenses.* In 1790, Friedrich Erhardt, a German botanist, named them *P. aeida* and *P. austera.* In 1796, Richard Anthony Salisbury, an English botanist, called the sour cherry *P. aestiva* and in the same year Moritz Balthasar Borkhausen, a German botanist, named them *C. acida* and C. *austera.* In 1804, Jean Louis Marie Poiret, a French botanist, used the names *P. plena* and *P.*

rosea. In 1805, Augustin Pyramus De Candolle termed the sour cherry *C. caproniana.* In 1827, Barthelemy Charles Dumortier, a Belgian botanist, used the name C. *bigarella,* and in 1831, Nicolaus Thomas Host, a German botanist, designated two sour cherries, C. *effusa* and C. *Marasca.* In 1832, Heinrich Gottlieb Ludwig Reichenbach introduced the name P. *marasca.* In 1843, Bechstein called the sour cherry *P. oxycarpa,* Wilhelm Gerhard Walpers named it C. *bungei* and in 1847, M. J. Roemer, a Swiss botanist, used the two names C. *heaumiana* and C. *tridentia.* In 1866, Philipp Johann Ferdinand Schur, a German botanist, named it *P. vulgaris* and in 1868, Louis Van Houtte used the name *C. rhexii.* In 1869, Karl Koch, a German botanist, designated it as *C. cucullata.*

Hybrids of *P. avium* × *P. cerasus,* called Duke cherries, are classified as *C. regalis* Poit & Turp. 1. H. Bailey (1927) believed the Duke cherry to be a botanical variety and classified it as *P. avium* var. *regalis* Bailey. The name was changed by Rehder to *Prunus* × *gondouinni* Rehd. Duke cherries are tetraploids and presumed to arise from pollination of sour cherry by an unreduced *(2n)* gamete of sweet cherry (Iezzoni et al. 1992). Although there is great variation among Duke cherries, they resemble the sweet cherry in appearance but have a tart flavor inherited from sour cherry. Sterility is commonly associated with the hybrid nature of these cherries. There are dark-colored Dukes with red juice and light-colored Dukes with colorless juice.

C. Classification of Ornamental Cherries

The ornamental Japanese cherries represent a separate group and are mostly natives of Eastern Asia. The basic species of Japanese cherries, *P. serrulata,* was classified by John Lindley (1799-1865), an English botanist. Weitch in 1906 and Koehne in 1909 attempted to clarify the classification of Japanese cherries. Hedrick (1915) listed the partial classification of Koehne, giving 61 names that can be regarded as synonyms or variants under *P. serrulata. P. serrulata* was also called *C. serrulata* by Elie Abel Carriere (1816-1896), *P. mutabilis* by Miyoshi, and by many horticulturists as a partially described species *P. pseudocerasus* Hort. Koidzumi in 1913, Miyoshi, and separately Wilson in 1916 and Miyoshi again in 1921 attempted to clarify the nomenclature of this difficult-to-classify group of cherries. L.H. Bailey (1927) included many previously described species as botanical varieties in P. *serrulata,* viz. var. *spontanea,* Wilson, with several forms that include f. *Shidare-Sakura* Koehne, f. *humilis,* Wilson, f. *Kosioyama,* Wilson, and f. *praecox,* Wilson. He abolished a number of species, *P. tenuiflora, P. Levelliana, P. mesadenia, P. Veitchii, P. verecunda,* and *P. quelpaertensis,* and included them in *P. serrulata* as var. *pubescent.* Earnest H. Wilson, a collector of oriental plants, also recognized several forms of the botanical variety *pubescence:* f. *sancta,* f. *Shibayama,* and f. *Taizanfunkun.* Bailey also accepted the determination of Makimo that *P. sachaliensis,* previously named P. *pseudocerasus* var. *sachaliensis,* Schmidt, *P. sachaliensis,* Koidz., *P. Sargentii,* Rhed., and *P. floribunda,* Koehne, should be a botanical variety within the species of *P. serrulata.* There were further classification attempts, in 1934 by Russel, in 1948 by Ingram, in 1950 by Hara, in 1961 by Sano, in 1963 by Makino, in 1973 by Ohwi and Ohta, in 1974 by Honda and

Hayaski, and in 1976 by Gashu, who undertook the placement of various cultivars into the right species. For these classifications see Jefferson and Wain (1984).

There are other basic species of Japanese cherries into which cultivars can be classified, which confuses the situation even further. One such species is P. *lannesiana* Wilson. This species also was named *C. lannesiana* by Elie Abel Carriere, *P. serrulata lannesiana* by Koehne, *P. pseudocerasus* var. *hortensis* by Karl Johann Maximovitz (1827-1891) and *P. donarium* by Philipp. Franz von Siebold (1796-1866). There are many forms in *P. lannesiana* listed by Wilson similar to those found in other species. *P. sieboldii* is another species of Japanese cherry originally described by Max Karl Ludwig Wittmack, editor of Gartenflora and a professor at Berlin. This species also was described as C. *sieboldii,* by Elie Abel Carriere and as *P. pseudocerasus* var. *sieboldii* by Karl Johann Maximovitz.

Jefferson and Wain (1984) recognized a serious nomenclature problem among the Japanese cherries. They realized that the taxonomic assignment of cultivars to wild Japanese species is inappropriate. Several of the Japanese cherries are indigenous to Japan or escaped from early cultivation. Many of the cherries that escaped from cultivation in Japan are the progenies or hybrids of species planted in mountainous areas for the horticultural interest of "cherry viewing" that started around 800. The earliest references on "cherry viewing" date back to 720 (Jefferson and Wain 1984). Japanese horticulturists selected ornamental mutations and perhaps hybridized desirable trees to improve their ornamental values. Between 1600 and 1867, Japanese gardeners selected many variants from the "wild" with ornamental merit. Mizuno in 1681 and 1716 in *Kadan Komuko* listed 40 cultivars, many of which are still in existence today (Jefferson and Wain 1984). Honda and Hayashi (1974) went even further and placed the origin of at least 150 ornamental cultivars between 794 and 1192 when many cherry trees were planted in the gardens. The Japanese established two terms to differentiate among cherries: mountain cherries *(Yama-zakura)* and village cherries *(Sato-zakura).* Jefferson and Wain (1984) proposed that the Japanese ornamental cherries are obviously horticultural mixtures of species. They should not be assigned to anyone species, but handled as the "Sato-zakura group," signifying that these are cultivated ornamental cherries. Placing the flowering cherries in a group clearly sets them apart from all other botanical taxa of *Prunus.* They proposed that the designation for each form should be *Prunus (Sato-zakura* group) cv. Fugenzō, as an example.

III. THE NATIVE HOME OF SWEET AND SOUR CHERRIES

The earliest description of the "cherry" comes from Theophrastus in ca. 300 B.C. He described a large tree with round, red fruit. From this description De Candolle (1986) concluded that Theophrastus described the sweet cherry. The name Theophrastus used for the cherry was *kerasos.* The Greek *kerasia* may had originated from the name of the town Kerasun, Pantuso on the Black Sea (possibly Giresun, Turkey, today) and became the species name of *cerasus.*

(Pontus, a territory in the times of Alexander the Great, was located in what is presently north-eastern Turkey.) This implied that the cherry originated in Pontus. Hedrick (1915) expressed a contrary opinion and agreed with those botanists who stated that the town received its name from the cherries grown in the area rather than vice versa. Thus, the name Kerasun may have signified that high-quality cherries were grown in Pontus, and Lucullus, among others, obtained prized specimens from there. Another outstanding cultivar that originated from Pontus is the 'Black Tartarian' (described later) brought to Russia by Prince Potemkin.

The name of the cherry, in old English, *ciris, chiri* or *cyrs,* is cognate to the Old High German *chirsa* or *chersa.* The name stems from classical Latin or Greek and varies little among the different languages. The classical Latin words *cerasus* (cherry tree) and *cerasum* (cherry) correspond to the Greek *kerasea* (cherry tree) and *kerasiov* (cherry), respectively. In West Germanic it was *keresja, kerisja, kirisja,* or *kirissa,* in Middle High German *kirse* or *kerse,* and Modern German *kirsche.* In Latin it was transformed into *ceresia* and *ceresea,* which were also the progenitors of the Romanic forms *ciriega* in Old Italian, *cereza* in Spanish, *cereja* in Portugese, *cereisa* or *cereira* in Provencal, and *cerise* in French. *Chery* or *chiri* in Middle English was not known until the fourteenth century (Murray 1893).

A. Sweet Cherry

De Candolle (1886) observed cherry *(P. avium)* in the forest of Ghilan (north of Persia, south of the Caucasus) and in Armenia; in Europe in south Russia; and generally from south of Sweden to the mountainous parts of Greece, Italy, and Spain. He concluded that sweet cherry had originated in an area south of the Caucasian mountains and a secondary dissemination took place into Europe. The area where De Candolle placed the origin of the cherry escaped the Ice Age during the Quaternary period. Therefore, it is possible that a secondary migration of cherry took place to Europe. However, areas of northern Italy, the Balkan Peninsula, the Carpathian Basin, and most of France also escaped the Ice Age and cherry could have survived this period in parts of Europe as well. Therefore, there was no need for a secondary dissemination to explain the presence of cherry in this area. If a secondary migration took place it had to occur very early. For all practical purposes, Europe should be considered as native territory for modern horticulturists who are looking for native characteristics in cherries.

Discorides (first century A.D.) mentioned cherries as *kerasia,* a dietary component. His concerns were only medical and although his writings confirm that he knew about cherries, his records do not give any evidence for their origin. He wrote: "Cerasia, if they be taken while they are new, are good for the belly, but being dried they stop the belly," according to the English translator J. Goodyear in 1655 (Gunther 1934).

Terrentius Varro (117-27 B.C.) described when to graft cherries in a manner that conveyed the impression that cherries were common in Italy in his time. Nearly 150 years later, Pliny the Elder described the cherries of Rome in A.D.

79, including the cherry cultivar: 'Apronian', 'Lutatian', 'Caecilian', a duracinus cultivar known in Campania as 'Plinian', 'Junian', the 'Lusitanian' cherry, a cherry that grows on the banks of Rhenus (Rhein), and Macedonian cherry, which was a small tree, and a Chamaecerasus, which was a small shrub, both of which were probably sour cherries. Some of these cherries were named after Romans and in all likelihood originated in Italy. 'Apronius' was named after Apronius, a Roman magistrate, and 'Lutatian' was named after Lutatius Catulus, a contemporary of Lucullus, who rebuilt Rome after it was destroyed by fire. 'Caecilian' commemorates the Caecilian family, rich, powerful friends of Lucullus, and 'Plinian' was named, naturally, after Pliny himself. The description of 'Junian' fits characteristics of the French "Guigne" or the English "Gean" group. Hedrick (1915) proposed that "Guigne" may be a version of "Junian." As an ancient Lusitania in the modern Portugal, 'Lusitanian', in Hedrick's (1915) opinion, may have the cultivar 'Griotte' of Portugal which was grown from ancient times in that country. Pliny mentioned that 'Lusitanian' was highly valued in Belgica (Belgium). Thus, Pliny established that *Prunus avium*, the sweet cherry, was grown in his time in Italy, Portugal, Belgium, and along the Rhine.

Even though the sweet cherry was common in Europe and in southern Asia (Fig. 1) botanists suspected that cherry is not indigenous to Britain and Western Europe. That there is no Celtic or Teutonic native name for cherry seems to confirm this observation (Murray 1893)

Pliny the Elder stated that Lucullus, a Roman general stationed in Asia Minor, a territory that included Pontus, brought back cherries upon his retirement in 67 B.C. from the region of the Black Sea. De Candolle (1886) was of the opinion that Lucullus may have brought cherries to Italy, but cherries were native in Europe as well as in northwestern Asia and were cultivated in Italy before Lucullus. Thus, Pliny's description of Lucullus bringing cherries back from Asia Minor may signify that cherries were cultivated in those days in northern Persia, but Pliny's comments cannot be construed as a proof for the origin of cherries. Regardless of the origin of cherry, Pontus is a location where excellent cherry cultivars were originated. Therefore, it is not surprising that Lucullus, a connoisseur of fruit, brought back excellent cherries from Pontus. It is recorded from a later period, in al-Biruni's list of plants, that both sweet and sour cherries were present in northern Persia in 1050 (Harvey 1975).

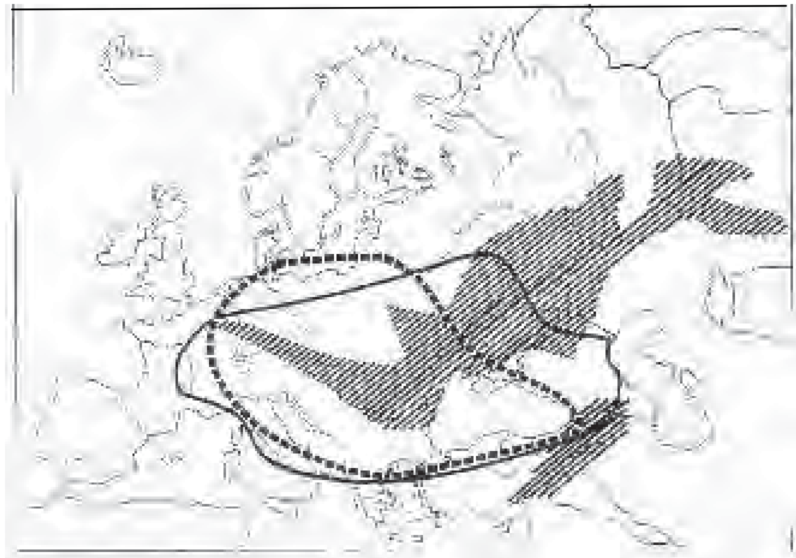

Fig. 1. Illustration of the native area of sweet cherry (striped area), sour cherry (solid line), and the ground cherry (broken line). (Illustration is redrawn after Terpo [1974]; sour cherry area and the area for *P. fruticosa* was added by Faust and Suranyi).

Sweet cherries were grown in southern Russia north of the Caucasian mountains. This is probable because the Hungarians learned the Russian name for cherries, *cberesbnia,* which became the Hungarian *cseresznye* during the period between 500 and 800 when the Hungarians passed through south Russia coming from the east. The name cseresznye (cherry) can be found in early deeds of Hungarian land grants beginning in 1256 when the earliest Hungarian language documents were produced (documents were previously written in Latin). The name of cherry can also be found in geographical descriptions in Hungary. *Cseresznyetó* (cherry lake), *cseresznyeszer* (cherry lodge) *cseresznyes* tetö (cherry mesa) all refer to various locations. Fekete *cseresznye* (black cherry) was mentioned in 1217, referring to the fruit itself (Suranyi 1992).

B. Sour Cherry

The Macedonian cherry and the Chamaecerasus, mentioned above in Pliny's description, were probably identical, and both were probably *Prunus fruticosa* Pallas, a synonym of *Prunus chamaecerasus* Jaquin. Nicolaus Joseph Jaquin (1727-1817), an Austrian botanist, kept the name *chamaecerasus,* perpetuating it because this name was used by Pliny (Hedrick 1915). The ground cherry, *P. fruticosa,* is native to Europe.

De Candolle (1886) described the native habitat of sour cherry as being from the Caspian Sea to the environs of Constantinople. He described sightings of sour cherries by botanists in the wild in Bithynia (area near Constantinople in Turkey on the Black Sea), at Mount Olympus, and on the plains of Macedonia. De Candolle (1886) also described *P. cerasus* as a wild tree from Italy and France. In Dalmatia, on the Adriatic coast of Croatia in the region of Zara (presently called Zadar), a liqueur, or cordial, called maraschino, has been made from small, black, sour, bitter, 'Marasca' cherries from prior to 1700. Even though this process is relatively recent, the sour cherries used for the process are unimproved and abundant in the region, indicating that they are likely to be native there. The so called Gypsy cherries are native in the Carpathian Basin. Hedrick (1915) assigned a much larger area than did De Candolle as the native habitat of sour cherry. Hedrick (1915) contemplated that sour cherry is native to an area bordered by Switzerland to the Adriatic Sea on the west, Germany on the north, and the Caspian Sea on the southeast.

Sour cherries were common in Italy in antiquity. Pliny the Younger described the "woods of ancient trees," surrounding his villa near Rome between 97-107, that were full with sweet chestnut, ash, poplar, linden, elm, and many suckering (certainly sour) cherries (Hobhouse 1992). De Candolle (1886) also quotes Virgil *(Publius Vergilius Mara* 70-19 B.C.), the great Roman poet, to say that cherries were in the woods of Italy. His comments apply to *P. cerasus* and not to *P. avium:* "Pullulat ab radice aliis densissima silva Vt cerasis ulmisque" (The most dense forest puts forth from root cherries and elms) (Virgil, *Georgics 2:17).*

As Hedrick (1915) stated, the development of sour cherry had to happen farther west or north from southern Russia. This can be substantiated by the location of land races. Land races usually develop in native areas of any given plant species. Land races can be characterized by specific descriptions under which many slightly differing clones can be grouped (Iezzoni et a1. 1992). Kolesnikova (1975) suggested that such land races of cherries developed in response to environmental factors in Asia and Europe. Such land races are Cigany (Gypsy, Zigeuner) and Pándy (Crisana, Karaser Wechsel), predominantly developed in Hungary; Oblacinska is a land race in Serbia; Mocanesti (Shepards's cherry) is a land race in Romania; Strauchweichseln, and Weinweichseln are land races in Germany; Stevensbaer a land race in Denmark; and Vladimirskaya is a land race in Moldavia. Thus land races indicate a large area as native sour cherry territory.

The development of Pándy as a land race is notable. It is a very high-quality sour cherry "discovered" around about 1848. In the beginning, some believed that it was a cultivar that originated along the river Körös (Hungarian name) or Crisana (Romanian name), which flows from the Carpathian Mountains of Romania to the Hungarian river Tisza. Hence its name Wechsel' in German and 'Crisana' in Romanian. "Pándy" is thought to be the Hungarian who first recognized the excellent quality of this sour cherry. Others suggest that a Turkish military officer brought it to Szentes, a city along the river Körös, as a gift (the Turks occupied Hungary between 1526 and 1680). Yet others believe that it was found in a garden in the village of Pando Today very few cherries are grown in but they are abundant in the surrounding area. There are other versions of its origin. The truth is that exactly where and when Pándy first was recognized for its excellence is unknown (Surányi 1985).

That sour cherry had to be native in the Carpathian Basin is indicated by the Hungarian word for sour cherry. The Hungarians did not learn the Russian name, *vishnya,* for sour cherries as they learned *cseresznye* for sweet cherries. The Hungarians use the word *meggy* for sour cherry, which is an original Finn-Ugor (the language family to which belongs the Hungarian language) word. There was no sour cherry in the original Asian home of Hungarians. Meggy originated from the word *mol,* a berry from a mountain plant, or from *ire-mol,* blood and berry. The word underwent transformations. The letter *I* became gy and the a or the more closely sounding e, transforming *mol* to *meggy.* Thus, the word usage "blood-berry" was transferred to a new fruit, the sour cherry, when the Hungarians found it in the Carpathian Basin (A magyar nyelv szótara 1967-1970). The Hungarians used the name "meggy" for locations with P. cerasus groves. Meggy, the sour cherry, was mentioned more often than cseresznye, the sweet cherry, among'the Hungarian location designations beginning in the thirteenth century when written records became more widespread. Names of locations listed since 1233 include *Meggyes, Meggyespatak, Meggyestelek, Meggyesmezo, Meggyeshalom, Meggyeskovácsi, Nyirmeggyes, Somogymeggyes, Zalameggyes,* and *Meggyespuszta,* and in an older spelling as *Medgyes, Medgyesbodzás,* and *Medgyesháza* (Surányi 1992). In the location combination names, the suffix refers to creek, patch, heath, or knoll, or in "Medgyesbodzás," an area where sour cherry ("meggy") and elder ("bodza") were common, indicating that sour cherries were abundant and probably native in that particular area. The large number of locations with sour cherry in their name also may indicate that sour cherries were widespread, and likely to be native in the Carpathian Basin. De Candolle (1886) justified his idea of secondary dissemination of the cherry with the argument that the Albanians, descendants of the Pelasgians (very early inhabitants of ancient Greece), called the sour cherry *vyssine,* an ancient name that reappears in the German *Weichsel* and the Italian *visciolo.* He estimates the use of the name"*vyssine"* before 600 B.C. It is notable that the Russian word for sour cherries is *vishnya.* Therefore, if the original word for sour cherries was vyssine and the Russians learned it later, then the development of the sour cherry must be clearly further to the north and the west than the Caucasian Mountains. This also easily explains why the Hungarians did not learn the Russian term for sour cherries and eventually used their old original term when they found sour cherries in the Carpathian Basin.

De Candolle (1886) considered the two cultivated cherries to be distinct species, but close in their characteristics. He stated that sour cherry is derived from sweet cherry. Later workers considered another species, *P. fruticosa* Pall. *(2n* =32), the ground cherry, as a probable parent of *P. cerasus* (Fogle 1975). Crosses in Sweden between *P. fruticosa* and either of the diploid or tetraploid sweet cherries *(P. avium)* have given progenies resembling sour cherries (Olden and Nybom 1968). Close examination of morphological traits strengthened the conclusion that *P. fruticosa* may be involved in the development of sour cherry. Families of hardy Russian cultivars show greater resemblance to the ground cherry than do families of less hardy cultivars (Hillig and Iezzoni 1988), and chloroplast DNA polymorphism studies suggest that the ground cherry is the maternal parent of sour cherry (Iezzoni et al. 1989).

Watkins (1976) used the argument that cherries, particularly the tetraploid sour cherry, reproduce fairly true from seed as a proof that the species belonging to *Eurocerasus* developed in isolation from species of subsection *Pseudocerasus*. They developed to the west of the central Asian center of origin while most other *Prunus* species developed to the east and this may account for the differences between the fruit-producing and the ornamental species. He does not distinguish between sweet and sour cherries.

Terpo (1974), a Hungarian botanist specializing in fruit-producing plants, designated a native area for sweet cherries from mid-France to the Volga River and from Germany to southern Italy and Greece (Fig. 1). He designated a much narrower area for P. *fruticosa,* from the Danube River to northeastern Russia ([Fig.1), which is a further indication of the northern origin of sour cherry. If the sour cherry is a hybrid between the ground cherry and sweet cherry then the hybridization should have occurred where the territory of the two species were common (Fig. 5.1). However, *P. fruticosa* may occur further south than Terpo contemplated it. One of us (D.S.) found *P. fruticosa* in two collecting trips made in 1970 and 1988 in Turkey and south of the Caucasian Mountains (Fig. 2).

Fig. 2. Locations of P. *avium* (stars) and *P. fruticosa* (dots) in Turkey where Surányi collected cherries in 1970 and 1988.

IV. EARLY RECORDS OF CHERRY CULTIVARS

A. Archeological Findings

Archeological evidence places cherry into the Neolithic Period [about 4,000-5,000 years ago). De Candolle (1886) described P. *avium* seeds found in Stone Age caves or dwellings of western Switzerland, Bourget, France, and Parma, Italy. Three stones of 7 mm in diameter were uncovered at Kempen an

Niederrheinen (Bertsch and Kand 1949). Two broken stones were also uncovered from the burned layer at Stimeg-Mogyorósdomb in Hungary from the same period (Hartyanyi et a1. 1968; Dombay 1960). According to Hartyányi and Nováki (1975) the domestication of cherry in the Danube Valley clearly dates to the late Neolithic Period (4000 years ago). Neolithic cherry seeds were unearthed in Kempen (lower Rhine Valley) and in Stuttgart (Renfrew 1973). There is also evidence from this period of the presence of sour cherry in England at Nympsfield (Roach 1985). Late Iron Age remains of P. *avium* were unearthed at Maiden Castle in Dorset, England (Roach 1985).

From the early Bronze Age (3500 years ago in Europe), important information was obtained for the presence of cherry at the Austrian Mondsee (Werneck 1955), at the Swiss Pfaffkerse-Robenhausen digs (Heer, cited by Ermenyi [1978]), and at Haugh Head, England (Roach 1985).

Seeds of cultivated cherries were found from pre-Lucullus times in Switzerland in Basel, Aalen, and Xanten. The seeds were 8 to 9 mm long (Renfrew 1973). Cherry stones from the early Roman period (400 B.C.) were found in Tac-Gorsium (Pannonia, the present day Hungary). At the same location mahaleb seeds also were discovered (Kocztur, cited by Ermenyi [1978]). Cherry seeds were found from the late Roman period at Nussdorf, Penzerdorf, and Linz, Austria (Werneck 1955). These seeds match the seeds of the local cherry land race (Werneck 1956). Archeological excavations in Germany along the Rhine revealed that the Romans used cherries in their diet and that they collected them in neighboring forests (Knörzer 1970a). One seed was found at Xanten-Colonia Ulpia (along the Rhine) dating to the first century (Knörzer 1967); four intact and 11 broken seeds were unearthed at Aachen from the same period (Knörzer 1967), and at Neuss the excavation of an ancient camp of Roman legionaries provided 64 burned seeds (Knörzer 1970). Excavated Roman wells also provided cherry seeds at Irel, Saalburg (Roach 1985), Rottweilben and Butzbach, Germany (Schroeder 1971; Knörzer 1970b). Figure 3, a mosaic found in the region, shows one of the earliest illustrations of cherries.

Roman soldiers who manned the fort at Caerws in Wales ate cherries and blackberries. Cherry stones were excavated at Silchester, Seley, West Witterring, and also from the waterlogged sites near the Thames in London (Roach 1985). Stones from these sites resemble the stones of the modern cultivated sour cherry. Excavation of a second century site under St. Thomas Street, in Southwark, England, revealed the remains of fruits, including cherries (Roach 1985).

Archeological finds of cherry seeds from the Middle Ages are more numerous. Evidence of cherry use in the Czech Republic from the seven to tenth centuries is provided by cherry and sour cherry seeds found in fireplaces, waste pits, and grave fillings. At Mikulcic parts of two cherry trees were also found (Opravil 1972). In the city of Uhersky Brod, during the archeological excavations of 1962, 2497 sweet and sour cherry seeds were discovered (Opravil 1966); in Opava 962 sweet and sour cherry seeds were found (Opravil 1964, 1965, 1969), and in Ostrova, Olomuec, and Pilsen, 51, 183, and 291 cherry seeds, respectively, were found in archeological excavations, indicating a considerable production of cherries in the area during the turn of the first millennium (Opravil 1964; Tempir 1962; Burian and Opravil1970).

The German evidence provides a similar picture. At Haus-Meer-Niederungsburg during the excavation of a tenth-to eleventh-century castle among various seeds of fruits were 1148 cherry seeds (Janssen and Knörzer 1970), and in an excavation dating to the same period in Neuss 1012, burned cherry seeds were discovered (Knörzer 1970a).

The Polish archeological evidence for the presence of cherries is from a somewhat later period. Cherry seeds from the tenth to the twelfth century were found at Opole and Wolin (Moldenhawer 1955). Cherry seeds from the twelfth to the fifteenth century were discovered in several Polish cities. At Posnan there were 54 cherry seeds and at Plock, 11 sweet and 24 sour cherry seeds, were found (Moldenhaver 1955). At Gdansk were 824 cherry seeds were unearthed and at Szczecin, 130 (Lechnicki 1955).

Fig. 3. Early illustration of cherries. Detail of a floor mosaic from the dining room of a Roman villa built in Cologne, Germany, in the first century. The mosaic was more likely installed during renovations carried out around 230. Chronological analysis is from G. Hellenkemper Salies in the *Bonner Jahrbuch* 184, 1984, p. 76.

From two wells at Budapest, Disz Square nos. 8 and 10, 66 cherry and 100 sour cherry seeds were discovered and 3 seeds were found in a clay pot at Hunyadi street 22 (Hartyányi and Nováki 1975). Confirmed wild cherry seeds from the thirteenth to the fourteenth century were unearthed from the fort of Kereki-Feherkti, Hungary (Hartyányi et al. 1968).

It is notable that relatively few seeds of cultivated cherries were found in Poland, Litvania, and Latvia, and from the southern edges of Europe. It is possible that the first improvement of cherries occurred in middle Europe during the Neolithic period.

B. Period Before the Sixteenth Century

The references to cherry by Theophrastus and Terrentius Varro have been mentioned in Section III. Hedrick (1915) quotes references to cherry by third- and fourth-century writers Athenaeus, Ammianus, Tertullian, and St. Jerome. Cherries were in cultivation relatively early in Spain and in Italy. Ibn al-Awwam in his book *Kitab ab-filaha,* mentioned that *P. mahaleb* was used as the rootstock described in the eleventh through the thirteenth centuries Spanish-Arabic documents (Hobhouse 1992). In England, the cherry was regularly grown in the gardens and orchards of the monasteries. At Norwich, beside the appleyard there was a *cherruzerd* or orto cersor, the cherry garden. At Ely, the records of sale for 1302 show that cherry trees were grown in the vineyard area (Roach 1985).

The 1295-1296 accounts for the Holborn gardens of Henry de Lacy, Earl of Lincoln, included an item for cherries, and cherries were commonly sold near the St. Paul churchyard. The churchyard had been the subject of much dispute in 1355, and cherries were specifically mentioned in the records of this incident (Roach 1985).

In Italy, Giovanni Boccaccio (1313-1375) mentioned cherries planted in a Florentine terraced garden (Hobhouse 1992). Pierandrea Mattioli or Matthiolus (1501-1577), a Tuscan from Italy, in translating the work of Dioscorides listed the fruits of Italy and included cherries.

Pietro de Crescenzi (1478) in *Liber ruralium commodorum* recommended middle size gardens (Fig. 4) for those who could afford this size, and larger ones, 4.8 ha including orchards, for wealthier people. He also recommended that trees should be planted in their rows spaced 6.5 m apart and include pears, apples, mulberries, cherries, plums, and such noble trees as figs, nuts, almonds, and quinces (Hobhouse 1992).

The German herbal, *German Herbarius,* printed in Mainz in 1485, does not name cultivars but groups cherries into two groups, sweets and sours, commenting that the sours make the mouth fresh *(frisch).* A woodcut in this herbal illustrates the sour cherry. Apparently the Germans until 1569 refrained from giving names of the cultivars when describing them in a medical herbal (Hedrick 1915). Keeping with this tradition, in *Gart der Gesundheit* the cherries were divided into four groups: (1) the *Amarellen,* sour, dark red cherries with long stems; (2) the *Weichselkirschen,* red, probably sour cherries with white juice and short stems; (3) the *Süsskirchen,* red or black sweet cherries with long stems; and (4) additional undefined types distinguished by their shape and the province in which they were grown (Hedrick 1915). In 1526, in England, appeared *The Grete Herball,* which was the *Le Grant Herbier* or *Arbolayre* translated "out of ye Frensshe into Engllysshe" using the same medieval figures. The illustrations were very general, some of them were made to serve for two different plants. In the *Arbolayre,* the illustration for cherry served also for *Atropa belladonna,* while in *The Grete Herball* it represented the cherry and the *Potentilla tormentilla* (Blunt and Raphael 1994). From the illustration it is impossible to tell just what plant it should illustrate (Fig. 5). A herbal, De *Historia Stirpium,* written by Leonhart Fuchs, a medical doctor, and published by Isingrin of Basel, Switzerland, in 1542 and a year later in German translation entitled *New Kreuterbuch*, also illustrates cherries. In Fuch's work, flowers and green, semi-mature, and mature fruits are all painted on the same plate (Fig. 6).

Fig. 4. Cherry trees are tended in this late fifteenth century miniature. The miniature illustrates the translation of Crescenzi's work.

In England, cherry is described in the *New Herball* of William Turner (1510-1568), a physician, published in part in 1551 in London, the second part (together with the first) in Cologne in 1562, and the whole work in three parts in Cologne in 1568, and in the *Herball* of John Gerard published in 1597 and greatly improved by Johnson in 1633.

Fig. 5. Cherry, in the *Grete Herball:* this woodblock was used for more than one plant.

Gerard obtained information from Matthiolus and from Rembert Dodoens (1517-1585) who published *Cruydeboeck* in Antwerp in 1554, and also owed much to Fuchs. Although Gerard may have adapted some of his material from others, he compiled a system, especially concerning cherries, that gives a good insight of his own thinking. Hedrick (1915) carefully interpreted Gerard's classification of cherries and somewhat modernized his descriptions.

According to Gerard (1597), the ancient herbalists considered four kinds of cherries: (1) the great and wild; (2) those tame or of the garden; (3) those that had sour fruit; and (4) those that are called in Latin *Chamaecerasus* or the *dwarfe cherry tree.* Gerard described the English Cherry tree as a high, great tree with large leaves and round cherries hanging on long stems. He contrasted this with the Flanders cherry which "brings forth his fruit sooner and greater than the other" and called it *Cerasus praecox, Belgica.* Hedrick (1915) interpreted these descriptions to mean that the English Cherry was the wild cherry *(P. avium)* and the Belgian Cherry was an early-ripening type of *P. avium.* However, it is unclear whether wild cherries extended into England. It is more likely, perhaps, that cherries were carried to England by the Romans and, if Gerard's wild type was indeed widespread, it may have escaped from cultivation.

Gerard also described the Spanish Cherry as a large tree with white flowers and large, light-colored fruit that was also white inside, and the Gascoin Cherry as having great fruit with occasional strikes of purple color. Hedrick (1915) equated the Spanish Cherry with the Yellow Spanish type of the Bigarreaus, and the Gascoin Cherry with 'Bleeding Heart', a cultivar that Joan of Kent brought back to Enland when her husband was in Guienne and Gascony in France.

Fig. 6. Cherry, an illustration from Fuchs' De *Historia Stirpium (1542).*

Gerard also described two sour cherries-the Cluster Cherry and the Morello, which he called Morell Cherry. Gerald's description of cherries was quite extensive. He described ornamental double-flowering types and a dwarf cherry which in all likelihood belonged to *P. fruticosa.* He mentioned the 'Heart Cherry', which is probably one of the heart cherries, and the 'Luke Wardes' cherry, which is one of the oldest named sweet cherries known in England. He described the Agriot Cherry which Hedrick (1915) equated with Griotte Commune, a sort that was supposedly brought back from Syria by the crusaders and recorded in France as early as 1485. Parkinson's *Paradisi in sale paradisus terrestris,* published in 1629, described 33 cultivars. He described many of the same cultivars as did Gerard and included cultivars such as the 'Naples Cherry', the name of which may indicate that this cultivar was from Italy.

Cherries were planted in the garden at Versailles. The map of the *Le Jardin Potager* Du *Roy* a *Versailles* planted by La Quintinye (16261688) clearly identifies cherries in one block near to the royal entrance (Tukey 1964).

In addition to description and illustration in pomological and botanical books, cherries were the subject of various paintings. A group of five illuminated manuscripts, called *Tacuinum Sanitatis,* that originated in Italy in the late fourteenth and early fifteenth centuries were derived from Arab medical treatises. These are known as medieval health books and their text is illustrated with paintings. Plants depicted in these book have some medicinal values. A harvest of cherry tree is illustrated (Fig. 7). A cherry tree also plays an important role in a painting known as the *Garden* of *Paradise* by an unknown Rhenish artist made between 1410 and 1420 (Fig. 8). In this complex painting, St. Dorothy picks fruit from the Tree of Life depicted as a cherry tree (Hobhouse 1992).

One of the known artists of his time, Giuseppe Arcimboldo (15271593) of Italy painted portraits composed of fruits and other plants. In 1590, he completed *Vertumnus,* the portrait of Rudolf II (15521612), Holy Roman Emperor from 1576 to 1612. Arcimboldo used several cherries in this portrait (Fig. 9), heart cherries for the lower lips, a dark sour cherry for the left eye, and lighter colored cherries as ornaments in the hair (Pieyre de Mandiargues 1977).

Fig. 7. Cherry harvesting probably for medical purposes. Miniature from *Tacuinum Sanitatis.* an Italian medical book from the late fourteenth to early fifteenth century.

Joachim Benckelaer's painting *Women With Vegetables*, painted in 1573, depicts a basket of cherries (Fig. 10). A Dutch work, *Madonna* at a *Table With Child*, painted during the first half of the sixteenth century, has cherries on a fruit plate on the table. Andrea Montegral's fresco, painted between 1426 and 1459, has a garland of fruit containing cherries. And, finally, inlayed tables of the Italian Renaissance are decorated with cherries along with other flowers (Fig. 11) (Rossi 1979). Cherries also entered into the folklore. Cherries were depicted in Transylvania on easter eggs (Malonyai 1909), as single fruits (*P. avium* or *P. cerasus)* or in umbels, perhaps picturing P. *fruticosa* (Fig. 12).

Fig. 8. St. Dorothy picks cherries from the Tree of Life. Detail from *Garden* in Paradise by an unknown Rhenish painter, painted between 1410 and 1420.

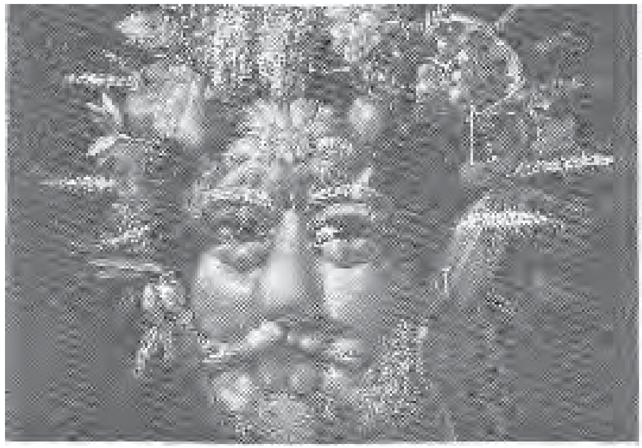

Fig. 9. Cherries as lips, eyes, and decoration in the hair. Detail from *Vertumnus* by G. Arcimboldo, a humorous portrait of Rudolph II. Holy Roman Emperor. Painted in 1590.

C. Period From 1600 to 1800

John Tradescant the Elder made a special trip to the Low Countries (Holland) in 1611 to collect new plants for the gardens being constructed at Hatfield where he was the head gardener for King Charles I of England. As the result of his trip he brought back a cherry that was named 'Tradescant's Black Heart Cherry' (Hobhouse 1992) or, as Parkinson termed it in 1629, John Tradescant Cherrie, also called 'Elkhorn' in the United States (Hedrick 1915). Thomas Skip Dyot Bucknell, a landowner in Sittingsbourne, Kent, who published the *The Orchardist,* carried out experiments in the 1740s in a 6-acre orchard planted with apples and cherries (Henrey 1975).

'Black Tartarian', a Russian cultivar, originated in Pontus and was brought to Russia by Prince Potemkin, the chevalier of Catherine the Great, in 1783 (Roach 1985). 'Black Tartarian' was introduced into England in 1794 and again in 1796. In 1796, 'Tartarian' was bought to England by the plant collector John Fraser of Sloan Square, Chelsea, who purchased it from a German who grew it in his garden in St. Petersburg (Roach 1985). It was introduced into America as 'Black Tartarian' by William Prince of Flushing, Long Island, during the early part of the nineteenth century. By the beginning of the twentieth century it became the favorite home-garden cherry east of the Mississippi (Hedrick 1915).

Fig. 10. Detail from the Joachim Beuckelaenis painting. *Woman With Vegetables.* painted in 1573.

Fig. 11. InIayed tables from Florence from the Renaissance period.

Fig. 12. Easter eggs from Transylvania from about 1900 (Malonyai 1909).
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Janos Lippai, the brother of Archbishop Lippai of Pozsony (Bratislava), and the gardener of the Archbishop's garden, described several cherry cultivars and growing techniques in 1667. He was aware of the high rate of flower production and the relatively low rate of fruit set among cherry cultivars. Self-incompatibility in cherry was not recognized until 250 years later.

Cultivars of cherries also were described in pomological terms in Italy beginning in the sixteenth century. A. Del Ricco in 1595 described'Aquaiole', 'Moscadelle', 'Duracine', 'Agriotte', 'Visciole con gambo lungo', Ciriegie a grappoli', 'Ciriegie visciole palobine con gambo corto', Ciriegie dette Turche', 'Ciriegie Amarenne o Marasche dette', 'Ciriege del Frate', 'Marchianne', 'Duracine Moraiole minute', 'Moraiole grosse', 'Ciriege San Giovanni', 'Ciriegie viscioline minutissime', and 'Ciriegie bianche'. It is obvious from this list that the Italians by this time were familiar with "duracine," the Bigarreautype cultivars as well as well as "bianche," or white cultivars in sweet cherries and also with sour cherries. Some cultivars had small fruit, others had large fruit (Basso 1982). This listing soon was followed by *Iconogia Plantarum* (Tomi X) of Aldrovani (1522-1605), painted by a team of artists, which depicts a great number of fruit trees of the sixteenth century, including six illustrations of cherries (Baldini 1990). Aldrovani's illustrations include pictures of *cerasa* and *ciriegie,* both meaning cherries (the current Italian word is *ciliegie).*

During the seventeenth and eighteenth centuries, the Medici family commissioned paintings of fruits, including cherries. The most important paintings in this series were painted by Bartolomeo Bimbi (1648-1724) who produced two 116 x 155-cm canvasses illustrating cherry cultivars. Basso (1982) identified 34 and 32 cultivars, respectively, in the two paintings and could identify all but 3 of 37 types. All types of cherries were represented, from very dark to bright red to almost white in color, similarly to those described about 100 years earlier by Del Ricco. Three additional Italian works are worthy of mention. One is the two-volume treatise written by P.A. Micheli (undated, c. 1700) in which he described some 25 cultivars cultivars (Basso 1982). The second is G. Gallesio's work, produced in 1817, that describes and illustrates 6 sweet and 8 sour cherry cultivars and describes a plum × cherry hybrid, 'Ciliego Susine', which may be the first description of this kind of fruit (Baldini and Tosi 1994). The third is by O. Targioni Tozetti in 1858, describing 16 types of cherry, including *Prunus mahaleb* and also a plum-cherry (Basso, 1982), which may or may not be the same as that described by Gallesio 41 years earlier.

Fig. 13. ‘Cerise de Hollande’, a cherry cultivar in H.L. Duhamel *Traite des Arbres fruitiers*, 1768. Volume 1, plate X.

Henry Louise Duhamel Du Monceau (1700-1782), a respected French horticulturist, included cherries (Fig. 13) in his multivolumed *Traité des Arbes*

Fruitiers (Raphael 1990). Prior to producing this book, Duhamel, in 1768, described a sour cherry, the first to be widely grown in Europe, which was known particularly among the French, as 'Montmorency a Longue Queue' or 'Cerise de Montmorency'. This cherry originated in the Montmorency Valley of France before the seventeenth century, probably as a seedling of 'Cerise Hative' or of 'Cerise Commune'. When 'Montmorency' arrived in America is not known, but it was grown much before William Prince spoke of it in 1832 (Hedrick 1915). It soon became very popular as a sour cherry and today is by far the most predominant sour cherry cultivar grown in North America.

Fig. 14. Illustration of cherries in Parkinson's Paradisi *in Sale* from 1629: 1, the May Cherry; 2, the Flanders Cherry; 3, the White Cherry; 4, the great leafed Cherry; 5, Luke Wards Cherry; 6, the Naples Cherry; 7, the Heart Cherry; 8, the bignarre or sported Cherry; 9, the wild cluster Cherry; 10, the Flanders cluster Cherry; 11, the Archduke Cherry; 12, the dwarfe Cherry. Illustration nos. 9 and 10 may be *P. padus* and no. 12 may be *P. fruticosa.*

In 1688 Ray described a new cherry, 'May Duke', which became well known worldwide. This is considered the first description of a Duke cherry, which turned out to be a hybrid between the sweet and sour cherries. The name 'May Duke' may be a corruption of Medoc, a district in Geronde, France, from where this cultivar was originated (Hedrick 1915). Nearly 60 years earlier, Parkinson (1629) described a cherry as "one of the fairest and best of cherries" named 'Archduke' (spelling of Parkinson) (Fig. 14). Thus the Duke name was mentioned before Ray described 'May Duke'. 'Arch Duke' (spelling of Hedrick) was scarce for unknown reasons for about 150 years after its description. It was rediscovered in 1847 in the nurseries of Thomas Rivers (England), where it has been grown for nearly a century. Close examination of this cultivar revealed that it differed from 'May Duke' (Hedrick 1915). Several dukes were known in the seventeenth century that, in the opinion of Roach (1985), originated in England since they were known in France as 'Anglais'. This means that they represented the few cultivars that originated in Britain; most other cherries grown in Britain in the sixteenth and seventeenth centuries had imported from the Continent. This suggests that the Duke name may have a different origin than the transliteration of Medoc, as Hedrick proposed.

D. Cherries in America

Cherry growing started in America with the first settlers and became widespread throughout the land. In 1954, Marshall remarked that although cherries were less popular in the United States than in Europe, cherries in the early days were planted everywhere in the United States, around farm houses, in gardens, and along the roadside. However, even by the time Marshall commented on widespread cherry production, the rapid increase in the use of processed foods resulted in profound changes in the pattern of production as well as consumption of cherries. U.S. cherry production increased from 45,000 t in 1890 to 315,000 t in 1980, while the number of trees decreased (Childers 1983). This resulted in the concentration of the industry in a few districts most suitable for cherries and a large portion of the crop was processed. By 1993, 74% of the estimated 376,000 t of U.S. production was processed and utilized frozen, canned, or brined.

Sweet cherries were brought as seeds to New York by the early Dutch settlers. In 1641, George Fenwick of Saybrook, Connecticut, wrote to George Winthrop, the governor of Massachusetts Bay Colony, about the plentiful supply of cherries and peaches (Hobhouse 1992). Peter Stuyvesant, the last Dutch governor of New York, distributed cherries and other fruits up the Hudson Valley to homesteaders (Hedrick 1915). Sturtevant noted (Hedrick 1919) that cherry stones were among the seeds mentioned in 1629 to be distributed by the Massachusetts Company, and cherries were planted at Yonkers, New York, in about 1650 and in Rhode Island in 1669. Cherries also were cultivated in Virginia and Maryland about the same time. In the 1700s, the French planted cherries in Nova Scotia, Prince Edward Island, and in early settlements along the St. Lawrance River (Iezzoni et al. 1992). About 20 cultivars were advertised by the Prince Nursery in 1767. Marshall (1954) interpreted this advertisement as to suggest that trees offered for sale prior to this time may have been propagated from seeds.

Cherries were planted by the colonists in Pennsylvania, New Jersey, Delaware, Virginia, and North Carolina (Marshall 1954). Even as early as 1676, cherries were reported to have been grown in "notable abundance" in Virginia (Hedrick 1915). As settlers moved westward so did the cherries. An important step in the westward movement was when Henderson Lewelling traveled from Iowa to Oregon in 1847 with 300 trees in tubs loaded on the wagons drawn by oxen (Marshall 1954). Among his cherry trees were a 'Bigarreau' and an 'English Morello'. The label of one of the trees was lost and it was renamed 'Royal Ann'. The cultivar was in reality 'Napoleon', and has been grown since 1820, but the name 'Royal Ann' persisted on the Pacific Coast (Marshall 1954). In 1850, Seth Lewelling (18191897) joined his brother Henderson in Milwaukee, Oregon, where Henderson had established a nursery under the name of Meek & Lewelling. Henderson Levelling moved to California in 1853 and the partnership with Meek was dissolved in 1857. As the sole proprietor of the nursery, Seth Lewelling started to develop new cultivars of cherries. In 1860 he introduced a dark cherry, the 'Republican', called by him 'Black Republican'. Five years later he introduced 'Lincoln'. In 1875 he originated two cultivars, both grown from the seeds of 'Republican', and named them 'Bing' and 'Yan' after two Chinese workmen working for him (Hedrick 1915). 'Bing', with a long, mahagony-colored fruit, has become the most important cherry cultivar of the United States.

A few small orchards were planted in California and plantings increased as more settlers arrived. The first order for named cultivars was placed by W. H. Nash and R. L. Kilburn of Calistoga, Napa County, to a New York nursery. The trees arrived after a long voyage around the Horn in the spring of 1850. The shipment included among other trees 'Napoleon' and 'Black Tartarian'. More cherry trees were available when Lewelling arrived from Oregon in the spring of 1851 and started to sell trees, including cherries (Olmo 1976). As the interest increased in cherry production, the search for new and better cultivars also expanded. 'Centennial', raised by Henry Chapman in Napa Valley, fruited first in 1876. The 'Oregon' was introduced by H. W. Prettyman of East Portland, Oregon, in 1888. 'Lambert' was introduced by J. H. Lambert, Milwaukee, Oregon, in 1887. 'Andrews' was fruited first in about 1896 by C. N. Andrews in a mountain valley near Redlands, California. 'Paul', found by E. V. D. Paul on a place purchased by him in Ukiah, California, was exhibited first in 1907. 'Nonpareil' originated in an orchard owned by the Earl Fruit Company at Vacaville and was not distributed. 'Early Burbank', originated by Luther Burbank, was sold in 1903 to a group of Vacaville growers and was valued for its earliness (Wickson 1914).

V. THE MODERN ERA, CHERRIES IN THE TWENTIETH CENTURY

After the turn of the century, the sweet cherry industry expanded even further, especially in the Pacific Coast states. Gardner (1913) noted that cherry production in Oregon was low because of insufficient pollination. Orchards had been small and planted with mixed cultivars. With the beginning of the cherry industry and larger plantings, fewer cultivars reduced cross pollination, causing poor fruit set. 'Napoleon' planted in solid blocks or interplanted with 'Bing' was unproductive. However, 'Napoleon' and 'Lambert' in combination gave satisfactory results. This was the beginning of the recognition of self-and cross-incompatibility in cherries, but it took almost another 20 years before horticulturists knew enough about the use of pollinizers, planting distances, and bee requirements to recommend orchard designs for the optimum pollination (Claypool et al. 1931). About 750,000 cherry trees were grown in Oregon in 1900. Tree number changed little until 1930 when the count was about 800,000. Cherry plantings increased after World War II. By 1950 the census recorded one million trees. Brining became a major use of Oregon cherries. Brining was established in the 1930s following research by professor E. H. Wiegand at Oregon State College and, by the 1970s, utilized half of Oregon's output (Zielinski 1976). Brining initiated the start of the maraschino cherry industry. Maraschino, or glace cherries, are bleached, cooked in colored syrup, and flavored by imitation maraschino flavor, for use in garnishing deserts or in cordials.

The cherry industry also expanded in California. The industry shifted to the Vaca Valley, then to Stockton and Lodi in the Central Valley east of San Francisco Bay (Olmo 1976). In 1911, about 5500 t of canned cherries were marketed, and in 1912, 244 carloads of fresh cherries were shipped to the eastern markets (Wickson 1927). Sweet cherry planting steadily increased in California, reaching 6000 ha by 1970 (Olmo 1976).

In Washington, early plantings of both sweet and sour cherries were mainly in the west coast counties where the climate was favorable for tree growth. As time progressed, more sweet cherries were planted in the dry regions of the state, while sour cherries remained west of the Cascades. From 1920 to 1930, sour cherry planting doubled and planting peaked in 1940. Since then, sour cherry production decreased gradually (Luce 1976) and presently it is a minor crop in Washington State. Sweet cherries were planted first in the western counties around farm houses and roadways. From 1920 on, larger blocks of cherries were planted in the central counties, where fruit splitting caused by rains was less frequent. Planting of sweet cherries steadily increased and in 1960 it was the third most important fruit crop in Washington State after apples and pears. Sweet cherry production steadily increased, and in 1993 Washington was the largest producing state in the United States.

In Wisconsin, the early success of orchards in Door County encouraged planting of sour cherries. In 1910 a single order of 41,000 cherry trees was placed for the spring of 1911. By 1950 there were over 1 million cherry trees in Door county. Economic considerations and yield variability reduced the size of the cherry industry so that in 1973 there only 1600 ha of productive cherry trees in the county (Klingbeil 1976). A sweet cherry industry developed in Montana around 1920. Metcalf (1976) estimated that about 1000 ha of sweet cherries were grown in Lake and Flathead counties. In 1910, cherry trees were numerous in Utah and their number slightly increased until 1964 when 1300 and 420 ha were planted with sweet cherries and sour cherries, respectively (Stark 1976). Sour cherry plantings increased even further and today Utah is one of the leading sour cherry producing states. New York is not a large producer of sweet cherries, but apparently New Yorkers like cherry ice cream. A large percentage of the New York sweet cherry crop (85%) was used in ice cream mixes in the 1960s (Slate 1976).

For more than 70 years Michigan has led the country in the production of "red tart" sour cherries. In the mid-1800s farmers of Grand Traverse County relied on the potato as their primary cash crop, but every farm also had its orchard of mixed fruits, which often produced more cash (especially cherries) than did potatoes (Lupton 1964). A leading citizen and banker of Traverse City, Berney J. Morgan, foresaw the potential opportunities in cherry growing and planted 5 ha of sour cherries in the 1890s. Another cherry enthusiast, John Kroupa, planted the first orchard (4 hal on the Old Mission Peninsula while working for the Ridgewood Farms in 1893 (Kessler 1971), a location exceptionally favorable for sour cherries. The Old Mission Peninsula is a small tongue of land that averages 1.5 km (1 mile) in width but extends 35 km (22 miles) out into Grand Traverse Bay (Fig. 15).

Ace Johnson, the captain of the steamship J. *T. Westcott,* transported ore from Escanaba to Elk Rapids. Captain Johnson came across the bay to Old Mission to pick up apples or other fruits and take them to Escanaba (M.L. Hilt, undated). After a few years of transporting fruit, Captain Johnson purchased a farm and employed John Kroupa to plant another cherry orchard (3-4 hal in 1896. Eventually, John Kroupa established a cherry planting on his own farm and became one of the most knowledgeable cherry growers in the area. At the beginning of the twentieth century there were only a few growers growing cherries commercially in the Traverse City area. The sour cherry industry of Michigan developed to a commercial processing scale during the second decade of the twentieth century with the establishment of the first canning factory in 1912 owned by Birney J. Morgan, Perry Hannah, and C. J. Kneeland, and the invention of the Dunkley cherry pitter in 1917 (Kessler 1971). In 1922 the Grand Traverse Packing Company of Traverse City froze the first cherries at the point of production (M. L. Hilt, undated). The number of trees increased dramatically within a few years from less than 500,000 in 1911, to more than 1 million in 1920, and to 2 million by 1933.

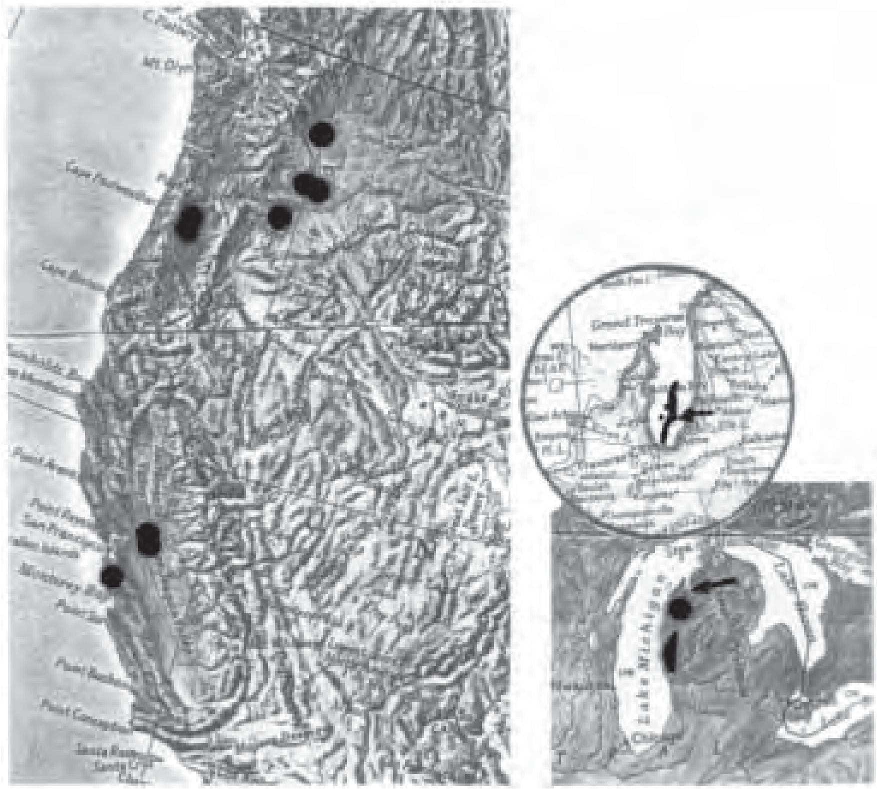

Fig. 15. Location of sweet cherry industry in California, Oregon, and Washington and the sour cherry industry in Michigan. Note that in California the cherry industry is located in the Santa Clara Valley near the coast where temperature is cool and in the Upper San Joaquim Valley where cool air gets into the valley through the opening through the mountains at San Francisco. The inset in Michigan shows the Old Mission Peninsula. Arrows indicate the location on the map and on the inset.

The size of the cherry industry increased further after World War II. By 1959 there were 3.5 million trees and by 1968 tree number reached the 4,350,000 mark. By 1926, Michigan produced 2200 t of frozen cherries, which increased to 2900 t in 1930 and 52,200 t in 1969 (Kessler 1971). In 1924 the "Blessing of the Blossoms", a one-day event, was conceived by Jay P. Smith, a newspaperman, which was converted to a Cherry Festival in 1926 and subsequently designated by the Michigan State Legistrature as the National Cherry Festival in 1928. The Michigan Association of Cherry Producers was organized in 1938 with A. J. Rogers, a grower and processor, as its first chairman.

An important step, especially in sour cherry production, was the development of mechanized harvesting. Experiments on adapting mechanical tree shaking to sour cherries in Michigan were initiated in 1956 by H. P. Gaston, a horticulturist of Michigan State College, and Jordan Levin, a mechanical engineer of the U.S. Department of Agriculture. Mechanical harvesting was adapted rapidly. By 1966 approximately 50% of all sour cherries in the state were harvested with mechanical shakers (Kessler 1976) and by 1969 the number increased to 75% (Kessler 1971). All commercial sour cherries are now harvested mechanically. Another step forward in producing highquality, processed sour cherries was the improvement in fruit handling after machine harvesting. For example, cherry quality can be maintained if cherries are precooled in water-filled tanks attached to the harvesting machines and carried cooled to the pitting plants.

Table 1. Cherry production and utilization in the United States, 1992.

	Production (t)		
State	Sweet	Sour	Total
Michigan	18,000	122,500	140,500
Washington	97,000		97,000
Oregon	55,000	4,750	59,750
California	31,000		31,000
Utah	3,200	16,500	19,700
New York	1,100	15,500	16,600
Wisconsin		4,550	4,550
Pennsylvania	1,100	3,000	4,100
Idaho	1,200		1,200
Colorado		750	750
Montana	800		800
Total	208,400	167,550	375,950

Note. Utilization of sweet cherries: 95,420 t fresh, 33,500 t canned, 66, 080 t brined; sour cherries 4400 t fresh, 45,000 t canned, 107,000 t frozen. *Source. Agricultural Statistics (1993).*

The growth of the Michigan sweet cherry industry is more difficult to follow. The rapid development in canning stimulated sweet cherry planting. In 1929 there were 79,000 sweet cherry trees in Michigan. Tree numbers increased to 112,482 by 1931, to 196,000 by 1940, and to 1 million in 1968. In 1930, 48% of the trees were planted in northwestern, 31% in central-western, and 21% in southwestern Michigan. Between 1930 and 1960, the sweet cherry industry shifted north, with 72% of the trees located north of Manistee, 21% in the central-west and only 8% in the southwest (Kessler 1971). After brining started in the 1930s, a greater portion of the Michigan sweet cherry crop was brined and by 1969 the bulk of the cherry crop went to brining (Kessler 1971). The brine market accepts immature cherries, enabling the grower to harvest before fruit becomes full ripe and susceptible to cracking. Marketing of fresh Michigan sweet cherries started in the mid-1960s (Kessler 1971).

Throughout the modern production era beginning in the 1970s, cherry production became more concentrated in area as production increased (Table 1, Fig. 15). Four states presently produce 96% of the U.S. sweet cherry crop and three states produce 92% of the sour cherry crop, and even in these states cherries are concentrated in small geographical areas that are exceptionally favorable for production.

VI. CULTIVAR IMPROVEMENT

Conscientious improvement of cherry cultivars started in North America by Luther Burbank about 1900. Breeding of sweet cherries started at the New York Agricultural Experimental Station, Geneva, New York, in 1911 by R. Wellington and was continued by R. D. Way, R. C. Lamb, S. K. Brown, and R. Andersen; at the Horticultural Experimental Station, Vineland, Ontario, Canada, in 1915 by G. H. Dickson and continued by G. Tehrani; at the Research Station. Summerland, British Columbia, Canada, in 1924 by A. J. Mann and continued by K. O. Lapins and W. D. Lane; at the Idaho Agricultural Experimental Station in 1934 by L. Verner; at the California Agricultural Experimental Station, Davis, in 1935 by R. M. Brooks and continued by P. E. Hansche; and at the Irrigation Experimental Station of Washington State at Prosser in 1950 by H. Fogle. continued by T. Toyama. In Oregon, Q. B. Zielinski introduced two cherry cultivars, 'Corum' and 'Macmar', from chance seedlings, but did not initiate cherry breeding. Several cherry cultivars were introduced from the Utah Agricultural Experimental Station by B. N. Wadley and S. V. Thomson from 1970 to 1982. Several private breeders introduced sweet cherry cultivars in California: F. W. Anderson introduced 'Bing d'Andy' (Bingandy); Marvin Nies introduced 'Ruby' and 'Garnet'; Floyd Zaiger introduced 'Starkrimson' and 'Zaiwite-Sweet'; and in Michigan, the Hilltop Nursery introduced 'Cavalier'. The cultivars introduced by each of these programs and the name of the breeders are listed by Brown et al. (1996).

Sweet cherry breeding began in 1925 in England by M. B. Crane (Crane 1947) and continued by P. Methews in the 1960s; in Germany at the Max Planck Institute beginning in about 1955 by M. Zwintzscher, at the Fruit Research Station, Jork, starting in 1953 by E. L. Loewel (Zahn 1985), and at Naumburg starting in 1961 by H. Michatsch and continued by M. Fischer; in Switzerland, at Wadenswil, in 1960 by E. Schaer and continued by R. Theiler Hedtrich (1985); in the Chech Republic sweet cherry breeding started in 1972 by J. Blazek and continued by J. Blaikova; in Romania, at Bistrita, beginning in 1950 by I. Ivan and, at Pitesti in 1971 by V. Cociu (Cociu and Gozob 1985); in Bulgaria, at Kustendil, in 1953 (St. Georgiev 1985); in Bulgaria at Plovdiv in 1988 by A. Jivondov and P. Gercheva; in Italy, at Verona, in 1965 by G. Bargioni, and at Bologna and Rome, ionizing radiation was conducted to produce short internode dwarf cultivars beginning in 1963 (Sansavini and Lugli 1988).

Cultivars were introduced in Italy also from Piacenca in 1972, Florence in 1983, and Rome in 1983. At the Ukranian Institute of Irrigated Horticulture at Melitopol, cherry breeding probably started in the 1950s by Oratovskiy and at Kiev, also in the 1950s, by S. H. Duka. In Australia, at the New South Wales Research Station, breeding started in about 1925 and was continued by F. T. Bauman.

U. P. Hedrick (1915), with the assistance of G. H. Howe, O. M. Taylor, C. B. Tubingen, and R. Wellington, summarized the existing knowledge on cherries and described 1145 cultivars. Origins of most of these cultivars were unknown. Hedrick (1915) remarked that to his knowledge none of the cultivars described in his book, *The Cherries of New York,* had originated by mutations, indicating their genetic stability. He contrasted this with the ornamental cherries, several of which are double flowered, weeping or fastigiate in growth habit, or have abnormally colored foliage that originated as mutations. Mutations, however, do occur in cherry. Most of the introduction in sour cherries were clonal selections of the 'Montmorency' cultivar. At least 10 such strains were introduced between 1925 and 1956 (Fogle 1975). In Hungary, a large number of clonal selections were produced from 'Pàndy' and 'Cigàny' sour cherries by S. Brozik [Tomcsanyi 1979). In Italy and in Canada, ionizing radiation experiments that began in 1963 produced artificial mutations of sweet cherries with short internodes (Lapins 1971; Sansavini and Lugli 1988).

Sour cherry cultivar development was preceded by identification of synonomy. In 1921, George Howe of the New York Agricultural Experimental Station compared 'King', 'Stark', 'Monarch', 'Sweet', and 'Large' Montmorency strains and found them to be identical. V. R. Gardner in Michigan initiated a program for improving 'Montmorency' by finding more vigorous and productive strains in 1930s and collected these variants, mutants, or strains. A sour cherry breeding program was started in Michigan by R. Andersen in 1971 and continued by A. Iezzoni. Sour cherry improvement started at the University of Minnesota in 1933. Sour cherry breeding commenced in Hungary at Budapest in 1948 by P. Maliga, and was continued by S. Brozik and J. Apostol; in the Ukraine at Melitopol, probably in the mid 1950s; in Romania at Pitesti in 1972 (Cociu and Gozob 1985); in and Germany in 1965 by M. Zwintscher. Cultivars introduced by each program are listed by Brown et al. (1996). The German program concentrated on disease-resistant cultivars based mostly on 'Shattenmorelle' and Köröser. In Hungary, P. Maliga, S. Brozik, and J. Apostol succeeded in producing high-quality self-compatible cultivars that can replace the outstanding 'Pandy', which is self-incompatible. The Romanian program is based on their own land races and the Russian program released cold-tolerant cultivars that are hybrids of *P. fruticosa* × *P. cerasus.*

The American western *(P. bessey)* and eastern *(P. pumila)* sand cherries have been utilized in the improvement of fruits in the North Central and Great Plains States of the United States and the Prairie Provinces of Canada. Work with sand cherries started in the Dominion Experimental Station at Morden, Manitoba, in 1896. The South Dakota Agricultural Experimental Station named at least 6 cultivars, and for a while the North Dakota and Minnesota Experimental Stations and the United States Department of Agriculture at Mandan, North Dakota, and Cheyenne, Wyoming, used sand cherries in their research, but have not released selections. In 1895, N. E. Hansen of the South Dakota Experimental Station started to use sand cherries to produce cherry-plums. The prime motivation for this work was the cold and drought resistance of sand cherries, which the investigators tried to transmit into high fruit quality cultivars. These cultivars never became popular. Their introductions are listed by Fogle (1975).

The outstanding breeder, Paul Maliga of Hungary, was able to solve most problems needed to improve sour cherries. He and J. Apostol succeeded in developing very high-quality, productive cultivars adapted to central European conditions, which overcame the incompatibility problems, poor flesh color, and limited size characteristic of most sour cherry cultivars. The outstanding cultivars released included 'Meteor korai' 'Erdi nagygyümölcsii', 'Favorit', 'Erdi jubileum', 'Erdi bötermö', 'Korai pipacsmeggy', 'Maliga emleke', and 'Csengödi'.

VII. ROOTSTOCK IMPROVEMENT

The earliest cherry orchards were seedlings. When grafting started, *P. avium* (mazzard) was used as the rootstock, although *P. mahaleb* (mahaleb) was mentioned as rootstock for cherries in the eleventh-thirteenth centuries in Spanish-Arabic documents (Hobhouse 1992). Miller, in his *Gardener's Dictionary* (1754), described the Mahaleb Cherry as a cultivated specimen, but does not mention it as a rootstock (Hedrick 1915). In the eighteenth century the French started use 'St. Lucie', the perfumed cherry *(P. mahaleb),* because of its limited suckering (Duhamel 1768). Targioni Tozetti mentioned mahaleb in 1858 as a rootstock in Italy (Basso 1982). In North America, mazzard was used first as a rootstock and this changed in favor of mahaleb when Charles Downing (1802-1885) proposed the use of the mahaleb cherry as a superior rootstock in 1845. Soon after this, in 1851, Thomas also recommended it as a dwarfing stock for cherries (Hedrick 1915). Mahaleb came into general use after 1860, and by 1890 it almost entirely replaced mazzard. Eighty years later, rootstock trials in the 1970s indicated that mazzard was a better rootstock for cherries and the use of mazzard increased again.

There are many requirements for a good cherry rootstock. Rootstocks need to be adapted to the soil, relatively resistant to soil diseases, and have dwarfing characteristics especially for fresh market sweet cherries, which are harvested by hand. About 1930, N. H. Grubb exerted efforts to develop better clones of mazzard cherries at the East Malling Research Station, England. As a result, clone *F12/1* was introduced in 1933, and later 'Colt' aP. *avium* × P. *pseudocerasus* hybrid, was produced, and 'Charger', another mazzard rootstock was released (Tydeman and Garner 1966). Increased activity in developing cherry rootsocks was apparent in the 1970s. A series of *P. avium* × *P. mahaleb* rootstocks clones were selected from 30,000 open-pollinated seedlings of P. *mahaleb* by Lyle Brooks in Oregon (Stebbins et al. 1978). In 1979, Schimmelpfeng and Liebster reported P. *cerasus* 'Weihroot' selections for rootstock of cherries. 'Weihroot' is a wild Bavarian genotype of P. *cerasus* and the selections were dwarfing to an extent of 20-30%. In 1980, Webster reported the use in England of two sour cherries, 'Stockton Morello' and 'Kentish', as dwarfing rootstocks. In the 1980s, several other groups attempted to improve rootstocks for cherries in Belgium, France, Germany, Romania, and Russia. The Belgians used species hybrids for their rootstocks and produced 'Damil', 'Camil', 'Inmil', and other GM numbers (Trefois 1985). The French used the 'St Lucie' cherry as the basis of their program (Perry 1987; Lichou et al. 1990). The German program started in 1965 (Gruppe 1985) and useful rootstock hybrids were selected from the intercrossing of various species within the subgenus *Eucerasus: (P. avium, P. canescens, P. cerasus* 'Schattenmorelle', and *P.*

fruticosa). The German program introduced the various Gisela numbers [Schmidt and Gruppe 1988). In contrast, crosses with subgenus *Pseudocerasus* species *(P. concinna, P. incisa, P. nipponica,* P. *subhirtella,* and *P. pseudocerasus)* did not yield useful rootstocks [Schmidt 1985). In Romania dwarfing of sweet cherries was important (Cireasa and Surdu 1985). In Russia, at Oryol, the program focused on frost tolerance, using exotic parents such as *Padus maackii* (Kolesnikova et al. 1985). In the United States in a limited way 'Vladimir' was used as a rootstock. Vladimir is the generic name of a group of morello cherries originating in Russia and introduced to America in about 1900. Details of activities of each breeding group can be found in the descriptions by Perry (1987). Despite all the effort exerted thus far, the rootstock problem of cherries has not been solved. Breeders were successful in producing dwarfing rootstocks that decrease tree size 25-30% compared to a tree grown on *F12/1* root. The most dwarfing rootstocks are 'Damil', a P. *fruticosa* selection, a *P. fruticosa* × *P. avium* selection, and the *P. cerasus* 'Weihroot' selections (Perry 1987). Thus, size reduction in sweet cherries by rootstock should be attainable.

VIII. JAPANESE CHERRIES AND THEIR MOVEMENT INTO AMERICA

In Japan, the flowering cherry tree, Sakura, or zakura in Japanese, is one of the most exalted of all flowering plants. As early as the fifth century the Japanese Emperor and his Court paid homage to the Sakura. During the sixth century, the 26th Emperor of Japan, Keitai Tenno, who lived in Neo-mura (village of Neo), planted a cherry tree in commemoration of his reign. The tree is still alive today (Fig. 16) and is called 'Usuzumi-no-sakura', which means "cherry tree of gray blossoms." 'Usuzumi' belongs to the species P. *spachiana* f. *ascendens* based on traditional classification (White 1992). Reverence toward cherries in Japan has increased over the centuries. By 1800, a collection of approximately 1000 cherry trees containing nearly 80 different selections had been planted in Kyoto. The number of types increased to 130 by 1990. The earliest records of Japanese cherries being introduced into the United States are probably those listed in the 1846 and 1847 catalogs of Ellwanger and Barry Co. of Rochester, New York, and Parsons and Co. of Flushing, Long Island, New York. The introduction of a wild species of Japanese cherries into the United States probably did not occur until 1876 when William S. Clark, first President of the Agricultural College, Sapporo, Japan, sent home some seeds of *Prunus sargentii* Rehd., native to the mountains of northern Japan and southern Sakhalin (Jefferson and Fusonie 1977).

In 1903, through the efforts of David Fairchild and Barbour Lathrop, the Office of Foreign Plant Introduction of the Bureau of Plant Industry, U.S. Department of Agriculture, imported 30 named cultivars of cherry trees into the United States. David Fairchild who traveled to Japan in 1902 was impressed by the picturesque beauty of the Japanese cherry trees and in 1905 ordered 75 flowering cherry trees and 25 single-flowered weeping-type trees from Japan, which arrived in May 1906 and were planted on the Fairchild estate in Chevy

Chase. Subsequently, in 1907, the Chevy Chase Land Company ordered 300 trees to be planted in the community of Chevy Chase.

Fig. 16. 'Usuzuni-no-Sakura', a 1400-year-old ornamental cherry tree in Neo village, Japan, in 1992.

Publicity about the Japanese cherry trees caused the wife of President William Howard Taft to become interested in this beautification project. Through her efforts, Colonel Spencer Cosby, the Superintendent of Public Buildings and Grounds, ordered 90 double-flowering Japanese cherry trees *(P. serrulata* 'Fugenzo') from Hoopes Brothers and Thomas Co., West Chester, Pennsylvania, in April 1909, to be planted on public grounds. By June, the Washington newspapers carried stories of a possible donation of cherry trees by the Mayor of Tokyo to Mrs. Taft. In August 1909, the Japanese Embassy in Washington, DC, officially informed the Department of State that the city of Tokyo intended to donate 2000 cherry trees to the United States. The cherry trees were shipped and arrived on 10 December, 1909 at Seattle and were taken by train on 6 January, 1910 to Washington, DC. Then, they were immediately transported to the Department of Agriculture's Garden Storehouse on the Monument Grounds to be examined by scientists from the Bureau of Entomology and the Bureau of Plant Industry. The team found the large trees seriously infested with insects and diseases and ordered destroyed them (Jefferson and Fusoni 1977).

Mayor Yukio Ozaki of Tokyo heard of the destruction of the gift of trees and made steps to replace the shipment. Scions were collected from 12 selections from the Ekita-mura area (village of Ekita) along the banks of the Arakawa

River, and the scions were fumigated and grafted to selected rootstock. The following December the trees were dug, refumigated, and by the end of January 1912, 6000 Japanese cherry trees were shipped to the United States. Half of the trees were destined to Washington, DC, as a gift from the people of Tokyo and the rest to New York City as a gift from the Japanese Society of Tokyo. The trees arrived at Washington, DC, in mid-March and were found pest free. On 27 March, 1912, Mrs. Taft participated in a planting ceremony in West Potomac Park with the wife of the Japanese Ambassador, Viscountess Chinda. Eighteen trees of the greenish-yellow flowered P. *serrulata* Lindl. 'Gyokio' were planted on the White House grounds. The cherry tree became an important symbol in Washington, DC, and their bloom is commemorated with parades and an annual election of a cherry queen.

IX. WORLDWIDE DISSEMINATION AND PRODUCTION OF CHERRIES

Although sweet and sour cherries are ubiquitous in the temperate zone, there has been little effort to take them farther south into subtropical regions. Breeding programs to develop low-chilling-requiring cherries are very recent (W. B. Sherman, personal communication). Although there are low-chilling-requiring *Prunus species* among the cherry genotypes, the existing high quality cherry cultivars all have high-chilling requirements.

Cool conditions may be required for another reason. Commercial production of sweet cherries are limited by rain falling during the ripening period, which causes cracking of Bigarreau-type sweet cherries and the subsequent brown-rot infection destroys the usefulness of the fruit. Moderately wet and cool conditions of Europe limit the development of rotting organisms. In North America, sweet cherries are grown in arid irrigated areas where cracking is limited. In hot climates cherries develop double fruit, an undesirable characteristic, that limits production.

Sour cherries are not subject to cracking, nevertheless they are also better adapted to cool climates. In the North American Continent, 75% of sour cherries are grown in Michigan and the rest in New York and in Utah. Production in Europe is centered in the states of the former Soviet Union, Poland, Hungary, the Czech Republic, and Romania, all with relatively cool climates.

As early as 1667, Lippai commented in his book, *The Garden of Pozsony,* that both the sweet and sour cherries prefer a cool location. Why cherries prefer a relatively cool climate also puzzled Chandler (1957), who noted that the trees of common sour cherry cultivars have rather long chilling requirements. At low elevations in southern California, bloom of the trees is greatly delayed and very few fruit set. The southern limit of sour cherry growing in North America, however, is not fixed by lack of winter chilling. Chandler (1957) thought that some other influence fixes the limit further north than where chilling would be inadequate and considered the absolute limit in North America for sour cherry the 36° latitude. He noticed that sweet cherry developed good flavor in districts where the summers are cool and was much better in the cool coastal areas of

California than in the hot interior districts. Lupton (1964) thought that the reason Traverse City area of Michigan is superbly adapted for cherry production was due to the broad expanse of water around it. "In early spring, the Bay's cool temperature keeps the cherry buds closed and in late spring the warmth of the water keeps temperature stable for good flower bud formation and continued growth."

Others also have tried to explain the localization of cherry production. H.V. Taylor (1949) remarked that "the cherry is a notoriously difficult crop to grow; the tree is fastidious of soils, and the management has to be skillful otherwise disappointment follows. That may be the reason why the growers of Kent (England) have obtained almost a monopoly of production and why fruit growers of other counties are hesitant to take risk of engaging in cherry production". Despite Taylor's remarks, cherry production in Kent has steeply declined (Tobutt 1985).

Most of the world cherry production is in Europe, its native home. North America, where cherries developed a secondary center of production, still accounts for only 16% of world production (Table 2).

Table 2. Cherry production worldwide (sweet and sour combined).

Country	Production (1000 t)
"Native" area (Europe and Asia Minor)	
Former Soviet Union	470
Germany	312
Poland	185
Former Yugoslavia	179
Italy	160
Turkey	105
France	102
Hungary	98
Spain	76
Czech Rep. + Slovakia	65
Romania	65
Bulgaria	60
Portugal	45
Greece	29
Austria	28
Belgium	15
Adapted area (Americas, Asia, Oceania)	
USA	376
India	21
Canada	15
Japan	11
New Zealand	10
Australia	10
Chile	8
Argentina	5

Source: Westwood (1988), Agricultural Statistics (1993), J. Apostol (personal com• munication).

This is in great contrast to the peach, where production in adapted areas is overwhelmingly greater than that in China, where it originated (Faust and Timon 1995). While the peach moved from the Orient to Europe; the cherry has never made the reciprocal trip to China.

X. CONCLUSION

The history of the cherry is very uneven. For almost 2000 years, from 300 B.C. to 1700, the cherry was a mediocre fruit harvested from native material. Suddenly, around 1700 outstanding cultivars appeared on the scene. During the 200 years between the discovery of 'May Duke' in 1688 and the introduction of 'Bing' in 1875, many outstanding cultivars were selected, most of which are still outstanding today. After a century of relative quiescence, purposeful breeding activity started at several locations worldwide, which undoubtedly will produce new cultivars in the future.

In addition to its uneven development there are several paradoxes in cherries. Sweet cherry trees are very large and need to be reduced in size. There are dwarf types in sour cherries, but because they are harvested by machines, a reasonably large tree is required under which the harvester can be maneuvered. Thus, the desired dwarf genes are located in the wrong species and it is difficult to transmit the dwarf size by conventional techniques. Sour cherries are tetraploids (2n =32), sweet cherries are diploid (2n =16), although tetraploid sweet-cherry types occasionally occur. Thus, there is a possibility to intercross sour cherries with tetraploid cultivars carrying the dwarf character. We have yet to succeed in this effort and the goal of a small sweet cherry trees still eludes the industry. The effect of gibberellic-acid-synthesis inhibitors is dramatic in sweet cherries, but they have not been exploited to produce trees small in stature.

The paradoxes continue. The market prefers firm fruit in sweet cherries, but unfortunately they crack when rain occurs close to harvest. The soft-fruited heart cherries do not crack, but are undesired. Thus, we have a dilemma in solving the cracking problem. The strongly nonelastic cell wall of Bigarreau cherries provides the desired firmness, but does not allow elasticity of cells and the fruit cracks severely. The strongly nonelastic fixed cell wall creates more paradoxes. In most large fruit development, cells separate and the resulting intercellular spaces greatly enlarge fruit size by allowing air in the fruit. The strongly fixed nonelastic cell wall of cherry prevents this. Thus, even though large cherries are preferred, it is likely that the cherry will remain small.

There are other difficulties. Sour cherry harvesting has become totally mechanized. Trunk shakers clamp onto the tree at the time when the bark is fully hydrated and separates easily from the woody elements. Even the most gentle shaker moves this bark around and the tree suffers as a result. What loosens and tightens the bark? Nurserymen have known this phenomenon for ages and bud trees when the bark slips, yet horticulturists do not have the first clue to the physiology involved.

The ultimate paradox is that while both sweet and sour cherries are ancient fruits, we still know very little about them. Although cherry is a high-value crop, production is small compared to other agricultural commodities. Thus, the number of researchers working with sweet or sour cherries is small. Nevertheless, results are forthcoming and improvements are in the pipeline. We may have better rootstocks in the near future, cultivars will be more disease resistant, and self-compatibility and fruit quality of sour cherries will be improved. However, as our predecessors have discovered, it may be difficult to improve the quality of sweet cherries over the existing outstanding cultivars.

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Origin and Dissemination of A ricot

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I. INTRODUCTION

Apricot is considered by many to be one of the most delicious of temperate tree fruits. It has been appreciated and grown for thousands of years on the slopes of mountains in Asia and at least two thousand years in Europe. There are many uses of apricot (Davidson and Knox 1993). It is enjoyed as fresh fruit, but a large portion of the worldwide production is preserved primarily by drying. In China, from the 7th century, apricots were not only dried, but also preserved by salting and even smoking. The black smoked apricots of Hubei were famous. Apricot jam is an important ingredient for the confectioner. It is used as a sweet adhesive in cakes such as *Sachertorte* and in diluted form as a glaze that finishes many confections. In Middle Eastern cookery, apricots are used in sweetmeats, especially in dishes with lamb, such as the so-called *mishmishio.* Apricots are also pitted and stuffed with almonds or almond paste. In China, the most common apricot grown is thinfleshed-cultivars produced for their seeds. Apricot seeds give the character of the Italian "*amoretti di Saronno"* and the character of macaroons and biscuits. Dried apricots from Hunza are small but famous, because the Hunza people enjoy remarkable health and longevity and attribute both in part to this fruit. Turkey also produces the so-called apricot leather, dried apricot flesh in the form of thin sheets, which is melted down for its highly concentrated flavor. The flowers of the Japanese apricot, mume, are revered for their beauty and mume trees have been increasingly used as ornamentals in Japan since the Nara era (7th-8th century). The use of mume for medicinal purposes began in the 19th century with the making of a special pickle, *ume-boshi,* from the fruit, which is believed to be conductive to health. Recently, mume is being used as a drink, the *ume-shu,* and as juice (Yoshida 1994).

Although the apricot is a desirable fruit, apricot production is severely restricted by ecological conditions. Consequently, although apricots are widespread geographically, they have not become pomologically important except in areas where the required ecological conditions (uniformly cold winters, frostless spring, and hot summers) exist (Bailey and Hough 1975; Layne et al. 1996). Relatively few people have worked in apricot research compared with other deciduous fruit crops and few comprehensive reviews have been produced. Notable reviews include those of Kostina (1936), Löschnig and Passecker (1954), Forte (1971), Bailey and Hough (1975), Nyujtó and Surányi (1981), Baldini and Scaramuzzi (1982), Mehlenbacher et al. (1990), and Layne et al. (1996).

II. CLASSIFICATION

A. Botanical

Apricots occupy a place between plums and peaches. They are graftable onto peach and plum and can hybridize with both species. For more than 17 centuries apricots were considered a form of early peach. Crescentius (1518) described apricot as part of the peach group and not as a separate fruit. Hieronymus Bock (1595) in his *Krauterbuch* wrote about apricots as *gelben Sommerpfirsiche* (yellow summer-peaches), Turner (1551) called apricot a "hasty peche tre," and according to Löeschnig and Passecker (1954), Maaler, in 1561, referred to apricots as *"kleine, frühzeitige Pfersich"* (small, early peach). Bauchin (1560-1624) in his *Kr uterbuch,* published in 1687, well after his death, was the first to designate apricot as a separate fruit species. Tournefort (1700), court botanist to Louis XIV and creator of Latin names for almost 200 well known fruit cultivars, separated apricot from peach and classified it as a separate genus, naming it *Armeniaca.* Linnaeus (1737), even before establishing his binomial system, included apricot with cherries and plums in the genus *Prunus.* For apricot he used the name *Prunus fows ovato-cordatis,* but recognizing Tournefort's prior use of *Armeniaca,* listed *Malus armeniaca* and *Armeniaca malus* as synonyms. Today, we consider that apricots belong to the *Rosaceae,* subfamily *Prunoideae,* genus *Prunus* L., subgenus *Prunophora* (Neck.) Focke, section *Armeniaca* (Mill.) Koch (Rehder 1940). *Prunophora* (apricots and plums) is the subgenus in which leaves in the bud are rolled up, *convolute,* showing well as the leaves begin to emerge from the bud (Bailey 1927). In the apricot section, there were several species recognized in earlier classifications, but recent taxonomists reduced the number of species, indicating that the differences between some previously described species and *P. armeniaca* are insufficient to maintain their species status. Thus, Wilson, during his exploration in China in 1907-1909, found it impossible to separate species by the shape or pubescence of the leaves. Leaves were more densely pubescent in young plants of *P. sibirica, P. armeniaca* and *P. mume* than in older plants in which the pubescence more or less disappeared (Sargent 1988). Consequently, several former species have became classified as botanical varieties within *P. armeniaca* (Bailey 1927). Presently, recognized species in this group are: *P. armeniaca, P. mume, P. brigantica, P. dasycarpa,* and *P. holocericea.* The existence of *P. holocericea* is still questioned, and *P. brigantica* may belong to plums. The brief descriptions of these species are as follows:

1. P. armeniaca, L. [Syn. *Armeniaca vulgaris* Lam.; *P. armeniaca* var *typica* Maxim.; *P. tiliaefolia* Salisbury] is known as common apricot (Fig. 1). Small tree with reddish bark up to 10-15 m in height. It is drought resistant and if dormant it is winter hardy. Leaves are large, ovate or round-ovate, sometimes slightly cordate at base, abruptly pointed, glabrous, closely serrate, the petioles are stout and gland bearing. Flowers are white or pink, solitary, appearing from lateral buds of last year's shoot. They open before the leaves. Fruit are variable, somewhat flattened, mostly yellow or whitish, overlaid more or less with red. The fruit of wild specimens ranges from 3 to 20 g, cultivated selections produce fruit 40 to 50 g, and exceptionally large types have fruit up to 100 g. The stone is somewhat flattened and smooth, ridged and sulcate on the edge.

Throughout the years there was some controversy about types closely related to *P. armeniaca.* As indicated above, the differences appear to be limited or inconsistent for clear definition and Bailey (1927) reduced the number of species and retained the previously described species as botanical varieties.

P. armeniaca var. *sibirica* Koch; [Syn. *P. sibirca* L.; *Armeniaca sibirica,* Pers.; *Armeniaca sibirica* (L.) Lamark; *Armeniaca* var. *sibirica* Koch.; *Armeniaca davidiana* Carriere] is known as Siberian apricot (Fig. 2).

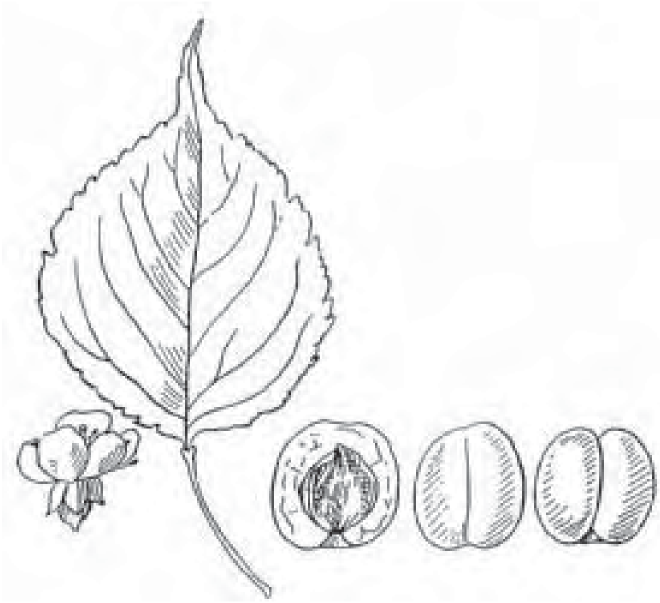

Fig. 1. *P. armeniaca*, wild specimen (from Löschnig and Passeker 1954).

Bush or small tree. Leaves are small and glaborous, sometimes sparingly' bearded beneath, ovate or rounded, long pointed, unequally crenateserrate. Flowers are white or pink, appearing early in the spring and usually in great profusion. Fruit is rarely more than 12 mm in diameter, yellow with a reddish cheek, practically inedible. Stone is smooth and very sharp edged.

P. armeniaca var. *mandshurica* Maxim. [Syn. *P. mandshurica* Koehne; *P. mandshurica* (Koehne) Skvortzoff; *Armeniaca* var. *mandshurica* Maxim.; *Armeniaca mandshurica* (Maxim.) Skvorzt.; *P. mandshurica* (Maxim.) Koehne] is known as Manchurian apricot (Fig. 3). Large tree, up to 20 m high. Shoots are smooth, green or light brown. Leaves are large, subcordate or cuneate at base, at apex long-cuspidate and acute, margin strongly double toothed, the serrations sharp and twice longer than wide. Flowers are large, white or pink, open before the leaves. Fruit nearly globular, about 25 mm long, yellow, red-spotted, succulent and sweet, stone small and smooth, the margin obtuse, the seed is sweet. The tree is very hardy. Its flowering period is extended, with the earliest flowers subject to spring frosts.

P. armeniaca var. *ansu* (Maxim.) Kost. [Syn. *P. ansu* (Maxim.) Komarov; *Armeniaca ansu* (Maxim.) Kost.; *P. armeniaca* var. *ansu* Maxim.] is known as Ansu apricot (Fig. 4). Tree is bush-like. Leaves are broadelliptic, at base short-cuneate, at apex acuminate, very glabrous, the margins crenate-serrate. Flowers are twin, pink, open very early. Fruit is subglobose, deeply umbilicate or sulcate, red, tomentose, the flesh is grayish brown and sweet and free from minutely reticulated stone which has only one sharp edge. Its wild form is not known. Cultivated in China, Japan, and Korea in areas where the winter is mild.

Fig. 2. *P. armeniaca* var. sibirica (Kostina 1936).

Fig. 3. *P. armeniaca* var. *mandshurica* (Kostina 1936).

2. *P. mume* Sieb. & Zucc. (Syn. *Armeniaca mume,* Sieb; *P. mume* var. *typica* Maxim.; *P. armeniaca* Thunb.). Japanese apricot (Fig. 5). Tree of dimensions of common apricot but the bark greenish or gray and the foliage is duller in color. Leaves are relatively small, narrow-ovate to nearly round-ovate, long-pointed, finely and sharply serrate, more or less scabrous, and lighter colored beneath. Flowers are sessile or nearly so and fragrant. Fruit is smaller than of *P. armeniaca,* yellow or greenish, the dry flesh adhering to the pitted stone.

Fig. 4. *P. armeniaca* var. *ansu* (Kostina 1936).

3. *P. brigantica* Vill. [Syn. *Armeniaca brigantica* (Vill.) Persoon; *P. Armeniaca* subsp. brigantica Dipp.] is known as alpine plum. Small thornless tree or shrub, with mostly small leaves and small smooth subacid fruit the size of small green-gage plum. Leaves are broad-oval or ovate, the blade 50-75 mm long, abruptly short and pointed, very sharply serrated, above glabrous or essentially so, beneath lighter colored. Flowers are light pink, they appear in clusters of 2-5, blooms after leafing. Flesh is white. The fruit is round, yellow and plum-like but scarcely edible. In France, the kernels were used to produce the *huille des marmottes,* an oil considered superior to olive oil (Downing 1862). It is native in Gallia (France) in a very small area on the south-western slopes of the Alps.
4. *P. dasycarpa Ehrh.* [Syn. *P. armeniaca* var. *dasycarpa* Koch.; *Armeniaca dasycarpa* (Ehrh.) Pers.; *Armeniaca dasycarpa* Ehrh.; *Armeniaca dasycarpa* Borkh.; *Armeniaca nigra* Desfon.; *Armeniacafusca* Tourp. & Rit.; *Armeniaca atropurpurea* Loison; *Armeniaca persifolia* Loison.J, known as purple or black apricot, produces a small tree. Leaves are small and narrow, mostly elliptic-ovate, finely and closely serrated, thin and dark green. Petioles are slender, and nearly or quite glandless. Flowers are large and long stalked, showy. Fruit is globular and plurri-like, dark purple, the flesh is tart and soft, stone is fuzzy. This apricot with dark purple velvety fruit is cultivated in Kasmir, Afghanistan, Baluchistan, and in Europe (Brandis 1874; Kostina 1936; Löschnig and Passeker 1952). It is considered a generic hybrid between apricot and plum *(P. armeniaca* × P. *cerasifera)* (Kostina and Riabov 1959) and as a result it has been also named as *Armenoprunus* Janchen. It is mostly self sterile (Nyujtó and Surányi 1981).

Fig. 5. P. *mume* (Kostina 1936).

5. P. *holocericea* Batal. [Syn. *Armeniaca holocericea* Batal.; *Armeniaca holocericea* (Batal.) Kost.; *Prunus armeniaca* var. *holocericea* (Batalin)] is known as Tibetian apricot (Fig. 6). Tree is 4-5 m tall, leaves are large, its short petioles and veins are pubescent. Fruit is pubescent, stone is round and seed is bitter. Few trees of this species were found by a Russian explorer in the 19th century between Batang and Litang in the west ern part of Sichuan Province of China. Its existence as a species should be questioned.

Fig. 6. *P. holocericea* (Kostina 1936).

Some morphological variants of apricots have ornamental values and have been given the subspecific designation of forma (f). These are summarized by Terpó (1974) as: f. *pendula* Dipp. or *pendula* (Jag.) Rehd. with hanging or pendulous twigs; f. *variegata* Hort. or *variegata* Schneid. with variegated leaves; f. *ovalifolia* with egg-shaped leaves; and f. *cordifolia* with heart-shaped leaves.

Botanists also recognized the variability of the fruit of *P. armeniaca* and distinguished several subgroups based on fruit characteristics as convariants (Conv.). These are: Conv. *minor* Schübl. & Mart., fruit is small, bitter and acidic, seed is mostly bitter; Conv. *vulgaris* Schübl. & Mart., fruit is large, with sweet mesocarp, juicy, seed is bitter or sweet; Conv. *dulcis* Schübl. & Mart., fruit is large and wide with red cheek, seed is sweet; Conv. *persicoides* Pers., fruit is flat, seed is bitter. This botanical classification has only limited usefulness as it was based merely on fruit size and sweetness or bitterness of the seed and does not take into account the ecological conditions, tree types, chilling requirements of the tree, adaptation to dry conditions and other important considerations.

Among the apricot types one has to mention the apricot plum, the cotplum, and the plumcot. Apricot plum *P. Simonii* Carr (Syn. *Persica Simonii* Decne), was named for Eugene Simon, who sent pits from China to France prior to 1872. Botanical position on the genus is doubtful, as it has some characters of apricot and those of plums (Bailey 1927). King (1939) studied several cotplums that were supposedly hybrids of *P. armeniaca* and *P. salicina.* Based on chromosomal configuration, he accepted these as true hybrids. Rolin and Blanet reported *P. cerasifera* hybrids with apricot in 1755 (Löschnig and Passecker 1954). Giorgio Gallesio in his *Pomona Italiana* illustrated an *albicocca susina* (cotplum) in 1817 (Baldini and Tosi 1994), which is probably the first illustration of such hybrids (Fig. 7D). Luther Burbank produced plumcots by crossing *P. salicina* and *P. armeniaca.* In 1909, he had as many as 65 to 75 thousand plumcot seedlings, and in a letter to D.P. Hedrick, indicated that there were no pure apricots or pure plums among the seedlings, but every possible variety and every possible combination was observed and all qualities were strongly expressed (Hedrick 1911). The first plumcot introduced from Burbank's crosses was 'Ruthland', introduced by George C. Roeding in 1907. The fruit was the size of an ordinary apricot with a deep purple-velvety skin, with brilliant red flesh and a pleasant subacid apricot-plum flavor (Wickson 1914). There are also hybrids between *P. mume* and apricot, the *Bungo-ume,* or between *P. mume* and plum, called *Sumomo-ume* (Yoshida 1994). Mehlenbacher et al. (1990) list several other species combinations, apricot × almond, several plum species × apricot, and peach × apricot.

B. Horticultural

A large percentage of the world's wild apricots have a very thin flesh, and because of this the fruit is not eaten and only the seed is utilized. In contrast, some types have thick flesh and are highly-desirable as fruits. In addition, the color and consistency of the fruit varies along with its shape. Because of the varied character of the fruit, apricot types have been classified from the horticultural point of view. The first known horticultural classification was done by Gian

Battista Della Porta about 1500. He divided the apricots into two groups: *bericocche* and *chrisomele* (Forte 1971). The *bericocche* fruit was round, with soft, whitish flesh, and its seed tasted somewhat like almond.

Fig. 7. Illustrations of apricots in Giorgio Gallesio's *Pomona Italiana*, 1817. (A) •*Albicocca* di *Germania'*, note the large size and the dark yellow color of the fruit compared with the pale color of C, and the small size of B and C. Fruit sizes can be compared because leaf sizes in all three pictures are about the same. (B) *Albicocca lucente*, (C) *Albricocca* di *Sardegna*, (D) *Albicocca* susina plum-like leaves typical of cotplum hybrids. Compare the leaves with apricot leaves shown in A, B, or C. The fruit is intense red.

Fig. 8. Apricots illustrated in Gerard's *Herball*, 1633.

The *chrisomele* group had yellow aromatic fruit, firm flesh, and sweet seeds. The name *mele d'oro* (golden fruit) was also used for this group. Gerard (1633) also distinguished two groups, the greater and lesser *abrecocke* trees (Fig. 8), which differed in fruit size and quality. Later, Dochnahl (1860) classified the apricot cultivars into 4 groups: (1) *Dasycarpa,* red fruit, bitter seed, long pointed leaf; *(2) Alberga,* small yellow fruit, early, bitter seed, small leaf; (3) *Chrisomem,* large fruited, yellow fruit with some red, bitter seed, large leaves; and (4) *Marilla* almost like *Chrisomem* but with sweet seed. The Royal Horticultural Society also attempted to classify the apricots. This classification was based on (1) the size of the flower (small or large); (2) color of the fruit (pale, deep yellow, red, orange, or magenta); (3) pores on the suture of the seed (pore size is smaller or larger than a needle can go through); and (4) taste of the seed (sweet or bitter) (Nyujtó and 1981). Hogg (1875) reworked the previous classifications with minor modifications, but his system has never been accepted. During this century, Kostina (1936), (1949), and Löschnig and Passecker (1954) also made attempts to classify apricot cultivars.

From 1928 to 1938, Kostina and others made an effort to collect apricots from all geographical regions. After examining 700 accessions, Kostina (1936) developed a classification system based on the following characteristics: (1) seed is sweet or bitter; (2) fruit skin is smooth or pubescent; (3) fruit is freestone or clingstone; (4) fruit flesh is white to cream colored, or yellow to orange; and (5) fruit is small, medium size, or large. From these she identified 48 basic combinations. Kostina (1969, 1970) also distinguished four major eco-geographical groups within the common species of *P. armeniaca.* These are: (1) *Central Asian group* including areas around Fergana, the Zerevshan mountains, Samarkand, and the Kopet-dag (a mountain range in northern Iran). This group is the oldest and the richest in diversity of forms. It includes selections from central Asia, Xinjiang (China), Afghanistan, Baluchistan, Pakistan, and northern India. Trees are vigorous, long-lived, and late blooming. Trees are adapted to a dry atmosphere but are sensitive to lack of soil moisture. Fruit is small, has a sweet kernel, and is excellent for drying. Cultivars ripen from May to September. The succeptibility of trees to diseases limits their planting in humid areas (Bailey and Hough 1975). (2) *Irano-Caucasian group* comprised of the Irano-Caucasian area and Dagestan (western shore of the Caspian Sea) and includes local selections from Armenia, Georgia, Azerbaijan, Dagestan, Iran, Syria, Turkey, and North Africa. Trees of this group are not as vigorous and long lived as those of the Central Asian Group. Trees are less winter hardy and begin to grow earlier in the spring. The kernels are sweet. Fruit is larger than of those of the Central Asian Group and the flesh is often white or light colored. (3) *European group* including types in Western Europe, Eastern Europe, and *zerdeli* or Ukrainian type. This group is the youngest in origin and the least variable. It originated from relatively few forms which, in the opinion of Kostina, were brought' to Europe from Armenia, Iran, and the Arab countries during the past 2000 years. (4) *Dzhungar-Zailij group,* which is considered the most primitive group and located north of Almaty (Alma Ata) and the Tien-Shan mountains. This group includes selections from Panfilov (Dzharskent), Taldy-Kurgan, and Almaty (Alma Ata) regions of Kazakhstan and from Ining (Kuldja) of Xinjiang. These trees have great winter hardiness, withstanding -30°C and are small fruited types.

Kostina (1970) further subdivided the European group into WestEuropean (most western European and North American cultivars belong here), East-European (cultivars of Bulgaria, Romania, Moldavia, and south Ukraine belong here), and North-European (mostly zerdely type seedlings adapted to the northern area of apricot production). Thus, Kostina made a definite distinction between the West-European types and any other apricots. This distinction seems to be important and will be discussed later.

Paunovic (1970) modified Kostina's classification, creating five groups: (1) Central Asian, (2) Asian-European, (3) European, (4) American, and (5) African groups. His reasoning was that the international use of cultivars in the case of apricot is not uniform compared with the more uniform use in other fruits because the adaptability of apricots to environmental conditions is much less compared with other fruits. Bailey and Hough (1975) also proposed that a North African group should be added to Kostina's grouping, including types grown in North Africa, Tunisia, and in the oases south of the Atlas Mountains. Apricots in these areas have low chilling requirements and are well adapted to climates with mild winters, which makes them a distinct group.

It is relatively easy to classify those groups of cultivars that were introduced from a closed production area and grown in a distinct valley or an oasis. It is more difficult to classify the European cultivars that have varied origin and have been selected for the best performance in a given area (Nyujtó and Surányi 1981). The difficulty in classifying the European types is clearly manifested in all classifications concerning this group. The classification somewhat reflects the origin of these cultivars. Kovalev (1970) considered only two ecotypes of the European apricot: (1) the southern European and (2) the east European types. Nyujtó and Surányi (1981) divided the European group into southern or Mediterranean and continental types. From these classifications it is clear that most authors separated the southern and northern type European cultivars, and separated these from the other apricot groups. None of the classifications was concerned with the P. *armeniaca* forms of China, especially those found in Shaanxi and Gansu Provinces. In these provinces, apricot fruit varies from small to medium, the flesh from whitish to intense yellow, the ripening period from early June to the end of August and the kernel generally sweet. Yuan and Du (1983) described 86 forms from Shaanxi. Some of these are illustrated in Fig. 9. and show the remarkable variability of the species. Zhang and Uu (1995) recorded that wild types may have large fruits up to 71 g in the same geographic region.

Because classification based on fruit characteristics frustrated horticulturists, Mándy (1949) attempted to classify apricots based on their leaves and found larger differences based on leaves than on fruits. He considered the length of the petiole (20-40, 41-55, or 56-70 mm long); the shoulder of the leaf, the size of the leaf (40,41-60, or 61-80 cm^2), serration of the leaf edge, and the tip of the leaf (short 10, medium 11-15, and long 16-20 mm). Nyujtó and Surányi (1981) used this system to identify 43 cultivars.

During the Turkish occupation of Central Europe (1510-1680), many apricots were brought into the region and most of them were propagated by seed. As a consequence, cultivar groups somewhat similar to land races have developed. These cultivar groups or land races, common in Hungary, are the basis of Nyujtó's classification (Nyujtó and Surányi 1981), as shown in Table 1.

Even in relatively recent times, apricot breeders have found horticultural classification useful because each group carries certain adaptability characteristics. Smikov (1983) attempted to fit 853 existing apricot cultivars according to the major classification groups of Kostina. He found that 416 cultivars belonged to the middle Asian subgroup, of which 110 were clearly Fergana types and 72 were types found in Kopet Dag. Only 5 cultivars belonged to the Irano-Caucasian group, while 232 cultivars belonged to the European group, of which 152 were West European, 40 East European, and 30 were zerdeli types. About 200 local cultivars belonged to the Dzungar-Zaily group. Finally, Mehlenbacher et al. (1990) list cultivars with characteristics important to apricot producers and apricot breeders. Their list of cultivars is not a classification but merely a recognition of cultivars with climatic adaptation, resistance to various diseases, suitability for processing, tree growth habit, and harvest time.

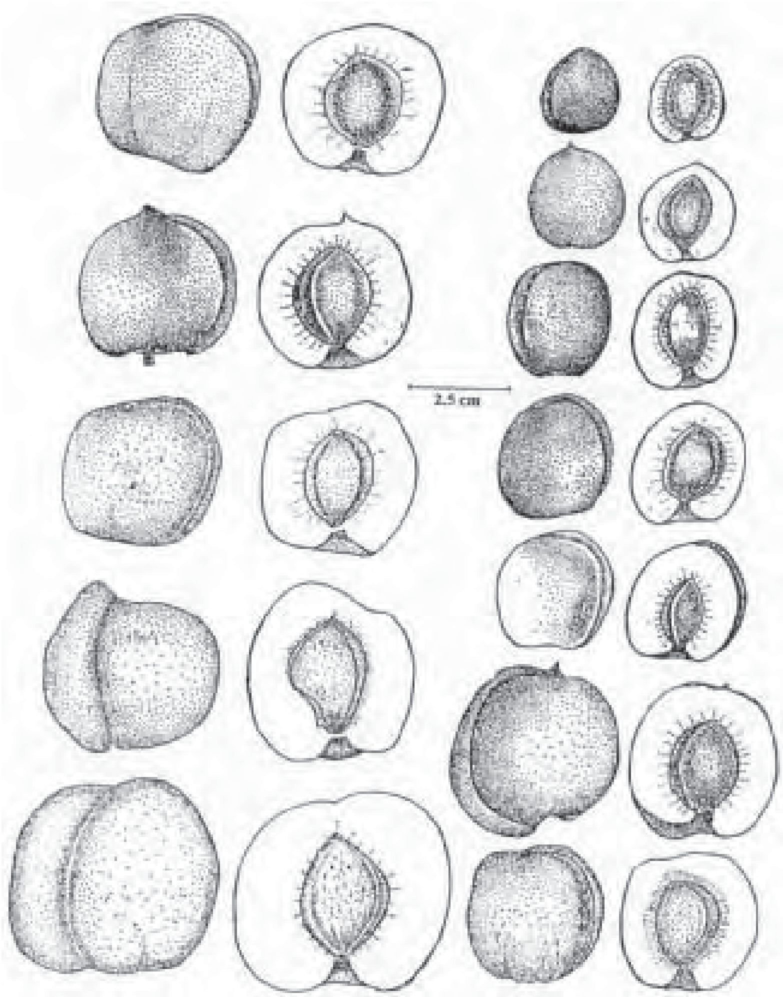

Fig. 9. Types of apricots found in Shaanxi Province of China.

From the above discussion, it is obvious that it is not simple to classify diverse groups of apricot cultivars. In fact, Tomcsányi (1979) recognized that with the introduction of new cultivars, derived from diverse groups, conventional thinking in terms of established categories in apricot classification is no longer possible.

Even though there are several groups of apricots, only a few cultivars are broadly adapted in each ecological area. Mehlenbacher et al. (1990) listed cultivars with wider adaptation only as exceptions: 'Canino', that grows in several Mediterranean countries, and 'Hungarian Best', that grows throughout central and eastern Europe under various names. In addition, the authors consider 'Nancy', a Hungarian type, and its descendants ('Royal', 'Blenheim', and 'Moorpark') are adapted well beyond their place of discovery in California and at the Cape of South Africa. Local adaptation, which has been, and still is, the major concern for each breeding program, makes classification not only difficult,-but pointless, because the ecological adaptation overrides any other characteristics of the fruit when large-scale production is concerned.

Table 1. Characteristics of Hungarian apricot cultivar groups. (Nyujtó and Surányi 1981.)

Cultivar group (land race)	Characteristics: Favorable	Characteristics: Unfavorable
"Hungarian" apricot	High quality fruit, yellow flesh color, adaptable to poor soils, self fertile	Short winter dormancy, alternating production, extended maturity, apoplexia[z] and *Monolinia* sensitive
Rose apricot	Hardy, excellent transportability, productive, machine harvestable, firm flesh, self fertile	Tends to overcrop and produce small fruit, flesh is often mealy, not precocious, sensitive to *Monolinia*
Giant apricot	Large fruit, good fresh fruit quality, precocious, early maturing	Poor self fertility, blooms too early, sensitive to frost, sensitive to *Monolinia*, flesh softens quickly
Cardinal apricot	High quality, large attractive fruit, excellent productivity, produces fruit also on secondary shoots	Short dormant period, blooms too early, bloom is frost sensitive, develops blind wood, occasionally sensitive to apoplexia[z] and *Monilinia*
Early Red	Very early maturity, productive, relatively resistant to apoplexia, long dormancy, tolerant to cold	Small, soft fruit, extended maturity period, self sterile
Rakovszky	Productive, well shaped and high quality fruit, attractive color, well developed canopy, self fertile	Occasionally produces small fruit, *Monolinia* sensitive, occasionally sensitive to apoplexia[z]
Ceglédi Dawn-Red	Large, attractive fruit, uniform productivity, small canopy, self fertile	Frost sensitive, fruit softens slowly, fruit remains green at suture
Almond-apricot	Attractive fruit, very firm flesh, excellent for machine harvesting, long rest period	Elongated, almond shaped fruit, trunk is sensitive to canker

[z]Disorder involving sudden wilting and death

III. LIN UISTIC EVIDENCE

The name of apricot *(albicocco, albericocco, albricooco)* was apparently derived from the combination of *Arbor precox* from the latin *praecocia* ("precocious") because of its earliness (Guerriero 1982). Columella (about 50 A.D.), the first who mentioned apricot, used the expression Armenian apple, *Armeniisque,* in his work *De Re Rustica.* Pliny (79 A.D.) used the word *praecocia* in his *Historia naturalis* as an occasional designation for *Pomum armeniaum* or *armeniaca arbor. Praecoquum,* a variant of *praecox* pI. *praecocia,* means ripen early, ripe in summer, premature, precocious. Discorides (around 60 A.D.) called it *mailon* or *armeniacon* (De Candolle 1886). Several authors (Kostina 1936; Loschnig and Passecker 1954; Blaha et ai. 1966; Goor and Nurock 1968) assumed that the English word apricot was derived from *praecocia.* Distinction has been made between the early ripening "fruit," apricot, and the later ripening "fruit," peach. Turner (1551) called apricot "abrecock or hasty peche tre." He remarked: *"The hasty peche tre hatch much broader leves then the peche tre and hys fruite is* a *greate tyme sonner rype then the peche is."*

Groups of words used for naming P. *armeniaca* include: (1) *kaysi* (Turkish), (2) *zerdeli* (Persian), (3) *Arbor-precox* (Latin), and (4) *Marille* (German). Depending on the dissemination of apricot, a given language may use the derivatives of more than one of the basic words depending on whether the apricot is seed propagated or grafted.

Kaysi is an Ottoman-Turkish word that originated from Pontus (Roman territory in northern Turkey). The local name of apricot in Ukraine is *zserdelj* or *zerdeli,* which stems from the Persian word *zardalju* meaning yellow plum. The Turkish and Persian words are occasionally mixed and include Turkish *kaysi* (grafted cultivars), *kuruk* (dried halved fruit), *kuraga* (dried fruit with seed); Tatar: *kajszi* (grafted cultivars), *zerdale* (propagated by seed); Bulgarian: *kajszija* (grafted cultivars), *zalazar,* or *zalzar* (propagated by seed); Romanian: *cais, caisi, caisa* Croatian: *kajsija* Albanian: *kajsi* and Hungarian: *kajszi.* Apparently the seed-propagated apricot was not the same quality as the grafted trees, and was so recognized by the Persian word in Tatar and Bulgarian designation of seed-propagated apricots.

The names derived from the Latin *Arbor-precox* include the Arabic: *al-barquq* (tree), *al-bareue, albarquq,* and *mish-mish* (fruit); Italian: *albicocco, albericocco* Spanish: *albaricoque* Portugese: *albricoque* French: *abricot* (fruit), *abricotier* (tree); German: *Aprikose* (fruit) and *Apricosebaum* (tree); Dutch: *abrios* Danish Swedish Norwegian: *abrikos* Finnish: *aprikoosi* Russian: *abrikos* and the English: apricot, and apricot-tree. The Italian *albicocco* and the English apricot were used in many forms in the past. The Italian forms include for the tree: *albicocco comune, albercocco, pesco armenico, meliaco, umiliaco, armellino* and for the fruit: *albicocca, albercocce, armeniache, pesche armeniche, meliache, armellini, umiliache, moniaca, biricoccola* (Tamaro 1901). The past English forms include: *abrecok, aprecox, abrecock, apricok, aprecock, abricot, abrycot, abricoct, apricote,* and *aprecott.* Murray (1888) gives a number of various uses of the word apricot. Some of his examples are notable and repeated here because they illustrate the use of apricot in the 16th to 18th centuries. In 1551, Turner wrote "Abrecockes ... are less than the other peches"; in 1573-80, Tusser remarked "Of trees or fruites to be set or removed: apple trees ... apricockes."; in 1578, Lyte recorded that "Therebe two kindes of peaches.... The other kindes are saner ripe, wherefore they be called abrecox or aprecox"; in 1601, Holland reported that "Abricots are ready to be eaten in summer"; in 1617, Rider remarked about "an abricot apple"; and in 1718, Chamberlayne gave instruction: "If an abricot be grafted upon a plumb ..." The word "apricot" was used since Richard Bradley's time in 1739 (Bradley 1739).

Names derived from South-German Austrian include *Marille* or *Malede* Czech: *merunka* Slovanian: *marulica* Polish: *morela* Slovakian: *marhule.* Kluge and Gotze (1934) remarked that old expressions of *Marille* included *Morling, Morich, Mollelein,* or *Molleten.* He also thought that the Schwabish *Mollele* originated from *ammarelle.* Guerriero (1982) mentions that the Latin name of apricot, *albicocco,* was not generally used throughout Italy in Roman times. The Roman dialect used *maniaga* or *magnaga* and a Tuscan dialect *armelliano,* all probably stemming from the word *armeniaca.* Thus it is conceivable that the basis of the German *Marille* or *Malede* originated from *armeniaca* through linguistic transformations. A lengthy discussion on this word can be found in Löschnig and Passecker (1954).

The Chinese *xing* or *hszin,* the Japanese *anzu,* and the Armenian *ciran* (reddish-yellow) or *sziranen* are different and do not correspond to any of the above words. According to Lindqvist (1991), the Chinese symbol, 杏, is composed of idioms of an open mouth under a tree, which can be found in many names indicating locations (Fig. 10).

The identity of the fruit known by the Hebrews as *tappuah* (Proverbs 25:11; Song of Solomon 2:3, 7:8, 8:5) is unclear. In most English translations of the Bible *tappuah* is translated as "apple" since linguistically it corresponds closely to the Arabic *tuffah* (apple). According to Hepper (1992), the other candidate for *tappuah* is the apricot. Apricots could have been grown in the area and *tappuah* was used as a place-name for localities where the fruit must have been important. The fragrance of *tappuah* is referred to in the Song of Solomon 7:8 and its sweetness in 2:3, both characteristics attributable to apricot. Hepper (1992) thinks that when Solomon wrote that "A word fitly spoken is like *apples of gold* in a setting of silver" (Proverbs 25:11) the king was referring to apricot.

Fig. 10. Locations in China with apricot in their name: (a) Xingzsen, (b) Xinghaj, (c) Xinghxinghxia, (d) Xingtaj, (e) Xinglung, Xinghajlien, (g) Ansu (North Korea), (h) Xinghua, (i) Xingan, OJ Xingji.

IV. ORI IN

The history of apricot goes back at least 5000 years in China and 2000 years in the western world. De Candolle (1886) places the origin of apricot in China. According to an account attributed to Emperor Yu (2205-2198 B.C.), the apricot was cultivated in China in his time (Roach 1985). However, Sun et al. (1983) remarked that the Book of Odes ("*Shii Ching,"* an anthology of verses written between the 11th and 6th centuries B.C., does not mention apricots but contains poems about peaches, plums, pears, hazelnuts, chestnuts, and jujubes. Nevertheless, apricot was known in China in 658 B.C. and superior apricot orchards existed there in the period 406-250 B.C. (Nyujtó and Surányi 1981). Later books not only mention apricot but verses were written about this fruit by Li taj-po (701-762) and Po Csü-ji (772-846). Chinese painters used apricot as a favorite subject (Fig. 11). Grafting of apricots began in China about 600 A.D. and defined cultivars developed after this time (Nyujtó and Surányi 1981).

Laufer (1919) identified Sogdiana (ancient name for the area around Samarkand) as the place apricot was native. Jeszejan (1977), an Armenian, naturally described Armenia as the native location of apricot. He based his conclusions on the fact that apricot culture had a long history in Armenia, especially in the area of Yerevan. Apricot seeds from about 3000 B.C. have been

Fig. 11. Apricot blossoms painted by a Southern Song Dynasty academic painter, Ma Yiian (ca. 1160-1225). Painting exemplifies the "broken branch" convention focusing on a corner of nature rather than on a broader landscape. In upper right is the writing of Empress Yang Mei-tzu-"meeting the wind, they offer their artful charm; moist with dew, they boast their pink blossom."

discovered at Sengevit and at Garni (both near Yerevan), but in the opinion of Aralkeljan (1951), a noted archeologist, the fruit form that these seeds have originated was brought into Armenia rather than produced there. De Candolle (1886), reviewing the available data on wild apricots in Armenia, stated that several qualified travelers, including Karl Koch, who traveled extensively in Armenia and the Caucasian mountains, did not find wild apricots there. The apricots these travelers found were all cultivated or escapes from cultivation. Based on this information, De Candolle concluded that apricot was not native in Armenia. Apricot seeds were found from a later period at the excavation of Karmir Blur (a fort near Yerevan) from the 8th century B.C. (Arzumanjan 1970). Still later, in the first century A.D., large apricot plantations existed around Echmiadzin (near Yerevan) that were cultivated by Armenian monks (Timko 1971).

Vavilov (1992) included the cultivated apricot into three of his centers of origin. The centers important for apricots are: (1) the *Chinese Center,* including northeastern, central, and western China as far as Gansu Province, and northeastern Tibet; (2) the *Central Asian Center,* the mountain area extending from the Tien-Shan south, through the Hindu Kush to Kashmir; it includes Afganistan, Tajikistan, and Uzbekistan; (3) the *Asia Minor Center,* the mountains of north-eastern Iran to the Caucasus and Central Turkey and Turkmenistan. Vavilov considered the Asia Minor Center to be the secondary center of origin of cultivated forms.

Crossa-Raynaud (1960) and Guerriero (1982) placed the origin of apricot in middle Asia, which corresponded to Vavilov's Central Asian Center and thought that apricot moved both east and west (Fig. 12). Consequently, if one accepts this theory, the Chinese Center of Vavilov also would become a secondary center of origin for apricot similar to the Near Eastern Center. However, the Siberian and Manchurian apricots are sufficiently different from the common apricot so that the Chinese Center of origin, as Vavilov contemplated it, may be the actual one.

The geographic area of each apricot type, as far as the botanical variety is concerned, is well described. The common apricot, *P. armeniaca,* is native in the Fergana area, the Hindu Kush, Kopet dag, and Armenia extending to Dagestan to the west and across the Tarim basin to Shaanxi and Gansu to the east (Fig. 13).

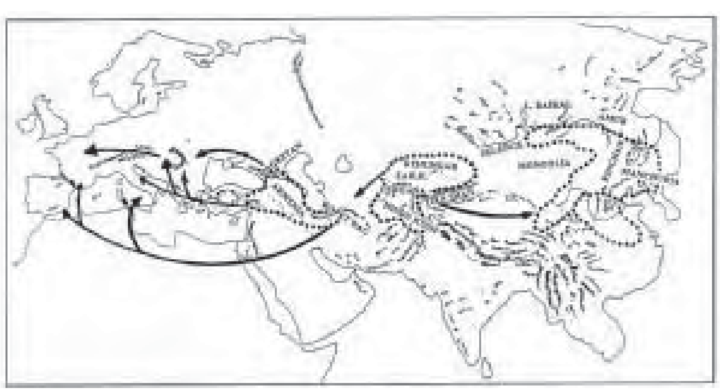

Fig. 12. Distribution of apricot from the Central Asian Center of Vavilov.

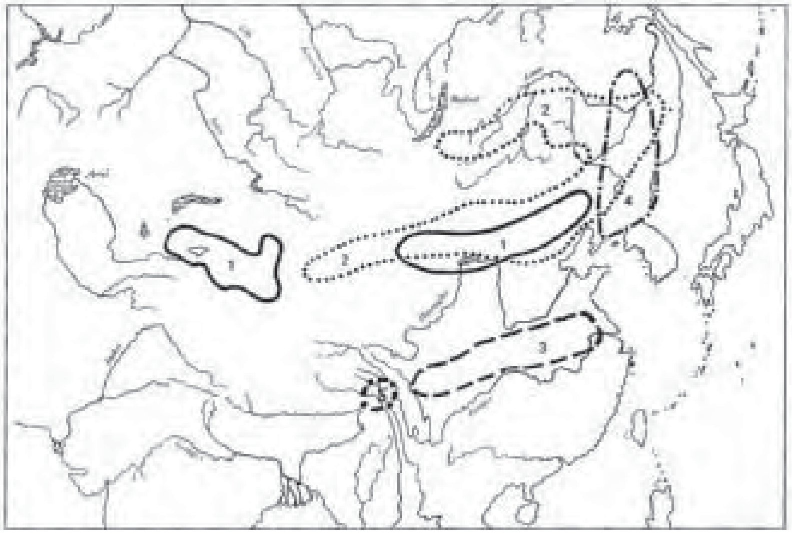

Fig. 13. Geographic distribution of apricot species in Eastern Asia. (1) *P. armeniaca* *P. armeniaca* var. *sibirica* (3) *P. mume* (4) *P. armeniaca* var. *mandshuriaca* (5) *P. holocericea.*

The Siberian apricot, *P. armeniaca* var. *sibirica* Koch, is located in northern China. Its northern limit is around the 50° latitude. It can be found in eastern Siberia in the valley of the Ussuri River, on the steep slopes of the Kinghan mountains dividing China and Siberia and on the slopes of mountains extending as far south as Beijing. The Siberian apricot extends westward across Manchuria and continues north and south of the Gobi desert; to the north, it occurs as far west as the valley of the Selenge River, while to the south, it extends through the mountains of Inner Mongolia and northern China as far west as the northern loop of the Yellow River (Fig. 13). Its native area is the largest compared to the other apricot types, and can be found in the second canopy level of the forest together with rhododendrons, mespilus, and Siberian apple.

The Manchurian apricot, *P. armeniaca* var. *mandshurica* Maxim, is found in eastern Manchuria and Korea, essentially east of the Siberian apricot (Fig. 13). It occurs on sunny slopes in groups of trees or mixed among other tree species.

The ansu apricot, *P. armeniaca* var. *ansu* (Maxim.) Kost., is a species that is cultivated in warm, humid areas of east China. There is approximately 1000 mm of rain and high (30°C) temperatures in this area (Gu Mo 1988). The Japanese apricot, *P. mume*, is also a native of China. It was introduced to Japan approximately 2000 years ago, utilized as a garden tree since the Nara era (7th to 8th century), and its breeding for ornamental use began in the Edo era (17th to 19th century). It is the southernmost species of apricots. It can be found in southern Gansu, Hubei, Sichuan, and Hunan provinces (Fig. 13). It is a relatively lowland species, at home in gravelly soils up to 200 m elevation.

Wherever native, apricot is considered a fruit of mountainous areas (Layne et al. 1996), with the exception of the ansu apricot. In China, Middle Asia, or the Caucasian region, apricot trees are always native on high mountains. Wild forms of *P. armeniaca* are found on the western slopes of the Tien Shan mountains and on the north-western slopes of the mountains around Fergana in dry, stony soil, up to 1200 to 1400 m, in the Shigar valley 2500 to 2800 m high, and near Ascole at 3650 m (Casini and Neri 1964). Frank Meyer, an American plant explorer also collected apricots at 1400 m altitude in the Tien Shan mountains (Vavilov 1992). In Turkestan, apricot is found between 1200 and 2200 m and in Manchuria near the south-eastern Mongolian border at 3000 m above sea level (Forte 1971).

The origin of apricot in mountainous regions may have a special significance. In general, chilling requirement, as an evolutionary attribute, is believed to have developed to prevent premature sap flow and dehardening processes in climates with fluctuating winters. Species that originated in very cold climates, occurring usually at high mountain tops, or on the fringes of fruit growing to the north, had no need to develop a high chill requirement as a protective system because most of the winter was cold enough to compel dormancy throughout the freezing period. Therefore, it is likely that the medium-chill-requiring apricot types developed on mountain tops in the Fergana or other sufficiently cool areas, and were subsequently moved to Africa, creating the low-chill-requiring types of apricots.

IV. DISSEMINATION OF APRICOT

A. Euro ean

The name *armeniaca* may indicate that apricot came to the western world from Armenia. Unger (1859) thought that Alexander the Great (356-323 B.C.) brought the apricot from Armenia to Greece and Epirus (Albania), from which countries it reached Italy. However, apricot apparently was unknown to the Greeks at the time of Theophrastus (327-287 B.C.), a contemporary of Alexander the Great (De Candolle 1886). Similarly, Roman authors including Cato (234-149 B.C.), Varro (116-27 B.C.), and Vergilius (70-19 B.C.), writing about agricultural subjects, did not mention apricot (Löschnig and Passecker 1954). However, it was mentioned as *Mela armeniaca* (Armenian apple) by later authors, such as Discorides (around 50 A.D.) and Columella (around 50 A.D.) indicating that it may have arrived in Roman territories during the first century B.C. (Löschnig and Passecker 1954). Pliny (23-79 A.D.), in his *Histaria naturalis,* used the names of *pamum armeniacum* or *armeniaca arbor* and occasionally the expression *praecaqua,* meaning early. Koch (1869) indicated that Lucullus and Pompeius may have learned about apricots in the war in which they attacked Armenia from Syria during 69-63 B.C. Lucullus had a villa and a garden to which he retired in 63 B.C. that was located on the Pincian Hill above the Spanish steps in Rome, and there he cultivated apricots (Hobhouse 1992). Thus, it is possible that the apricot arrived in Italy during the first century B.C. directly from Armenia and not through Greece.

Apricot was cultivated throughout Asia and it is difficult to know where it may have come from to Europe. Harlan (1861) described *P. armeniaca* as native from around Kabul (Afghanistan) and bearing yellow, acid, and inferior fruit. He also encountered five sorts grown in production, one of which was especially luscious. It required careful manipulation in gathering, because it was so delicate that if one should fall to the ground, the shape would be destroyed. In Ladakh (Pakistan), according to Moorcroft (quoted by Darwin 1893), there were 10 kinds cultivated, all raised from seed except one, which was propagated by budding. Apricot was known in Islamic gardens; al-Biruni in 1050 provides us a list of fruits, among which he mentions apricot (Harvey 1975). Erman (quoted by Pumpelly 1871) mentions it as a "wild peach" of Nerchinsk, Siberia, as a true apricot, containing a very agreeable kernel in a fleshless envelope. According to Sturtevant's notes (Hedrick 1919), apricot was cultivated throughout the entire East, in Kashmir and northern India, in China and Japan, northern Africa and southern Europe. Around Damascus it was cultivated extensively and a marmalade was made from the fruit. Because of its widespread occurrence and use in Africa, Regnier and Sickler (quoted by McIntosh 1855) assigned a native area to apricot between the Niger and the Atlas. In the oases of Upper Egypt, the fruit of *"mish-mish"* is dried in large quantities for the purpose of commerce. Regnier saw wild apricot grown in upper Egypt, but in the opinion of De Candolle, they must have been grown from discarded cultivated stones (De Candolle 1886).

The apricot arrived in Europe and was distributed there in various ways. Löschnig and Passacker (1954), based on word usage, describe three different routes of entry into Europe: (1) the northern route from China to the Balkans; (2) the southern route from Armenia through Syria, Arabia, Greece, Italy, and northern Africa; later it was also spread into Russia; and (3) middle route distribution from the Danube valley to Germany. The Roman soldiers played a major role in this distribution pattern, carrying the seeds plants from place to place.

Crossa-Raynaud (1960) assigned a different set of routes for apricot dissemination from its origin in Middle Asia: (1) to the Middle East, into Egypt and North Africa. This branch produced the cultivars 'Klabi', 'Beladi', 'Luzi', 'Bedri', and 'Amor Leuch' in Tunis, and the apricots of the oases, 'Mich-mich'. These African types are noted for their low cold requirement. (2) To Greece, middle and southern Europe extending north from the Mediterranean Sea. According to him, this group is represented by the cultivars 'Nancy', 'Royal', 'Luizet', 'Ampuis', and 'Rouge du Roussilon'. These cultivars require a considerable amount of chilling, their fruit is large, and essentially this is the group that disseminated into California, South Africa, and Australia. (3) To the East. Cultivars of P. *niaca* var. *sibirica* belong here. These cultivars are distinguished for their very high chilling requirement and their exceptional winter hardiness.

According to Crossa-Raynaud (1960), the apricot entered into Russia from the west during the 17th century, but into Ukraine, Crimea, the Caucasian area, and Turkestan directly from the Middle East. The local name of apricot in Ukraine, *zerdeli,* indicates a direct entry from Persia. Possible distribution routes of apricot from its native areas to the modern production areas are illustrated in Fig. 12.

Regardless of the original entry into Europe, a major entry of apricot to Central Europe directly from Turkey must be considered. Early archeological evidence indicates that apricot was in Pannonia (Hungary) in Roman times. At

Budapest, in *Aquincum* (a Roman settlement), apricot seeds were found dating from approximately the first century 1985). An apricot seed was found in a 9th century grave at Balatonszentgyörgy (Sagi and Füzes 1967) and from the 14th century, apricot seeds were unearthed from a well located at Disz Square 10, Budapest and Novaki 1975). The first mention of apricot in the Hungarian language occurs in the 14th century "Besztercei Dictionary." This indicates that apricot existed in Hungary well before the 16th century. However, the Turkish occupation of Hungary (1526-1680) greatly increased apricot plantings in the Hungarian planes. Even today, in Hungary, the present centers of apricot production clearly overlap with the 16th-century location of Turkish estates of the Sultan (Nyujtó and Surányi 1981). The Hungarian word for apricot, *kajszi,* has a Turkish origin and did not appear in the word list of Szikszai Fabricious Balazs in 1590, but was used after 1600. This is an indication that the Turks brought the apricots with them. The Turkish apricots were apparently superior compared to the existing European cultivars and were desirable for planting. Consequently, propagation material was exchanged between interested parties. For example, Miklos Archbishop of Augsburg, Germany, requested budwood from Tamas Nadasdy's garden in Hungary in 1551. Boldizsar Batthyanyi requested budwood from Job Kavasy's garden in Hungary. Gessner, a Swiss horticulturist, in his 1561 book, *Horti Germaniae,* mentions Hungarian apricots as *"magna et optima"* (largest and best) (Nyujtó and Surányi 1981). Apparently the influence of Hungarian apricots increased apricot production in western Europe. Turner (1551) indicated that at that time there were still very few apricots in England but apricots were commonly grown in Germany around Cologne. Nevertheless, the importation from Turkey continued. During the 17th century, Cardinal imported apricot nursery stock directly from Turkey, and propagated them himself by grafting. From this period on, there is ample evidence described by Nyujtó and Surányi (1981) that apricot was grown in Hungary. In 1664, János Lippay, the gardener of the Archbishop of Pozsony (Bratislava), described four distinct cultivars, but at the end of the 18th century, Samuel Tessedik, a well known horticulturist, still used seedlings because grafted apricot trees did not survive on his high-sodium soils along the rivers of Tisza and Körös. Thus, development of land-race-type populations in the area dominated by the Turks, including Hungary, Serbia, and Croatia, was entirely possible. These cultivar groups (perhaps land races) are the basis of Nyujto's classification described previously.

There was an upsurge in production of apricots in the early 18005 in Hungary. In 1792 there was only two square miles of blowing sand in the area of Kecskemet (central Hungary), but this increased three-fold by 1805 and soon there was blowing sand everywhere. The increase in blowing sand was due to years of severe drought and increased sheep production that devastated the meager grass cover over the sandy areas. Expanding agriculture demanded more land, and consequently the sod over the sand was broken up. The Hungarian Congress discussed the danger of blowing sand in 1807 and encouraged the planting of apricots and plums, which were known to be able to establish themselves in sandy soils. The effort was successful, and there are records that beginning in 1855, Lipot Aszódy and Sons, and from 1858, the Herz Brothers exported apricots from Kecskemet to Krakkow, Warsaw, Vilnia, and St. Petersburg (Nyujtó and Surányi 1981).

In Italy, in the 7th century, apricots were grown south of Naples along with other fruits (Hobhouse 1992). In 1552, Girolamo Fiorenzuola in his *La grande arte della agricola* recommended apricots as one of the fruits that are suited to make *spalliere* or hedges growing against the low lattice fences (Hobhouse 1992). Matthioli (1500-1577) described three apricot cultivars (Martini 1988). A rare inventory taken at Villa Lante at Bagnaia north of Rome after the death of Cardinal Gambara in 1587 describes several fruits, including an orchard of apricots (Hobhouse 1992). Also in the 16th century, Tebaldi's *Discorso sull' agricultura* described the production of almonds, apricots, and peaches, while the work of Francesco Carletti (1573-1636) spoke about preservation of peaches and apricots by addition of sucrose (Forte 1971). In 1699, Bartholomeo Bimbi, an Italian painter of the Medicis, painted a large canvas with 9 apricots and 36 peaches. Eight of the apricot cultivars were identified by Cristoferi and Faccioli (1982) as 'Albicocca Grossa di Germania', 'Alessandrine o di Malta', 'Bianche di Genova', 'Di Padova', 'Di Venezia Del Padre Napoli', 'Mikliache', 'Nostrale', 'Tardive', and 'Tardive Del Padre Napoli'. He also painted a smaller canvas of 'Albricocche di Germania'. In 1758 Giorgio Gallesio in his *Pomona Italiana* describes five cultivars, including 'Albicocca di Germania' (Fig. 7A), a cultivar obviously originated in Germany, and 'Lucente o Alessandrina' (Fig. 7B) (Baldini and Tossi 1994). Alexander Bracci (ca. 1480) listed 100 plant species planted in the Medici villa Poggio a Caiano, outside Florence, which included several fruit and nut species-among them apples, pears, plums, peaches, figs, elderberries, mulberry, walnuts, and chestnuts (Emboden 1987). Apricot was not among the fruits listed. This may mean that apricots were not good enough or luscious enough to be included in the outstanding garden of the Medici the Magnificent.

In 1676, Cause published a book in Amsterdam containing a chapter on how to grow apricots (Janson 1996). The baroque gardens at Het Loo (The Netherlands) were constructed around 1685 for William of Orange (1650-1702). In the reconstruction of this garden, based on contemporary descriptions, peaches, apricots, and nectarines grew on the sunniest walls. Thus, apricot was grown in Holland in the middle ages (Hobbhouse 1992). Langley in 1729 also wrote about apricots and illustrated the Roman and Turkish types (Fig. 14).

The fact that apricots were grown throughout Europe is also indicated by archeological research, which discovered apricot seeds in Austria. Werneck (1955) found large apricot seeds (24.4 x 16.7 x 9.6 mm) at Linz that dated to the 1st century.

The interest in Europe in apricots was also expressed in 1819, when the Carlowitz nursery of Dresden in its sales catalog offered 13 apricot cultivars. A similar list of cultivars was produced in 1813 by J. L. Christ in his book, *Vollstaendige Pomologie*, published in Frankfurt. It was about stone fruit production and described 16 apricot cultivars (Janson 1996).

Apricots were introduced to the Roussillon area of France by the Arabs prior to 1000 and into the Loir valley by Renato I d'Aragona, Duke of Lorena, in 1442 (Forte 1971). Because of the relatively late move of apricot to northern France, it is not surprising that apricots were not included in Charlemagne's *Capitulare,* written in 800. Apricots were planted at Versailles in the garden designed and built for Louis XIV by Jean de la Quintinye (1626-1688) (Tukey 1964).

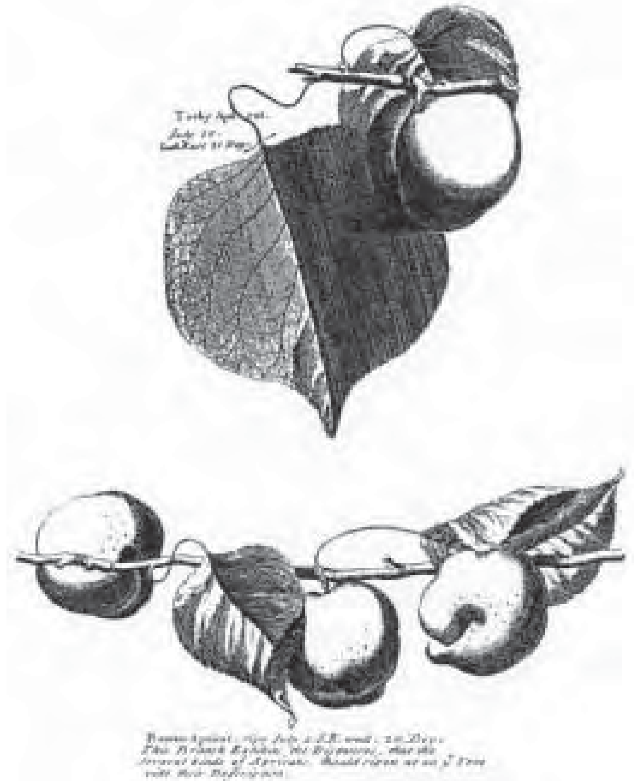

Fig. 14. Illustration of Turkish and Roman apricots from Langley's *Pomona, 1729.*

Why did apricots not move to the north of France until 440 years after their introduction into country? The answer probably lies in the fact that the southern types, introduced by the Arabs, were unsuitable to the north and the northern types arrived through an entirely different route. We suspect that import of Turkish types through Hungary was the origin of the great France cultivars that became important worldwide. In 1777 Andrieux described nine apricot cultivars (Janson 1996). 'Nancy', the cultivar to which a number of excellent cultivars can be traced, was noticed near Nancy and was originally described as 'De Nancy' in 1755. In 1889, Mathieu described 32 synonyms for this cultivar, including the name *'Peche-apricose'* (Löschnig and Passacker 1954), which name was carried to England and is believed to be the predecessor of 'Moor Park'. In 1767, the sales catalog of nurseries operated by Carthusian monks at Paris described 10 apricot cultivars (Janson 1996). 'Royal', an important cultivar, was found as a distinct tree among the seedlings obtained from the seed of 'Nancy' and sent to Michel Harrey, director of the Luxemburg Gardens in Paris in 1808. The name was given to this exceptional plant after the King Louis XVIII, had expressed his delight with a box of fruit given to him in 1815 (Stander 1983). 'Rouge du Roussillon' appeared around 1830 in the eastern Pyrenees area. It is a good producer, grown in the area of Roussillon, but carries the limited adaptability common to most apricot cultivars. Another important cultivar, 'Luizet', was discovered by Gabriel Luizet, owner of a nursery, among his seedlings in 1838. This cultivar was spread into almost every country of Europe and North Africa (Got 1958). The authors believe that 'Luizet' inherited its adaptability from the 'Hungarian Best', rare among apricots for its adaptability to a wide range of environments, but unfortunately 'Luizet' is a relatively shy producer. Yet another cultivar, 'Pavioi', was found in Lyon by Paviot near the end of the 19th century and soon spread to the rest of Europe. The last great cultivar of France that needs to be mentioned is 'Bergeron', found among a group of seedlings in Saint-Car au Mont d'Or in 1920 by M. Bergeron.

Apricots were introduced into Spain by the Arabs, likely during the regime of the Umayyads (661-750), who conquered Spain between 711 and 719. Three manuscripts written in Spain in the 11th and 12th centuries mention apricots. The book of agriculture compiled by Ibn Bassal in about 1080 describes many fruits, including apricots (Hobhouse 1992). The second book, describing Andalusian agriculture, written by Ibn al-'Aww m (1190) one hundred years later, also mentions apricots as one of the fruits suitable to the Andalusian hillsides and describes ways to care for them along with a considerable list of other fruits. Ibn al Baitar (1220) produced an encyclopedia of medicinal values of plants in which he describes the values of apricots and about 20 other fruits. Production of apricots slowly increased and the importance of apricots was enhanced. The major cultivar of Spain, 'Bulida', was discovered in Murcia between 1920 and 1930. The other important cultivars are 'Canino' (Syn. in France 'Bulida du Roussilon'), discovered as a chance seedling at Sagunto, near Valencia, by General Canino between 1910 and 1920, 'Moniqué', and 'Paviot'. Planting of apricots especially increased during the period from 1955 to 1967, from 4.5 to 20.8 thousand hectares (Ministerio de Agricultura 1975).

Apricot production extended as far north as England. Thomson (1848) said that it was brought to England from Italy in 1524, while Mcintosh (1855) gives the date of introduction to England as 1548. Roach (1985) reports that John Tradescant in 1620 sailed to North Africa as a voluntary passenger on a naval vessel rounding up pirates and brought back a cultivar named 'Algar' from Algiers. Gerard (1633) in his *Herball* mentions the aprecocke or abrecoke trees and illustrates the greater and lesser aprecocke trees (Fig. 8). He describes the two types as almost identical, with the exception that the lesser apricot bears inferior fruit. Parkinson (1629) described four different cultivars, adding the 'White' and 'Masculine' to Gerard's greater and lesser aprecockes, and his friend Mr. Millen had five sorts: the 'Common', the 'Long and great', the 'Muske', the 'Barbary', and the 'Early aprecocke'. In 1688, Leonard Meager increased the cultivars offered for sale by the Brompton Park Nursery to seven. He offered the 'Algar, 'Civet', 'Masculine', 'Orange', 'Roman', 'Ordinary' and 'Great Turkey'. According to Roach (1985), the 'Roman' was synonymous with the 'Common' and it was a very old cultivar that may have gone back to Roman times and was the most widely grown apricot until the introduction of 'Moor Park'. 'Moor Park' was introduced by Admiral Lord Anson, and was fruited at Moor Park, near Watford in

Heresfordshire in 1760 and was superior to all previous cultivars. In 1777, Richard Weston, in his nursery catalog, offered 'Temple', which was a synonym for 'Moor Park'. Driver (1788) thought that 'Moor Park' was synonymous with the so called "peach-apricot," which probably had been brought over from France at the beginning of the 18th century. Switzer, in 1724, reported a very large apricot cultivated in Berkshire, which was as large as a large peach and was called "French apricot" (Roach 1985). Later Hogg, based on graft-compatibility evidence, decided that 'Moor Park' was probably a seedling of the peach-apricot (Roach 1985). In those days apricot was recommended more than it was before. Reverend John Lawrence, Rector of Yelvertoft in Northamptonshire, in the 1723 edition of his book "The gentlemans recreation" offered an engraved plan of a fruit garden planted with 84 trees (Janson 1996). Lawrence recommended planting three apricot trees among apples, pears, cherries, plums, peaches, and nectarines. Apricots represented 3.5% of the orchard, about twice their proportion in the gardens of Versailles (Tukey 1964). Brookshaw produced two books, the *Pomona Britannica* and *The Horticultural Repository*, listing the best varieties of English fruits in 1817 and 1823, respectively. In these books, he describes five apricot cultivars (Janson 1996). In 1835, there were 17 cultivars in England according to Sturtevant (Hedrick 1919), but Hooker (1818) in his *Pomona Londoniensis* named only 'Moor Park', which may indicate its superior quality. 'Blenheim', another great English cultivar, originally called 'Shipley's', was introduced by Miss Shipley, the daughter of a gardener to the Duke of Marlborough at Blenheim, some time before 1830 (Roach 1985). This cultivar was exported to California and became widely planted.

B. Worldwide

The Spaniards apparently took the apricot to the New World and established it in their earliest settlements. It thrived in the drier parts of Mexico (Magness 1951). The English also established apricots in Virginia where Capt. John Smith reported that it was grown in 1629 (Magness 1951). Manning reported that it was grown abundantly in Virginia in 1720 (Hedrick 1919). Thomas Jefferson planted apricots at Monticello and noted in his garden book in 1769 that he planted peach stocks for budding ("inoculating") apricots and field planted apricots in 1771 and future years. Jefferson remarked in 1809 that he planted apricot stones sent to him by Mrs. Hackley from Cadiz, Spain, and in 1810 that he planted Bordeaux apricots. Cultivar names are rarely mentioned in his record but he definitely had two cultivars: 'Angelic' and 'Large Early' in addition to seedlings raised from the seeds of 'Meliache' and 'Albicocche' (Baron 1987). Regardless of early plantings, apricot has never proved well adapted to the climate of the eastern United States and apricot growing remained confined to the area west of the Rocky Mountains, largely in California, with some commercial quantities also grown in Washington, Oregon, and Utah.

In 1817, Coxe described six apricot cultivars (Janson 1996). During fruit exhibits of the Massachusetts Horticultural Society apricots were regularly shown. In 1830, more apricots were shown than before, but only one cultivar, 'Moorpark', was represented at the exhibit. Some of the 'Moorpark' fruit were large. Specimens of E. Phinney on 27th July measured 15 em in circumference. Nevertheless, the number of cultivars grown increased (Manning 1880). In 1862, A. Downing described 20 cultivars with 86 synonyms. In 1871, C. Downing reported 12 cultivars that included some old types: 'De Nancy', 'Royal', 'Moorpark', 'Kaisha', 'Apricot Peche', and 'Mush-Mush'. In 1875, Thomas listed 20 cultivars that included the same favorites ('Nancy', 'Royal', 'Blenheim', and 'Moorpark'). In 1879, the American Pomological Society recommended 11 cultivars (Hedrick 1919). At the beginning of this century, apricots were grown in the Eastern United States, but apricot growing was unsuccessful because the early frosts destroyed the flowers. The favorite cultivars in the East were 'Moorpark' and 'Peach Royal' (Hedrick 1950).

Apricot was introduced into California by the Mission Fathers. Vancouver found apricots at the Santa Clara Mission in 1792 (Wickson 1927). Later, when the best English and French cultivars were introduced, the area of cultivation greatly increased. The number of trees reported in California in 1899 was about 3 million, occupying nearly 16,000 ha. Fruit was dried and canned. The shipment of fresh apricots from California was 290 carloads in 1910 (Wickson 1927). In 1920, there were 25,600 ha of apricots in the United States and 96% of this area was located in California (Wellman 1927). Production increased between 1909 and 1920 by 3,000 t per year. In the early 1920s most of the crop was dried (67%) or canned (29.5%) and only a small fraction utilized as fresh fruit (1.3%) (Wellman 1927). The California area increased steadily until about 1940, reaching the 32,000 ha level, and decreased afterward. By 1965, apricot area in California was at about the same level as at the turn of the century, with yield at a corresponding level. Production was 141,000 t during the early 1920s, increased to 250,000 t by 1940, and decreased again to 181,000 t by the early 1960s (Foytik 1961).

Around 1876, Russian Mennonites introduced apricots directly from Russia and propagated the plants from seed in Nebraska. The Russian strain was the subspecies *sibirica* (Hedrick 1950). They only had a few named cultivars, which included 'Budd', 'Gibb', and 'Alexander'. According to Professor Budd, the Russian apricots were hardy in Iowa but did not bear well and blossomed too early. He recommended only the 'Shense' apricot (syn. 'Acme'), which was a cultivar introduced from northern China (Bailey 1894).

Apricots, unlike peaches, underwent relatively little improvement in North America. Two of the major apricot cultivars of California are 'Royal', imported from France, and 'Blenheim', introduced from England, both at an early date (Hesse 1951). These two cultivars are almost identical at most locations and even experienced growers have difficulty identifying them. In contemporary descriptions they are listed as 'Royal Blenheim' (Hesse 1951). Another imported cultivar is 'Moorpark', originally called 'Moor Park', which was imported from England. It was excellent for drying, not so good for canning, and too late for shipping (Hesse 1951). In 1885, J. E. Tilton discovered a seedling on his estate at Hanford, Kings County, California, which he named 'Tilton' and it became one of the most important cultivars in California (Foytik 1961). No apricot introductions from Asia have been made that were comparable to the introduction of the 'Chinese Cling' peach. The two old cultivars, 'Royal Blenheim' and 'Tilton', remain the mainstay of the California apricot industry. Melenbacher et al. (1990) estimated that 'Royal Blenheim' produced 41% and 'Tilton' 39% of the California apricot crop.

In 1890 and 1891, some apricots were planted in Arizona. At Phoenix, 'Blenheim', 'Moorpark', and 'Royal' were planted to test their productivity (Devol 1895), but the apricot industry never became important.

In Canada, production in British Columbia nearly mirrored the apricot situation of the United States. In the Okanagan and Similkameen valleys, apricot plantings increased from 51,000 trees in 1925 to 201,000 trees in 1955, and decreased to 70,000 trees by 1967. The decrease was caused by the decreased demand for fresh market fruit (Trumpour 1969). Apricots are also grown on a small scale in Ontario and were introduced by Russian settlers. They thrive best near the shores of Lake Ontario and Lake Erie.

In Australia, apricot has been popular ever since the first settlers occupied the land. Production has been concentrated in the Murray River irrigated area of South Australia.

Jan van Riebeeck, commander of the first European settlement at the Cape (1652-1662), planted the first apricots in South Africa sometime between 1659 and 1662, and their descendant, known simply as the "Cape apricot," was the most common type for a long time (Stander 1983). At the end of the 19th century, Harry Pickstone imported a cultivar, 'Royal', from France that became the leading cultivar of South Africa until the 1980s. Another important cultivar of South Africa, 'Bulida', was imported from Spain in the 1930s, and the third important cultivar, 'Peeka', was the first locally bred apricot released to the industry in 1966. Cape apricots are harvested in November and December. They were exported beginning in the 1930s to Europe. In 1938, 100,000 5-kg packages were exported and this figure increased to 153,000 in 1954. Beginning in the 1960s, demand for Cape apricots declined, but increased again in the 1980s (Stander 1983).

Table 2. Production of apricots worldwide.

	Production (1000 t)						
Year	Europe	N& S America	Asia	Africa	Oceania	Total	Reference
1948-52	230	206	145	50	35	666	Nyujtó and Surányi (1981)
1975-77	590	166	397	146	62	1361	Nyujtó and Surányi (1981)
1985-87	745	129	624	213	37	1748	Layne et al. (1996)
1993	783	200	941	244	31	2199	FAO (1994)

Apricot production worldwide is slightly over 2 million t, but still constitutes less than 1% of the total fruit production. Nearly half of the crop is produced in Europe, followed by Asia. World production increases slowly at about 3% per annum. During the last 50 years, production increased in Asia, Europe, and Africa and remained level in America and Oceania. The production during the last half of this century is given in Table 2. The 10 largest producers (1,000 t) in 1993 (FAO 1994) were Turkey (400), Spain (199), Italy (192), France (156), USA

(144), Pakistan (140), Iran (118), Hungary (80), Tajikistan (65), and China (60). It is unknown whether apricot production for seed is included in the Chinese total.

VI. CONCLUSION

Apricot and peach have similarities in their origin, but differ in their dissemination and development. Both species originated in Asia and were brought to Europe by the Romans. However, dissemination of apricot was much slower in Europe than that of peach. Both are excellent desert fruits, but peach has become a foremost fresh fruit while apricot has remained largely a dried product. The difference manifested itself early. According to Fischer and Benson (quoted by Löschnig and Passecker 1954), between the 3rd and 15th centuries apricot was considered to be an early peach and was not considered a separate species by Crescentius (1518), written in 1304-1309, or Hieronymus Bock (1595). Apricots were disseminated only slowly in France. In the 17th century, only 1500 m^2 of the king's fruit garden at Versailles were planted to apricot as compared to 27,500 m^2 for peach. One possible reason could be the size of the fruit; apricot was much smaller than peach, which made it less desirable. The reference to small size was expressed in 1561 by Maaler, who called apricots *"kleine, frühzeitige Pfersich"* (small, early peach) (Loeschnig and Passaker 1954). Where did the large-fruited apricots originate?

Table 3. Size of apricot fruits at Fergana and Samarkand as determined by Kostina.

	Fruit Distribution (%)		
Location	Large	Medium	Small
Fergana	3	55	42
Samarkand	21	57	22

Source: Guerriero 1982.

Large-fruited apricots may have entered into Europe from Middle Asia through Greece, as proposed by Crossa-Raynaud (1960). There are occasional large-fruited types both in the Samarkand area and in China. Kostina.determined fruit sizes in the Fergana and Samarkand apricots (Guerriero 1982). There were more large-fruited types at Samarkand than at Fergana (Table 3). A comparison of average fruit sizes is 'Royal' (35-50 g), 'Rouge de Rousillon' (38 g), 'Canino' (50 g), 'Luizet' (55 g), and 'Peche de Nancy' (55 g) (Couranjou 1977).

Gu Mo (1988) described the size of fruit in a number of Chinese apricot cultivars and reported some exceptionally large fruit (Table 6.4). However, these large types apparently were not imported into Europe, because the West-European types were different from the Asiatic types. Thus, Crossa-Raynaud's (1960) proposal may not, after all, be the explanation for the appearance of large-type apricots.

Table 4. Size of apricot fruit in selected Chinese cultivars, described by Gu Mo (1988).

Cultivar	Fruit Size (g)	
	Average	Largest
Most cultivars	30	50
Luotaoxhuang	50	78
Chuanling	45	75
Hongjingzhen	71	120
Huaxianajiexing	100	150

It is clear that apricots were in Europe from the first century B.C., but did not become important until the 17th century. The increase in appreciation of apricots during the 17th century coincides with the Turks bringing apricots to Hungary. A special quality and or considerable size advantage is required to make this an important fruit crop. However, the Turkish apricots were, and still are, relatively small. Of 57 Turkish apricot cultivars described by Gülcan (1988), all but two had smaller fruit than 60 g and most of them were under 40 g. Therefore, it is difficult to imagine that the present West-European cultivars appeared in Europe as a simple Turkish import. In most apricot growing nations, including Turkey, apricots are preserved by drying, and for this purpose medium-to small-size fruit is preferred. The Hungarians, because their climate is not warm enough, could not dry apricots but used them instead as fresh fruit. For fresh fruit consumption, the large-fruited types are the most suitable. Thus, the imported Turkish types must have undergone a selection process for size in Hungary during the development of the eight Hungarian land races identified in Nyujtó's classification. It is conceivable that members of these improved land races were carried further west, becoming the ancestors of the West-European group of cultivars. The evidence for this theory is scant. The French apricots, introduced from the south by the Arabs did not move north likely because of adaptation difficulties. The French apricot culture was augmented only when 'Nancy', a northern type, was discovered in 1755. 'Nancy', according to Löschnig and Passecker's (1954) illustration, and Tomcsanyi's (1979) description, is very close to, and perhaps a descendant of the 'Hungarian apricot' group. It is possible, considering the time of appearance of 'Nancy' and the previously described geographic movement of apricot material in the 18th century, that seed from the Turkish Hungarian group was carried to France and was the origin of this cultivar. 'Royal', in turn, originated as a seedling of 'Nancy'. 'Blenheim', another important cultivar, indistinguishable from 'Royal', may be another seedling of 'Nancy'. 'Moorpark' also can be described as a descendant of 'Nancy', the "peach-apricot" as it was named in England. *'Albicocca di Germania'* (Fig. 7A) illustrated by Gallesio (1817) is considered to be the peach-apricot, 'Nancy', by Tamaro (1901). Finally, 'Tilton', likely to be a seedling of the major California cultivars, 'Royal', 'Blenheim', or 'Moorpark', is the latest addition to the West-European group among the major cultivars. These major cultivars, forming the West-European group of Kostina, point to the influence of the Hungarian apricots in the development of the European cultivars. Such reasoning also distinguishes the other major line of apricot cultivars, the descendants of 'Canino'. These likely stem from the low-chilling type from North Africa and may form the basis of the Mediterranean group, thought to be separate from the West-European group by several classifiers.

Modern analysis, involving DNA markers, might answer where and how the high-quality, large-fruited apricots originated. At present, we must consider the 17th century as the time and Central Europe (Hungary, Croatia, Serbia, and perhaps Romania) as the location where the ancestors of the present apricot cultivars were selected and 'De Nancy' the mother cultivar from which the modern line of apricots originated. This view also points to the narrow genetic origin of apricots and explains the slow progress in apricot improvement in recent times.

Throughout this review, we referred often to the special ecological conditions apricots require. We have done this because several other authors made this point. However, the adaptability of apricots should be reexamined. 'Hungarian apricot' and all its indirect descendants 'Royal', 'Blenheim', 'Moorpark', 'Albicocca di Germania', and even 'Luizet'-are well adapted in many conditions where chilling is satisfactory and winters are not too harsh. 'Canino', representing the other line of apricots, is also well adapted. However, its adaptation area includes low chilling and mild winter locations. It is used extensively as a parent in breeding programs in Africa. In the last 10 years in Europe there has been an increased use of new cultivars developed recently in the United States ('Orange Red', 'Goldbar', 'Goldstrike', 'Tomcat') and Canada ('Hargrand', 'Harval', 'Haroblush', 'Harojoy', 'Harostar'). These cultivars also appear well adapted. Thus, one cannot make a blanket statement about the local adaptation requirement in apricots. Apricot is a low-chillingrequiring species. Low-chilling-requiring types may start sap flow early in fluctuating winter climates, with the result that the tree is injured by relatively moderate levels of subsequent cold. Injured bark is sensitive to diseases. In addition, apricots have varying heat requirement for spring bud break. Types with low heat requirement bloom very early and are extremely sensitive to spring frost during or after bloom. Considering these factors, it is not surprising that there are many climates in which apricot cultivars do not do well. A better understanding is needed of the factors that limit cultivar adaptation and lead to better breeding and selection methods for improved cultivar adaptation.

Apricots are best for eating when the fruit is completely ripe. Apricot fruit softens fast when ripening is initiated. Apricots readied for the fresh market must be harvested relatively early to prevent softening during marketing. The use of fresh apricots decreased when the fresh fruit had to be harvested early and was transported over long distances because of significant losses in flavor quality and losses caused by brown rot following harvest. This resulted in limited market potential for fresh fruit. Apricots would be a good candidate for genetic transfer of traits that keep the fruit firm. If a non-softening type, or non-melting flesh equivalent to processing peach is created, we consider apricot to be a fruit whose time is still to come as a fresh market fruit. More mention should be made of the unique and varied flavors of apricot (more so than peach). The problem is that most consumers have never tasted a tree-ripened apricot and have no idea what an excellent, aromatic flavor is waiting for them to discover.

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Origin and Dissemination of Plums

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I. INTRODUCTION

Plums are a diverse group of plants. The fruits may be small or large, round or elongated, green, black, purple, blue, red, or yellow; the trees may be shrub-like with slender branches, or have a strongly constructed framework; and the foliage may be delicate or the leaves may be coarse and heavy and occasionally red, retaining an attractive appearance all summer. Hedrick (1911) commented that the range of fruit size and shape, flavor, aroma, texture, and color in plums is greater than in any of our orchard species. The silhouettes of fruit of a few typical plums are illustrated in Fig. 1.

The diversity of plums is also expressed in their names. There are plums, prunes, bullaces, damsons, date plums, green-gages, mirabelles, cherry plums, egg plums, and sloes. The origin of plums also varies. Some species originated in Asia, others in Europe and America.

Plums are eaten fresh or dried. Accordingly, a distinction is made between plums and prunes. Stubenrauch and Wickson (1927) defined prune as a plum that dries whole without fermenting. The fruits used for making prunes are also used fresh and are then called plums. Plums are used dried, or are made into jelly, jam, juice, liquor, brandy, cognac, and cordials. They are also used in baking and for confection.

Plums may have been the first species among all the fruits to attract human interest. Three of the most important species of plums. *P. domestica, P. salieina* and *P. simonii* are not known in the wild and presumably were selected cultivated very early by humans. It is more remarkable that the earliest cultivation of *P. domestica* began somewhere between Eastern Europe and the Caucasian mountains, whereas *P. salieina* and *P. simonii* were brought into cultivation in Asia.

In China, since ancient times, millions have extolled plum blossoms. According to the Chinese, "plum" blossoms defiantly brave snow and frost and spread their fragrance when they bloom in cold winter and greet the new spring before all plants begin to wake up. Lu You (11251210) wrote more than 600 poems in praise of "plum" blossoms (Wang 1994). Lin Hejing (420-589) devoted all his efforts to creating paintings of "plum" blossoms. From the Tang Dynasty (618-907) to the Qing Dynasty (1644-1911), there were about 250 famous artists who specialized in "plum" paintings (Wang 1994). Even though the Chinese say "plum," the paintings depict blossoms of *Prunus mume,* a *Prunus* species that is closely related to apricots. The early bloom time also indicates that the flowers painted belong to the species *P. mume.* In Japan, *mume* is often called "Japanese apricot" or "Japanese plum" (Yoshida 1994) and in China "Mei plum" (Wang and Ma 1986). Close examination of the flowers indicates that the flowers of *P. salicina,* the Chinese plum, are sufficiently different from those found in the paintings (Fig. 2). Although it is beautiful, the Chinese plum art does not illustrate plums per se, but a species closely related to apricots.

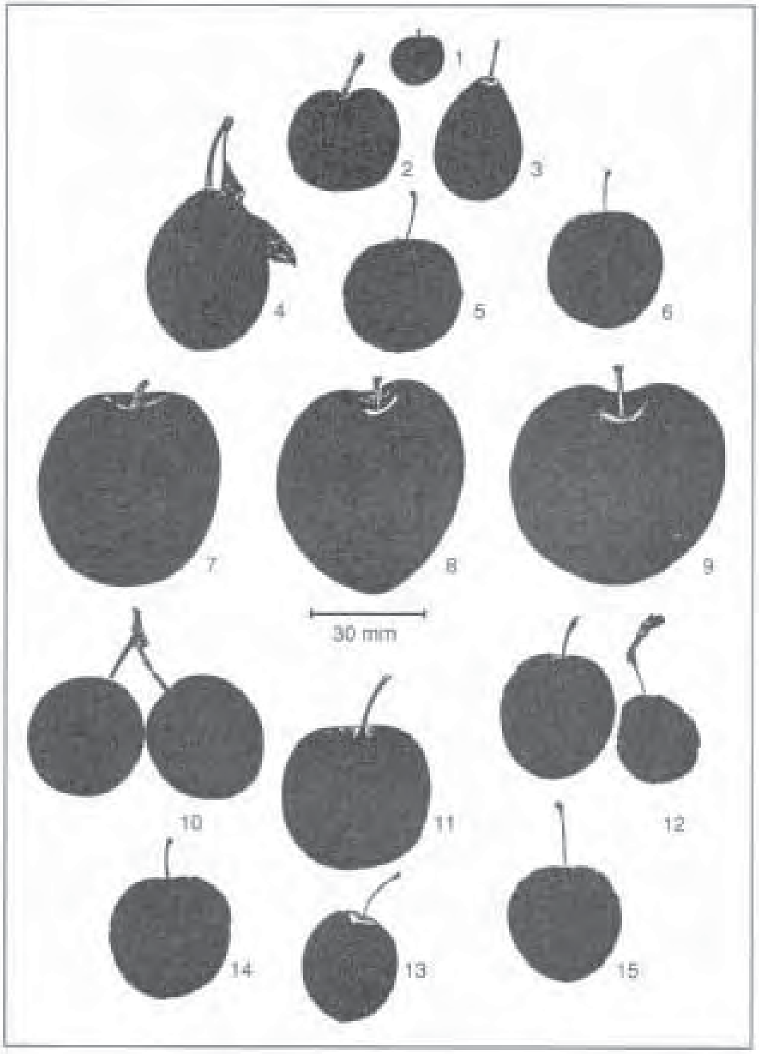

Fig. 1. Silhouettes of various types of plums. 1. Sloe *(P. spinosa),* 2. Bullace *(P. insititia),* 3. Damson *(P. insititia),* 4. 'Italian prune' *(P. domestica),* 5. *P. cerasifera,* 6. 'Arkansas' *(P. munsoniana),* 7. 'Santa Rosa' (hybrid), 8. 'Burbank' (hybrid), 9. 'Friar' (hybrid), 10. 'De Soto' *(P. americana),* 11. 'Green Gage' or 'Reine-Claude' *(P. domestica),* 12. 'Forest Garden' *(P. hortulana minenl,* 13. Mirabelle *(P. domestica),* 14. 'Cheney' *(P. nigra),* 15. 'Pottawattamie' *(P. americana).*

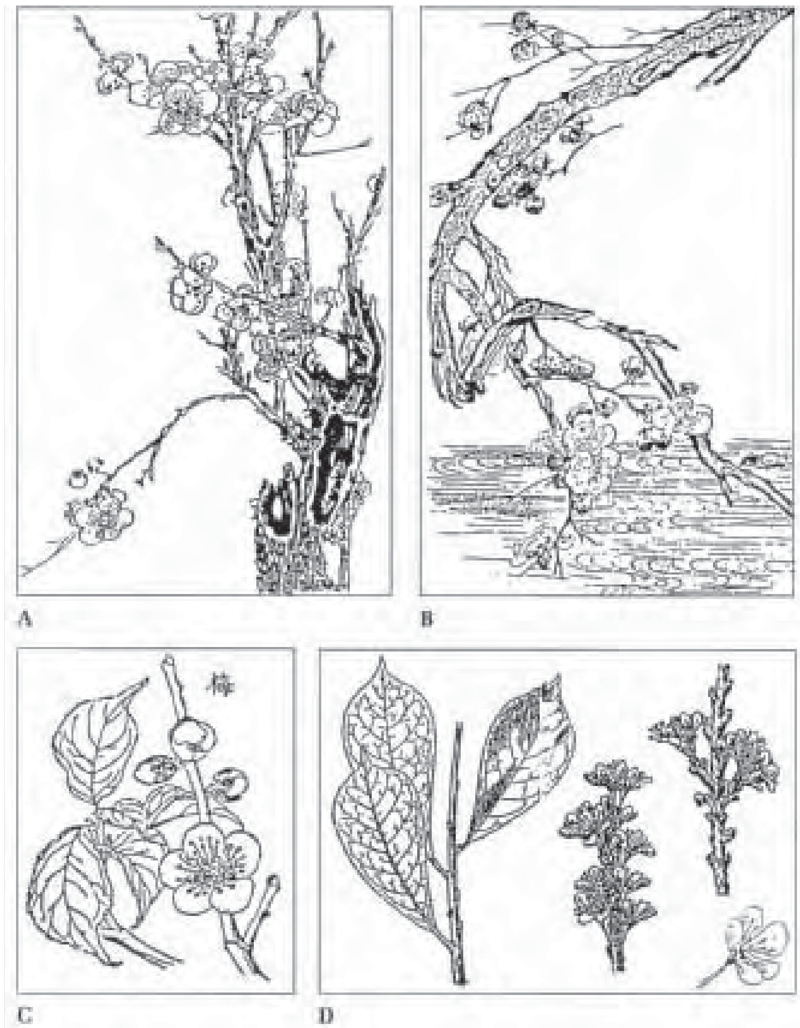

Fig. 2. Comparison of flowers. A and B. Colored Chinese woodcuts from 1782. Flowering "plum" trees by an unknown artist in Hsu Hai (V. dynasty) style (Hejzlar 1972). C. Flowers of *Prunus mume* from the Chinese botanical dictionary. D. Flowers of *P. salicin*a drawn after specimens in the herbarium of the Royal Gardens, Kew, as *P. triflora,* Roxbg. (Bailey 1927). Note that the flowers of the "plum" painting resemble those of *P. mume,* (a species closely related to apricots) and not of *P. salicin*a (the plum of China).

In Transylvania, Romania, plum seeds were used as the motif in wood carvings on gift items. In these motifs, occasionally two or three seeds were delineated, five oval shapes of seeds were arranged as a rose, or four oval-shaped seeds were carved in a diagonal pattern (Fig. 3) (Kos 1980).

World production of plums has remained constant during the last decade, with the exception of Asia, where production has doubled since the early 1980s. World production is 7 million tonnes (Table 1), a third of which is produced in Europe and an equal amount in Asia. The largest concentration of dried prune production is in California, which dries nearly 90 percent of its prune output. Plum production is divided into two categories. Production of hexaploid prunes *(x),* including *P. domestica* and *P. insititia* cultivars, in 1987-89 was, in thousand tonnes (numbers in parentheses indicate production of dried prunes): United States 640 (610); former Soviet Union 977; Yugoslavia 780 (37); Germany 431; Hungary 195; France 90 (90); Chile 30 (30); Argentina 30 (30). Production

Fig. 3. Various motifs used in carving in Transylvania that were derived from the plum seed.

Table 1. Worldwide production of plums in thousand tonnes; data from FAO (1990, 1992,1994).

Continent years	1979-1981	1988	1989	1990	1991	1992	1994
Africa	78	117	154	154	131	144	149
North Central America	719	755	1011	843	987	980	1035
Asia	863	1341	1427	1582	1537	1619	2634
Europe	2862	3208	2818	2196	2008	2433	2688
Oceania	26	22	24	24	23	24	17
Former USSR	873	1000	1166	1000	800	800	738
World	5518	6584	6750	5960	5655	6181	7261

of diploid *(2x)* plums, including Asian and native American cultivars and their hybrids, was in 1987-89, in thousand tonnes: China 789; United States 226; Spain 77; Italy 58; Argentina 48; Mexico 84; Japan 68; Korea 36; Pakistan 48; Egypt 38; South Africa 17; and Australia 18. (Okie and Weinberger 1996).

Outstanding reviews of plum cultivars and history include Hedrick (1911), Wight (1915), Cullinan (1937), Weinberger (1975), Roach (1985), Ramming and Cociu (1990), Körber-Grohne (1996), and Okie and Weinberger (1996). Plum rootstocks have been reviewed by Okie (1987).

II. CLASSIFICATION

A. Botanical

The early history of genus *Prunus* is inherently connected with that of plums. Pre-Linnean botanists John Ray (1627-1705), Joseph Pitton de Tournefort (1656-1708), Johann Jacob Dillenius (1687-1747), and Herman Boerhaave (1668-1738) considered *Prunus* to include only plums. Carolus Linneaus (1707-1778) adapted the name *Prunus*, used by his predecessors for the plum alone, for a genus in which he placed plums, cherries, apricots, and seven other species. Michael Adanson (17271806) and Antoine Laurent Jussieu (1748-1836) of France returned to the pre-Linnean classification, but Joseph Gaertner (1732-1791) of Germany followed the grouping of Linneaus. The controversy continued. Augustin Pyramus De Candolle (1778-1841), Johan Jacob Roemer (1763-1819) of Switzerland, and Joseph Decaisne (1809-1882) of France held that the plum alone belongs to *Prunus*. George Bentham (1800-1884) and J. D. Hooker (1785-1865), authors of *Handbook of the British Flora* Asa Gray (1810-1888), a Harvard botanist, and his coworkers; and Adolf Engler (1844-1930) and Karl Anton Prantl (1849-1893), authors of *Natürlichen Pflanzenfamilien*, published in Berlin, extended the genus *Prunus* to all of the stone fruits. Even after the number of plants belonging to the genus *Prunus* appeared to be settled, Nathaniel Lord Britton and Addiston Brown, Director and President of the New York Botanical Garden, respectively, in their *Illustrated Flora of the Northern nited States*, in 1898, listed only plums and cherries under the genus *Prunus*. The diversity of views of what species belong to *Prunus* is an indication that differences separating the species are not very distinct. The difficulty is not eased by restricting discussions to plums alone.

Most plum species are diploid $2n = 16$; the sloe is tetraploid $2n = 32$, but in the Caucasian mountains in Georgia, *P. spinosa* has been found with $2n = 16$, 32, 48, 64, or 96 and *P. cerasifera* with $2n = 32$ or 48 (Zohary 1992). *Prunus* hybrids have intermediate chromosome number, $2n = 40$, and *P. domestica* and *P. insititia* are hexaploid $2n = 48$. Weinberger (1975) lists 18 species that are horticulturally important. Only 12 species are important for the purposes of this historical discussion. For the complete list of cultivated plum species, readers should consult Bailey (1927) or Rehder (1954).

1. Basic S ecies. The two basic species are *Prunus spinosa* and *P. cocomilia*. *P. spinosa* L., known as sloe or blackthorn, is a low, spreading, thorny bush. Leaves are small, oblong, elliptic-ovate, and very numerous. Flowers are white, small, borne singly or in pairs and often occur on thorns. Fruit is small, not larger than a large pea, blue, and usually persists until the winter. This species is widespread in Europe, North Africa, and Northern Turkey. Botanically recognized forms are ssp. *frutieans (macrocarpa)*, a larger bush with less thorn and larger fruit and ssp. *dasyphylla (tomentosa)*, a pubescent bush. Garden

forms are: f. *plena* with double flowers and f. *purpurea* with pink flowers and purple foliage. Bajashvili (1990) encountered arborescent forms of sloe in the Caucasian mountains with larger leaves and larger, less astringent fruit. Some of these forms appeared to be polyploid, $2n$ = 48, 64. Some forms were closer to myrobalan (see *P. cerasifera* below), when characterized by various combinations of fruit color, leaf size, and bud size. Pollen of these forms appeared to be closer to the pollen of *P. domestica.* Russian botanists (see Zerov 1954) described *P. spinosa* ssp. *macrocarpa* as *P. stepposa*, elevating it to the species level. They also described another variant as *P. moldavica* Kotov. *P. spinosa* is clearly a polymorphic species.

P. cocomilia Ten. (Syn. *P. pseudarmeniaca* Held. and Sart.) is known as mock apricot. It is a bush or small tree with thorny branches. Leaves are oval or broadly ovate, more or less pubescent. Flowers are white or greenish white, in pairs, appearing with the leaves. Fruit is small yellow, oblong-ovoid, rather good for eating. The species has been described as being from Italy, but it is native in the southern part of the Balkan peninsula on the sides of high mountains and near the Mediterranean coast of Turkey (Brovitz 1972). Var. *puberula* Schneider has been described, but in the opinion of Borvitz (1972) it may be a hybrid of *P. spinosa* × *P. cocomilia.*

P. cerasifera Ehrh. (Syn. *P. domestica* var. *myrobalan* L.; *P. myrobalana* Loisel.) is known as cherry plum. The French cherry plum, commonly called myrobalan, is widely used as plum rootstock. Cherry plum is a slender, often thorny, shrub-like small tree. Flowers are small, white, comparable with most types of *P. domestica.* Fruit is small, less than 2.5 cm in diameter, globular, cherry like, yellow or red with soft, sweet, juicy flesh, depressed at stem end. The species is native from the Balkans to the Caucasian mountains and southwest Asia. Fresh and dried fruit of *P. cerasifera* have been used for centuries in the Tien Shan and Pamir mountains and seedlings are widely used as rootstocks for domestica plums. The fruit color of cherry plum is highly variable. D. (unpublished) found yellow, red, purple, and black colored fruits of myrobalan when he explored plum species in Asia Minor.

Some botanists differentiate between the cultivated and wild forms of *P. cerasifera.* They contend that the cultivated form is *P. cerasifera macrocarpa* Erem. & Garkov., whereas the wild form is *P. divaricata* Ledeb. *P. divaricata* was collected in the Trans-Caucasian region by Ledebour, who named it in 1820, and is native from Macedonia to northern Persia. The tree is branching from the base with branches quite prostrate with yellow fruit. Bailey (1927) considered the botanical position of *P. divaricata* Ledeb. as var. *divaricata* Bailey [Syn. *P. divaricata* Ledeb., ssp. *divaricata* (Ledeb.) Schneid.], but decided that it was not different from the main species or at best is only a form of it. Therefore, it does not deserve species status. There are other recognized forms of *P. cerasifera* based mostly on eco-geographical adaptation: ssp. *ursina (P. ursina* Kotschy) grows in southeast Turkey and Syria; ssp. *caspica (P. caspica* Kov. & Ekm.) occurs in the Caspian coast of Caucasia; var. *iranica* (Koval.) Erem & Garkov, the Iranian cherry plum; and var. *nairica* Koval., the form frequently found in Armenia. These subspecies were considered separate species, as indicated by the name in parentheses. However, after collecting a large number of specimens, Kovalev (1939) came to the conclusion that the Syrian, Caspian, and Armenian forms are not sufficiently different from the main species to consider them distinct species and should be considered only as a botanical variety of P. *cerasifera.* As mentioned above, there are tetraploid and hexaploid races of P. *cerasifera* but they are morphologically very similar to the diploid species (Watkins 1981; Beridze and Kvatchadze 1981). Eryomin (1991) remarked that the Iranian and Armenian forms of cherry plum appear to be cultivated types with larger fruit than the other wild types.

Cherry plums have many hybrids, among which those that are well known are the Marianna plum, *(P. cerasifera* × *P. munsoniana* 'Wild Goose') and 'Methley' *(P. cerasifera* × *P. salicina).* Kovalev (1941) also described *P. ferganica,* a hybrid of *P. divaricata* and *Amygdalus ulmifolia.* There are probably many other hybrids because *P. cerasifera* can be crossed with several *Prunus* species.

In their deliberations, various authors throughout their botanical sections often noticed and discussed "larger fruited types" of a given species. The larger fruited forms are often designated *macrocarpa.* In our experience, when wild fruited species are crossed, tree and branch structure and leaf and bud morphology of the seed parent are transmitted to the progeny but fruit size increases. Often we could not distinguish between seed plant and its F1 seedlings until the seedlings fruited. Although our experience is limited regarding plums, we wonder whether the *macrocarpa* forms are true forms of the species or hybrids with a larger fruited pollen donor.

There are ornamental forms of P. *cerasifera.* Best known among them are the var. *planteriensis* Hort. with full double red or white flowers; var. *pendula* Hort., a weeping form; and var. *acutifolia* or *angustifolia* Hort., a form with narrow willow-like leaves. Var. *pissardii (P. pissardii* Carr, *P. cerasifera* var. *atropurpurea* Dipp), a form with purple leaves and dark red fruit, was introduced to France by Pissard, the French head gardener to the Shah of Persia in 1880. Today, there are at least 50 cultivars of red leafplums, excluding known synonyms (Jacobson 1992). Yoshida (1987) increased the importance of this species by suggesting that P. *cerasifera* is the progenitor of all plum species, because of its wide native range and cross compatibility with many other plum species.

2. arden Plum and Damson. These include *P. domestica* and *P. insititia* and all their variations. P. *domestica* 1. (Syn. *P. communis* Huds., *P*. Borkh., *P. domestica* ssp. *oeconomica* Schneid., *P. sativa* Rouy et Cam., *P. italica* Borkh.) is known as the common garden plum. It is a strong-growing small tree. Leaves are large, thick, dark green. Flowers are white, large, usually in clusters. Fruit varies in form but is firm in texture and usually not depressed at stem end. This is the most important plum species in cultivation today. Linneaus, in 1753, divided *P. domestica* into 14 sub-species using the list of Bauhin published in his *Pinax Theatri Botanici* in 1623. Both of them included species other than *domestica* in their description of garden plum. *P. domestica* is unknown in an originally wild state and the typical form of this species is the prune. Crane and

Lawrence (1952) suggested that *P. domestica,* a hexaploid, originated as a hybrid between *P. cerasifera* Ehrh., a diploid, and *P. spinosa,* a tetraploid, via either chromosome doubling of the hybrid tetraploid or a product of unreduced gametes from both parents. Crane (1949) indicated that native areas of *P. spinosa* and *P. cerasifera* overlap (Fig. 4) and a hybrid could occur. Crane and Lawrence (1952) reasoned that *P. cerasifera* has a yellow base color and red anthocyanin in its skin, while *P. spinosa's* has green ground color and blue skin color. The supposed hybrid, *P. domestica,* has both green and yellow undercolor and red and blue skin colors that apparently combine the characteristics of both parents. Rybin (1936) found spontaneous, highly sterile interspecific hybrids between *P. cerasifera* and *P. spinosa* in the Caucasus, in the Maikop area: Rybin crossed the two species and obtained seedlings that he regarded as resynthesized *P. domestica.* Endlich and Murawski (1962) also crossed *P. cerasifera* and *P. spinosa.* The F1 generation was nearly sterile, but the F_z generation had about 50 percent of its seedlings with *2n* =48 chromosomes. The hybrid nature of *P. domestica* was further emphasized by Zhukowsky (1965). Several authors (Johansson and Olden 1962; Webb 1968; Weinberger 1975; Watkins 1976, 1981; and Zeven and De Wet 1982) accepted the explanation that the garden plum is a hybrid of *P. cerasifera* and *P. spinosa.* Subsequent cytological studies indicated that the origin of *P. domestica* is more complex since *P. spinosa* itself may be a tetraploid containing two different genoms (Salesses 1973; Reynders and Salesses 1990). Eryomin (1991) suggested that *P. domestica* is a hybrid of *P. spinosa* and *P. cerasifera macrocarpa,* the cultivated form of myrobalan, and placed its origin in the area where cultivated forms of cherry plum existed, namely Iran, Trans-Caucasian countries, and Asia. Zohary (1992) argued that the evidence supporting an allopolyploid origin of *P. domestica* and the participation of *4x, P. spinosa* in the formation of this species is far from being satisfactory. He proposed that the available cytogenetic evidence seems to indicate that *2x, 4x,* or *x, P. cerasifera* was the sole wild stock from which the cultivated *x,* garden plum could evolve. Reynders and Salesses (1991) tried to use Restriction Fragment Length Polymorphism (RLFP) to study the origin of garden plum, but they were unable to obtain restriction patterns sufficiently satisfactory to establish a definitive map.

Brovitz (1972) described native or naturalized stands of *P. domestica* on hillsides and slopes up to 1900 m elevation in Turkey. Lin and Shi (1990) reported stands of *P. domestica* in wild forests along the Ili River in Northwestern Xinjiang Province of China with neither of the presumed parental species nearby. Since the IIi valley is the major crossing road of the silk route through the Tien Shan mountain range, the possibility exists that seeds of *P. domestica* were carried there rather than the species being native there.

P. domestica is considered a relatively young species. None of the Neolithic seed remains are helpful in establishing the origin of *P. domestica.* Werneck (1959), using archeological evidence, concluded that *P. domestica* is indigenous to middle Europe.

Fig. 4. Overlapping areas of *P. cerasifera* and *P. spinosa* after Terpo (1974) 1=*P. spinosa*; 2=*P. cerasifera*. The eastern extent of the range of *P. cerasifera* is undetermined, hence the loop is not closed.

Gavrilovic and Paunovic (1962) pointed to a population of *P. domestica* Widespread in Hungary-Serbia-Bosnia and the neighboring countries of Romania and Bulgaria, under the names of 'Pozegaca' (Serbia), 'Besztercei' (Hungary), 'Küstendili' (Bulgaria), often referred to as the Pozegaca Besztercei group, and placed the origin of this species in the Balkans. Terpo (1974) considered the overlapping areas of *P. cerasifera* and *P. spinosa* where a hybrid could occur and placed the origin considerably further east into northern Turkey or the southern Caucasian area (Fig. 4). Eryomin (1991) also considered Trans-Caucasia or Iran as the place of origin for *P. domestica.*

Because of the variable fruit, a number of subgroups have been proposed as subspecies of P. *domestica.* Such subgroups are the prunes, the Reine-Claude or green-gages, and the yellow egg plums. Bailey (1927) thought that P. was also a variety of this species. However, there are reasons to believe that *P. insititia* is distinctly separate and it is regarded here as a separate species.

Kárpáti (1967) studied the flower structure of plums. He especially considered petal shape and color. Based on this study, he rearranged the plum types belonging to the two species, *P. insititia* and *P. domestica,* as follows: (1) *P. insititia* Jusl. includes *P. italica* (Borkh.) Karp. (damsons); convar. *pomarium* Boutigny; convar. *claudiana* Poiret (Reine-Claude); convar. *ovoidea* Martens (egg plums); and convar. *mamillaris* Schubl. et Mart. (date plums). (2) *P. domestica* L. includes *P. syriaca* (Borkh.) Karp. (Mirabelle group); convar. *prisca* (Werneck) Karp.; convar. *cerea* (L.) Karp. This arrangement is the opposite of the arrangement of plum groups that other botanists previously believed in. It puts the Reine-Claude group, the egg plums, and the date plums into *P. insititia* and the Mirabelle group into *P. domestica.* He has not only rearranged these well-defined plum groups but has also disputed the parental species that produced the hybrid nature of some of them. For example, he claimed that *P. syriaca* (Borkh.) Karp. is a *P. cerasifera* × *P. domestica* hybrid instead of *P. syriaca* Borkh., a *P. domestica* × *insititia* Koch hybrid. His study and reclassification reaffirms our opinion expressed before that plums are a group of fruit with widely hybridized plants and it is difficult to find the original species upon which to base the botanical classification. Petal shape and flower color are variable characteristics and in plants such as petunia, cultivated and perhaps hybridized since ancient times by the South American Indians, a great variability exists that is independent from other characters. Therefore, it is questionable how much advancement Kárpáti's classification contributes toward sorting out the basic plum species.

Prunes. In western America, the word *prune* is used for plums that can be dried whole. In Europe the term is used to designate a distinct pomological group of plums in which fruit is usually reddish or blue, elongated, high in sugar content, and firm. The fruit is excellent for drying. Prunes are part of the Pozegaca Besztercei group. There are many cultivars with prune in their name. William Prince (1828) speaks of 'Italian Prune', a cultivar originated in the early 1800s in Lombardy, Italy, and William Robert Prince (1831), in his *Pomological Manual,* describes the 'German Prune' and 'Agen', the 'French Prune'. The origin of the 'German Prune' is uncertain. First described in 1771, 'German Prune' is generally believed to have been carried to Europe from Asia during the Crusades. Smith (1978) lists *Musquee de Beszterce,* and *uetsche Musquee de Hongrie* as synonyms for 'German Prune' and remarks that it belongs to the group that in Germany was called small *Zwetschen* or *Hauszwetschen.* She remarks that 'German Prune' reached Germany in the 1600s and the name *uetsche* or *Zwetsche* was not widely used until 1700. The origin of 'Agen' also goes back to the times of the Crusades when the Benedictine monks brought the 'Date Plum' from Turkey or Persia. It was planted in their garden in the vicinity of Bordeaux, France, and afterwards became the 'Agen' (Hedrick 1911). It was recorded in 1796 and first called 'd'Ente'. The 'French Prune' belongs to a group of red prunes indistinguishable from 'Agen'. Since the discovery of 'Agen' many of its hybrids have been introduced at various locations (Odier 1993).

The locality of origin of 'German Prune' and 'Agen' underscores the opinion of Terpo (1974) and Eryomin (1991) that the origin of *P. domestica* is located east of the Balkan peninsula. The Romans planted large orchards of prunes in Pannonia (northern Balkans and southern Hungary), which may have caused the confusion about the origin of this group and could explain the Hungarian synonyms of the 'German Prune' described above ('Musquee de Beszterce' and 'Quetsche Musquee de Hongrie').

Reine-Claude Gages. These comprise a number of round, very high quality, golden or green plums classified by botanists as either subspecies or distinctly different species. In 1753, Linnaeus called them *P. domestica cereola* in 1803, Borkhausen named them *P. italica* in 1904, Poiret separated them under the name *P. claudiana.* The origin of the Reine-Claude group, like the origin of the other *P. domestica* subspecies, is also unknown. Koch (1876) found plums in the

Trans-Caucasian regions that were very similar to Reine-Claude, and assumed that Reine-Claude originated in that region. In 1545, a French botanist, Pierre Below (1517-1564), brought Reine-Claude gages to the Chateau de Blois from Italy (Blanchet 1996). Duhamel de Monceau illustrated it in 1768 (Fig. 5). Hogg (1884) thought that Reine-Claude was brought from Greece to Italy and was cultivated under the name of Verdocia. He probably based his opinion on Parkinson's (1629) cultivar of Verdoch, which is thought to be the present-day 'Green Gage'. Gallesio (1817-31) illustrated 'Verdacchia' (Fig. 8.13B) as a prune and not as a 'Green Gage' (or 'Reine-Claude'). Hedrick (1911) summarized a number of reasons why Verdocia was not Reine-Claude, which leaves the origin of Reine-Claude uncertain.

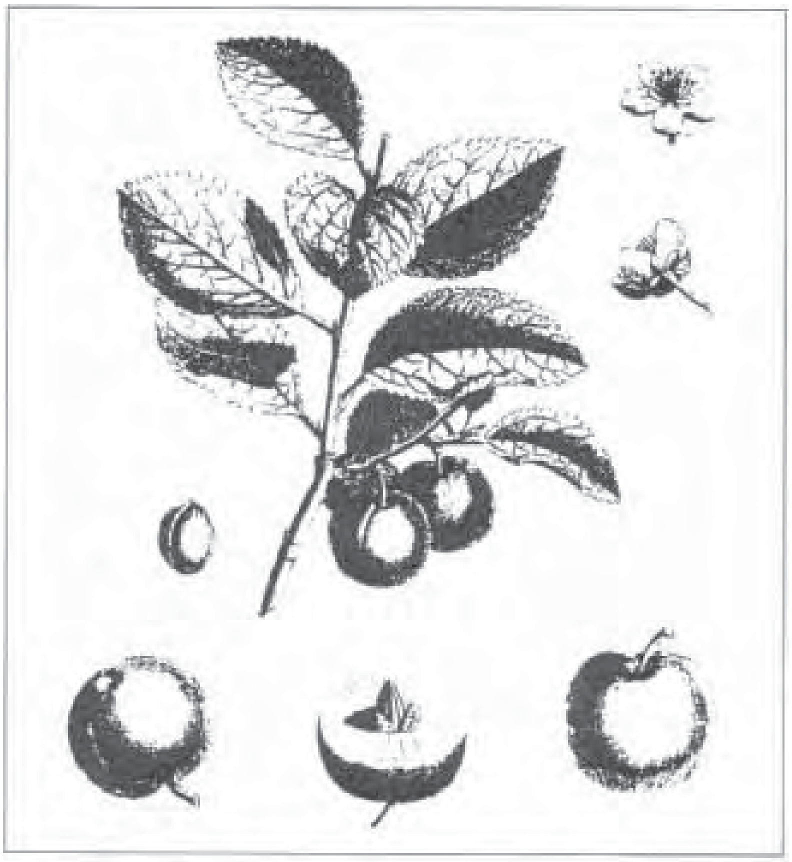

Fig. 5. Reine-Claude illustration in Duhamel du Monceau’s Traite des Arbres fruitiers, 1768.

Yellow Egg Plums. This group has large, distinct, handsome fruit. Parkinson (1629) mentioned 'Imperial', which later became 'Red Magnum Bonum', as a cultivar belonging to the yellow egg plums. In 1676, John Rea described 'Yellow Egg', and Knoop of Holland used the name of 'Prune d'Oeuf Blanche' in 1771, indicating a French origin. Duhamel, in *Traite des Arbes Fruitiers* (1768), described Yellow Egg as the 'Dame Aubert'. Kraft in *Pomona Austriaca* (1792), used the name 'Die Grosse Weisse Glanzende' or 'Die Albertus Damenpflaume'. These references show that the Yellow Egg group had an early origin.

Hedrick (1911) classified a few additional groups, the *Perdigon plums,* the *Imperatrice plums* and the *Lombard plums.* None of these groups received the attention of botanists required to separate them as subspecies or botanical varieties; therefore, their botanical importance is questionable today.

P. insititia L. [syn. *P. insititia subsylvestris* Boutigny, the wild form, *P. insititia* var. *Juliana (subsylvestris)* Boutigny, *P. domestica* var. *insititia* Bailey, *P. domestica* subsp. *insititia* (Jusl.) Schneid., *P. domestica* var. *nigra* A. and G., *P. insititia syriaca* (Borkh.) Koechne, *P. italica* (Borkh.) Ashers and Graebn., *P. insititia* Borkh., *P. claudiana* Poir] includes damson, bullace, mirabelle, and St. Julien. *P. insititia* cultivars are readily distinguishable from the garden plum. The trees are dwarfer and more compact, leaves are much smaller and more ovate, fruits are smaller, less than 2.5 cm in diameter, purple or yellow without intermediate colors and the stones are smaller but much more swollen than those of the garden plum.

During the years since the description of *P. insititia,* several subdivisions have been proposed. However, according to Brovitz (1972), who studied this species extensively in Turkey, it is difficult to distinguish truly wild and cultivated populations. Some of the subdivisions, such as *P. pomarium* Boutigny, *P. insititia glaberrima* Wirtg., var. *alpina-orientalis* Werneck, and var. *leopoldiensis* Simk., have lesser importance. Others are easily distinguishable and are important. Among the important subdivisions one must consider P. *insititia syriaca* (Borkh.) Koechne, the mirabelles, which are used for fruit in France, and *P. insititia* var. *Juliana,* the St. Julien plums, which are used extensively as rootstocks.

Hedrick (1911) discussed the name bullace. According to him, it is difficult to distinguish between damsons and bullaces. The name bullace refers to the round shape of the fruit but it is not certain who used it first. Apparently there are variations of this name, of which *bullis, bulloes,* and *bullum* were the most common. Murray (1888) claims that the word began to be used in 1688 by R. Holme, who used the word to describe a spinous or thorny shrub whose fruit may be eaten as bullas. In 1862, W. Coleman defined bullace by writing that "The Bullace is a plum ... a variety of the common sloe, from which it chiefly differs in the superior size of all its parts especially the fruit" (Murray 1888). Today it is difficult to identify any cultivars clearly belonging to this group.

There are differences of opinion about the systematic position of the mirabelle plums, *P. syriaca* Borkh. (Syn. *P. insititia* var. *syriaca* *P. domestica* × *P. insititia* Koch). The tree is small. Leaves are elliptic and pubescent. Flowers are greenish-white. Fruit is round, yellowish or golden, more or less freestone. The assumption is that the word *mirabelle* is derived from *mirable,* meaning wonderful, and it was used first by the French. Mirabelle plums are important in France and are regarded as diminutive of Reine-Claude. Hedrick (1911) stated that they are not *P. cerasifera* hybrids, yet Terpo (1974) still lists them as *P. cerasifera* × *P. domestica.* Thus the opinion is divided on the hybrid origin of this type. It is believed that they came from Asia Minor or Armenia and entered into Roman colonies through the Mediterranean area (Wadier 1991) and were introduced to the Lorraine region of France by Rene (1409-1480), provincial monarch of Lorraine. There are early maps indicating that mirabelles were planted in orchard settings as early as 1749 around the village of Soncourt, France (Fig. 6).

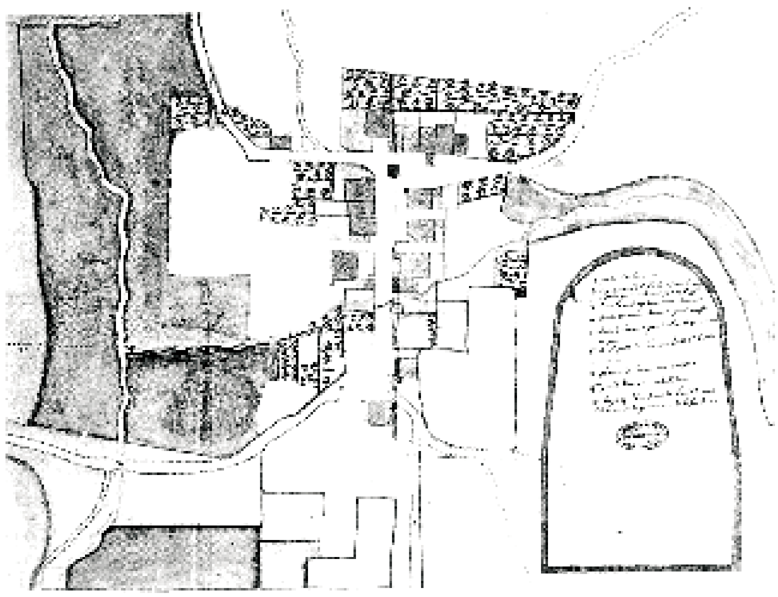

Fig. 6. Mirabelle orchards around the village of Soncourt, France, 1749. (after Wadier 1991). The sizeable orchard shows the extent of plum growing at that time. It is notable that the orchards are around the village and not in a mediaeval walled-in garden, as was customary in the Italian and French gardens a century earlier.

St. Julien plums are classified by some as *P. insititia* var. *juliana (sub-sylvestris)* Boutigny. This is an upright group with pubescent leaves beneath, and with medium size, dark blue fruit with long peduncules. In 1754, Miller described a plum as "St. Julien" (Hedrick 1911). In 1804, Poiret reclassified it (Lamark and Poiret 1804) as *P. domestica* 1. subsp. *insititia* Schneider var. *juliana* (L) Poiret. It finally became a botanical variety of the species *P. insititia.* Both Miller in 1754 and Carriere in 1892 speak highly of St. Julien plums as rootstocks (Hedrick 1911). The rootstock characteristics of St. Julien plums were discussed throughout the old horticultural literature. Whether the St. Julien name ever was applied to a specific cultivar is unknown. Küppers (1976), after studying St. Julien plums for 40 years, came to the conclusion that St. Julien was not a cultivar but a plum type ranging in appearance from small fruited plums to wild bullace to a large-leafed wild plum *(P. spinosa),* creating an extraordinary picture of hybridization within the section of *Prunophora.* According to him, there was a group of plums in the Loire Valley in the Nievre region that were processed for prunes in the Middle Ages. As nurseries increased in the 1850s, they planted seeds of "St. Julien" plums for rootstocks. Even at the time of their first use, seedlings of St. Julien were known for their great non-uniformity, susceptibility to diseases, and deficient compatibility with peach. Carriere in 1892 started vegetative propagation of St. Julien and selected better types. As time progressed, only the vegetatively propagated types remained (Küppers 1976). Among the old recognized forms are 'Petite St. Julien', 'Gros St. Julien', and 'St. Julien de Toulouse.' Several clonal selections have been made, including a series designated by letters (St. Julien A, B, C, J, K) made in East Malling, England (Tukey 1964) and newer ones made in France. Thus, St. Julien became a well-defined series of rootstock cultivars after about 500 years of existence.

. Asiatic S ecies. The Asiatic species include *P. salicina* and *P. simonii. Prunus salicina* Lindl. (syn. *P. triflora* Roxb.; *P. japonica* Hort.; *P. Hattan* Tamari; *P. ichangana* Schneid.; *P. botan* Hort.; *P. masu* Hort.), known as the Japanese plum, is a strong-growing small tree. Leaves are oblongovate, pointed, shiny, and dull beneath. Flowers are few from each bud (commonly about 3), and white. The fruit is variable, large and firm; skin is yellow or light red. Some cultivars, such as 'Satsuma', have red flesh, and others, such as 'Kelsey', have greenish flesh. As with *P. domestica*, the wild form of this species is unknown. According to Yoshida (1987), *P. salicina* may have originated in the Yangtze River Basin and was spread across eastern China. The history of 'Zhui Li' cultivar goes back more than two millennia. Species described under various names, such as P. *ussuriensis* Kov. and Kost., P. *gymnodonta* Koehne, P. *thibetica* Franch., and P. *consociiflora* Schneid, are all P. *salicina* with minor variations and would not be considered separate species today. An early illustration of plum in a book by Hsu Kwan-Chi (1562-1633) probably depicts P. *salicina* (Fig. 7).

Fig. 7. Illustration of plum in Hsu Kwan-Chi’s (1562-1633) book, *Encyclopedia of Agriculture*.

Prunus simonii Carr. (syn. *Persica simonii* Decne.) is known as Simon or apricot plum. First described in 1872 (Kovalev 1941), it has no wild form, but was in cultivation in China, Japan, and Central Asia in the 1st century. The tree is conspicuous because of its narrow, erect habit. Flowers are white, 2 or 3 together, and precede the leaves in the spring. Fruit is 2.5 to 5 cm in diameter, firm in texture, smooth, maroon red, adhering to the small pit. Botanical position is doubtful since it has some characters of apricots. Chow (1934) describes it as an occasionally cultivated plant of north China. Because of its resemblance to apricot, it is often considered an apricot-plum hybrid. Okie and Weinberger (1996) think that it is more likely an upright form of *P. salicina.* It is also used in the California hybridization programs as parent of the so called California Japanese plum cultivars because of its firm flesh and strong flavor.

. American S ecies. Five American species are discussed here: *P. americana, P. nigra, P. angustifolia, P. hortulana,* and *P. munsoniana.* The other species can be found in botanical books by Rehder (1954) or Bailey (1927), or in a description by Hedrick (1895). Other American plum species are less important in the origin of commercial cultivars and are not discussed here in detail. These include *P. subcordata* Benth., Pacific plum, native of California and Oregon; *P. mexicana* Wats., big-tree plum, native from southwestern Kentucky to western Tennessee to Oklahoma and Mexico; *P. rivularis* Scheele, creek plum, native in Texas; *P. orthosepala* Koechne, native from Kansas to Texas; *P. alleghaniensis* Porter, Allegheny plum, native from Pennsylvania to Connecticut; *P. umbellata* Ell., black sloe, native near the coast from South Carolina to Florida; *P. maritima* Marsh., beach plum or shore plum, native from New Brunswick to Virginia; *P. gracilis* Engelm. & Gray, Oklahoma plum, native to western Arkansas, Oklahoma and northern Texas; *P. lanata* (Sudw.) Mack. & Bush, common from Illinois to Texas [Gray considers it a variety of *P. americana* and named it accordingly *(P. americana* var. *mollis* Torr. and Gray)]; and *P. reverchonii* Sarg., hog plum, native in Oklahoma and Texas. Rehder (1954) considers it closely related to *P. rivularis* and thinks that it may not be different from *P. rivularis.*

P. americana Marsh. (syn. *P.latifolia* Moench.; *P. hiemalis* Michx.; *P. ignota* Nels.), known as common wild plum, is a small, thorny, spreading tree. Leaves are oblong-ovate, not glossy, pubescent on the veins. Flowers are large, white, and appear in clusters before the leaves. It is the most widespread among the American plum species. Its native range is from Massachusetts to Georgia to near the Gulf of Mexico and to Utah and New Mexico to the west. In the East, fruit quality is poor, but in the West, edible forms are abundant. It is well adapted to the cold North and several cultivars were developed from this species there.

P. nigra Ait. (syn. *P. borealis* Poir.; *P. mollis* Torr.; *P. americana* var. *nigra* Waugh.), known as Canada plum, is a more showy tree than *P. americana.* Flowers are large, white changing to pink. Fruit is oblong, orange red; the stone is large and much compressed. Its native range includes New Brunswick (Canada), New England, New York, Michigan, Wisconsin, and northern Ohio.

P. angustifolia Marsh. (syn. *P. chicasa* Michx.; *P. stenophyllus* Raf.), known as Chickasaw plum, is a small, bushy tree, usually suckering from its roots and forming thickets. Leaves are oblong-lanceolate, 5 cm long, sparingly pubescent. Flowers are white, preceding the leaves. Fruit is small, cherry-like, red or yellow, yellow dotted, clinging to the small rough stone. Its native range is from Delaware to Florida and Texas. It is abundant on sandy soils. This species gave rise to only a few cultivars, but it was important for southern adaptation.

P. hortulana Bailey (syn. *P. hortulana* var. *waylandii* Bailey) is known as hortulana plum. The relatively tall (5-10 m) tree is distinct, nonsprouting. Leaves are elliptic-ovate, 7.5 to 10 cm long, shiny, lightly pubescent. Flowers are white, preceding the leaves; fruit is oblong, 2.5 cm in diameter, red to yellow, white dotted, with little or no bloom. Its native range includes Central Kentucky, Tennessee, to Iowa and Oklahoma. The species was first distinguished in 1892 to designate cultivars of plum intermediate between *P. americana* and *P. angustifolia. P. hortulana* represents a range of hybrids between *P. americana* and *P. angustifolia* (Bailey 1927).

P. munsoniana Wight and Hedr. is known as Wild Goose plum. This species represents a range of forms separated out of the old Hortulana class, of larger and freer growth than the variants of *P. angustifolia*, hardier, with more pointed leaves and larger flowers. Trees are 6.5 to 8 m tall and forming thickets. Leaves are 7.5 to 10 cm long, lanceolate, slightly pubescent on veins beneath. Flowers are white, and appear either with the leaves or before them. Fruit is oval, bright red or yellowish, marked with white dots. Native range includes Kentucky and Tennessee to Mississippi, Texas, Minnesota, and Kansas. According to Bailey (1927), the botanical status of this group is uncertain. Nevertheless, this group gave rise to a number of cultivars.

B. Horticultural

The diversity of plums intrigued early horticulturists and they tried to group them according to various criteria. Konrad Gesner in his *Horti Germaniae* in 1560 identified nine groups of plums: (1) large fruited plums with purple skin, occasionally yellow, acidic; (2) small, late, yellow plums *"Zipparten"* (3) early, small, multicolored plums ripening with oats, *"Haberkriechen"* (4) Neapolitan plums, long, sweet, pale colored, *"Curtius Lindau"* (5) Hungarian plums of two kinds, one larger and longer, the other sweeter than *Curtius Lindau* (6) outstanding Hungarian plums, *"Damascena"*, firm flesh, acidic; (7) yellow Hungarian plums ofthe size of an egg, with yellow color, and pleasant taste; (8) a diverse group of plums not classified under the previous groups; (9) plums in the forest and in hedges, and sloes.

Jaques Dalechamps (1586 87) in his *Historia generalis plantarum Lugduni* distinguished five kinds of plums: *"Damascena"* , with dark skin, pleasant flesh, and small stone; (2) *Perdrigona,* syn. *Iberica,* with firm flesh, sweet and pleasant taste; (3) yellow plums; (4) *Asinina,* large, purple, elongated plums; (5) *Pruni dactyla* (date plums), large, purple, egg-shaped plums.

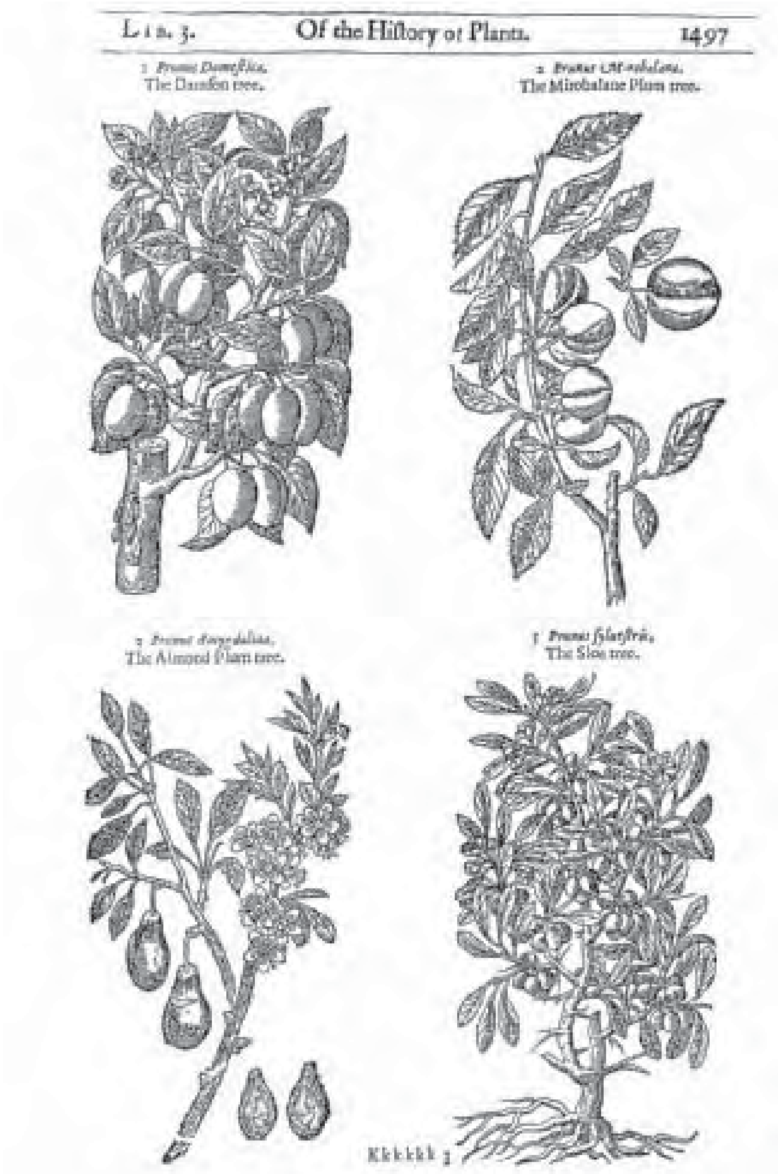

Fig. 8. Plum illustrations in Gerard's *Herball* (1633).

In John Gerard's *The Herball,* enlarged by Thomas (1633), five types of plums are described: damson, myrobalan, almond plum, damascene plum, and the sloe. Four of these are illustrated (Fig. 8.). Caspari Bauhin in his *Pinax Theatri Botanici* in 1623 set up 15 different groups that constituted the basis of Linneaus's classification. Even though Linneaus's classification was botanical, the groups he mentioned under the species constituted a horticultural listing of existing groups. This is clearly indicated on page 475 of Linneaus's *Species Plantarum I,* which includes the description of the 9th and 10th species of the genus *Prunus (P. domestica* and *P. spinosa)* (Fig. 9).

Taft (1894) commented that relatively little attention had been paid to the diversity of the native American plum until L. H. Bailey studied the plums in detail and made a new classification. Taft classified American plums essentially into four groups: (1) The Americana Group *(P. americana).* This species is found from New England to the Rocky Mountains and extends to Manitoba and Texas. The group is characterized by a firm, meaty, usually compressed, dull colored, late fruit, with thick and usually very tough skin, and large flattened stone that is often quite free. All the cultivars that belong here have a light purple bloom. (2) Wild Goose Group *(P. hortulana).* This embraces cultivars with a wide-spreading growth, a firm, juicy, bright-colored, thin-skinned fruit, a clinging, turgid, comparatively small, rough stone, and with peach-like ovate-lanceolate, long-pointed leaves. The species is located in the Mississippi valley from Illinois southward. (3) The Miner Group *(P. hortulana* var. *mineri).* It differs from the basic species because of its dull, comparatively thick leaves and a late, very firm fruit. Cultivars of this group are hardy, and Taft (1894) recommended them for Michigan. (4) Chickasaw Group *(P. angustifolia).* The trees of this group have a slender, spreading, and irregular growth. The fruit is small, generally red, and more or less spotted. The flesh is soft, juicy, and adheres very tightly to the small, broad stone. Even in the cultivated state the trees are quite thorny.

Page 475 from *Species Plantarum I. 1753.*

[English translation the Latin text.
P. domestica. simple flowers, leaves long, oval. *P. inermis* plum without thorns, leaves are eiongated-oval. plums are larger sweet, or small blackisb-blue. *Hungarica*. plums are large, thick:, sauerish. *Juliana*. plums are longish, blue. *Pemicana*. plums are black with firm flesn. *Cerea*. plums are wax-yellow, whitish-yellow or colorless. *Acinaria*. plums are large, red and round. *Maliformis*. plums are large, yellow, sweet, and apple shaped. *Augustana*. plums are smaller, ripe in August. plums are small early. *Cereola*. plums are small greenish-yellow. *Amygdaliana*. plums are almond shaped. *Galatensis*. plums are white, long and sauer. *Brignola*. plums are reddish-yellow with outstanding flavor. *Myrobalan*. plums are round blackish-purple and sweet. *P. spinosa. Prunus* with thorns and elongated leaves.]

Original Latin text.

9. PRUNUS pedunculis simplicibus, foliis lanceolato-ovatis convolutis	*domestica*
Prunus inennis, foliis lanceolata-ovatis. *Hort. Cliff 1 . Horl. ps. 124. Mat. Med.* 232. *Roy.Llugdb.* 268.	
Prunus *Bauch. pin. 443.*	
β Pruna majora dulcia & parva *Bauch. pin. 443.*	Darnascena
γ Pruna magnacrassa subacida *Bauch. pin. 443.*	hungarica
d Pruna oblonga caerulea. *Bauch. pin. 443.*	juliana
e Pruna nigra: camedura. *Bauch. pin. 443.*	pemicona
z Prona coloris cerae ex candido inluleum pallescente.	cerea

Bauch. pin. 443	
η Pruna magnarubra rotunda. *Bauch. pin. 443.*	acinaria
ϕ Pruna rotundaflava dulcia mali amplitudine. *Bauch. pin. 443.*	malifonnis
ι Pruna angosto maturescentiaminora & austeriora. *Bauch. pin. 443.*	augustana
κ Pruna parva paecocia. *Bauch. pin. 443.*	praecox
λ Pruna parva exviridi flavescentia. *Bauch. pin. 443.*	cereola
μ Pruna amygdalina. *Bauch. pill. 443.*	amygdalina
n Pruneoli alba oblongiusculi acidi. *Bauch.. pill. 443.*	galatensis
o Pruna exflavo rufescentiarnixti saporis gratissima. *Bauch. pin. 443.*	brignola
ξ Prunus flueto rotundo nogro purpureodulci. *Bauch. pin. 443.*	myrobalan
Habitat Europae *australioris locis elevatis.*	
10 Prunus spinosa, foliis lanceolatis *Hart. Cliff 1* . *Fl. Succ.* 397. *Mat. Med 231. RoyLugdb.* 268. *Hall. Helv.355.*	*spinosa*
Prunus sylvestris *Bauch. pin.* 444. *Tabem. ic. 992.*	
Habitat in Europae *col/ibu3 apricis.*	

Fig. 9. Description of *Prunus domestica* by Linneaus in *Species I, 1753.* Original Latin text reproduced as it appears on page 475.

III. HISTORY

A. Archeo otany

1. Euro e. Archeobotany of *Prunus* species was reviewed by Bertsch and Bertsch(1947) and Korber-Grohne (1996). Additional information was provided by Baas (1974), Erményi (1975 1977), and Hartyanyi (1978). The oldest remains are stones of *P. insititia,* damsons and St. Juliens, going back to Neolithic times. In Ukraine, along the river Dnipro, an ancient culture, the Trypilians, existed 3,000 to 8,000 years ago. People belonging to this culture already cultivated plums 6,000 years ago. Seeds found at Novaja Russesti, Ukraine, indicate that the primitive plum grown at that time had a relatively large seed (Erményi 1975 1977). The impression of one plum seed, found at Varvarovka XV, from the late Trypilian culture 5,000 years ago, was interpreted by Janusevics (1976) to represent a cherry plum × wild apricot hybrid. Additional archeological evidence indicated that cherry plums and sloe were also present in the area, which means that hybrids could have occurred at this early Neolithic time. Pieces of plum stones uncovered at this site signify that such hybrids did indeed occur (Erményi 1975 1977). Stones unearthed in Bedburg, Germany, and in Novaja Russesti, Ukraine, from around 6,000 years ago indicate a relatively large geographic area of Europe where plums were used. According to Knörzer (1974), the damson seed found at Bedburg must have come from orcharding because there were no wild damsons in Germany at that time.

At the beginning of the Bronze Age, in Switzerland there were colonies that built their dwellings on poles. Damson seeds have been found in the garbage pits of these colonies at Robbenhausen-Pföffikersee, Switzerland, and Wangen-Bodensee and Sipplingen-Bodensee, Germany. Plum production was also established in England during the very early Neolithic period. Roach (1985) lists several English sites where stones of plums were found. The earliest remains were of the native species, namely the sloe. Stones of sloe were unearthed at the Glastonbury lake village, from the Middle Bronze, Bronze, and Iron Ages. Dimbleby (1985) noted that in a Bronze Age shaft at Wilsford, England, near Stonehenge, *Prunus* pollen (most probably sloe) was found. Table 2 lists representative finds from prehistoric times.

Table 2. Archeological finds of plums from prehistoric times (list is not all-inclusive).

Location	Time period	Type of plum	Reference
Ehrenstein, near Ulm Germany	4060-3956 B.C.	Damson	Hopf 1968
Dnyetrov-Prut (Novaja Russestii)	Neolithic	Cherry plum? hybrids	Erményi 1975 77
Kluczbork, Poland	Neolithic	*Prunus* sp.	Opravil 1963
Nowe Cerekwiew, Poland	Neolithic	*Prunus* sp.	Opravil 1963
Bedburg-Garsdorf, Germany	Late Neolithic	Damson	Knörzer 1974
Robenhausen, Switzerland	Late Neolithic	Damson	Heer 1866
Sipplingen, Germany	Late Neolithic	Damson, St. Julien	Bertsch and Bertsch 1947; Baas 1971
Wyeregg at Untersee, Austria	Late Neolithic	Damson, St. Julien	Bertsch and Bertsch 1947; Baas 1971
Ravensburg	Late Neolithic	Damson	Renfrew 1973
Salamis, Cyprus	Late Neolithic	Damson	Renfrew 1973; Hjelmqvist 1963 64,1973
Wangen	Bronze Age	Damson	Bertsch and Bertsch 1947
Seengen, Riesi, Switzerland	Late Bronze Age	Damson	Neuweiler 1935
Lengyeli, Hungary	Late Bronze Age	P. *domestica*	Hartyanyi et al. 1968
Glastonbury, England	Bronze Iron Age	Sloe	Roach 1985
Schwiibish Hall	Early Iron Age	Damson	Bertsch and Bertsch 1947
Am Lac de Neuhatel	1050-860 B.C.	Damson	Jaquat 1988

[Neolithic period from 4000 to 2500 B.C.; Bronze Age from 2500 B.C., includes the Egyptian (from the III to the XXth Dynasty), Sumer, Assyrian, and Minoan civilizations until the time of the Trojan War, about 1200 B.C. The first use of iron was credited to the Hittites in Asia Minor about 1400 B.C. and the Iron Age lasted to about 500 B.C.]

From the Roman period, seeds of damson, garden plum, and intermediates were found. In Saalburg, Germany, in a well of the fort, 41 whole and 22 broken seeds of damsons were unearthed from the period of 83-260. At Rottweil, Germany, during the excavation of the Roman city, 13 seeds of intermediate forms and 3 seeds of *P. domestica* were found. Slightly more north in Germany, in Aalen and Butzbach, from Roman wells and at the military camp at Neuss, 42 seeds of damsons and 17 seeds of P. *domestica* were found. At another Roman military camp at Linz, Austria, from the period 14 to 80, more than 300 seeds were recovered. According to Werneck (1961), the seeds at Linz were Celtic in origin. The Romans had brought them to Linz, where they adapted to local conditions. However, Erményi (1975 77) thought that all types of plums were known in Austria and were produced there before the Roman occupation. At Linz, several plum seeds from the period between 380 and 425 were recovered from an area that indicated that the fruit had been used in religious sacrifices. The seed from this period can be classified into 3 groups: (1) 10 to 16 mm long, round or oval, with variable shape; (2) an intermediate group resembling the prunes, 12 to 16 mm in length with pointed ends; (3) true prunes, 18 to 22.5 mm in length with pointed ends and a raised dorsal suture. Plums were recovered from Roman sites at Silchester, Manchester, and Caerwant in Monmouthshire, England. Charcoal remains of bullace were found from the Roman period at Silchester and from the Anglo-Saxon period at Hungate in Yorkshire. Damson and domestic plum stones have been excavated from late Iron Age settlements at Maiden Castle in Dorset and at the Roman site in Silchester. Even though the domestic plum and damson were not native to England, the archeological evidence indicates that they were grown there in the Roman period and perhaps even earlier (Roach 1985). Representative locations from the Roman period where plum seeds were excavated are listed in Table 3.

Table 3. Archeological finds of plum seeds from Roman times (list is not all-inclusive).

Location	Time period	Type of plum	Reference
Saalburg, Germany	83	St. Julien, Damson	Baas 1951
Neuss, Germany	1st century	*P. domestica*	Knörzer 1970
AaIen, Germany	1st century	Damson	Baas 1974
Xanten am Rhein, Germany	1st century	St. Julien, Sloe	Knörzer 1981
Aachen, Germany	1st century	*P. domestica*	Knörzer 1967
Köln, Germany	1st-2nd century	St. Julien, Sloe	Knörzer 1987
Rottweil, Germany	186	St. Julien	Baas 1974
Köngen, Germany	141-160	*P. domestica,* Sloe	Maier 1988
Tac-Gorsium, Hungary	2nd century	*P. domestica*	Hartyányi et al. 1968
Ellingen, Germany	2nd-3rd century	St. Julien	Frank and Stika 1988
Balatonbereny, Hungary	4th century	*P. domestica*	Sági and Füzes 1967

Plum production in Europe increased during the Middle Ages and is reflected by the increasing number of archeological finds. In the Czech Republic, at Uhersky Brodu, 6 domestica and 17 damson seeds were found from the 12th century

(Opravil 1976). In Olomouc, Ostrava, Opava, and Plzen (Moravia), many seeds of damsons, mirabelles, and domesticas from the 16th century were found.

In Poland, at Szczecin, 58 damson and *P. domestica* seeds were found. At Gdansk, 1,700 seeds were collected from the 10th-11th century. At Opole, 168 seeds were unearthed from the 12th century. Seeds of various types were found in the Wawel at Krakow from the 12th-13th century, at Posnan from the 12th century, and at Wroclaw from the 12th-13th century.

From the excavation of a medieval fort near Buderick, Germany, very rich plant material was found from the 11th-12th century. Among the material there were seeds of damsons and round-and egg-shaped fruits belonging to the Green-Gage group.

In Hungary, seeds were found at Budapest during the excavation of a house (#10) at Disz square, and from a fort at Kereki-Feherkö. At Pees, a plum seed adhered to a jar was discovered, indicating that plums were also in this area. Plum seeds recovered during the Middle Ages are listed in Table 4.

2. America. Even though plum was a native fruit in America, it apparently had limited use by the indigenous peoples. A few plum seeds were recovered at the Smiling Dan settlement along the lower Illinois Valley (Asch and Asch 1985). This was a Middle Woodland settlement that lasted from 250 B.C. to 400 A.D. (Sant and Stafford 1985). The inhabitants of Smiling Dan used grapes and hazelnuts extensively, but judging from the few seeds, plum was not an important component of their diet. This is notable, because in the vicinity of the settlement (3 km) there is a creek called "Plum Creek," indicating that plums were present in relatively recent times when the creek was named, and the possibility exists that plums were present at the time of the Indian settlement.

Similar to the Smiling Dan inhabitants, Indians of the Bluff-Dweller culture in the Ozark mountains in Arkansas used plums to a negligible extent. Even though the Bluff-Dwellers used grapes and various nuts, plums were not important for them. The Bluff-Dweller culture before the earliest Pueblo culture, which existed from the 1st to the 5th century. Beautiful strings of beads, made from Ozark gromwell, a plant of the *Boraginaceae,* were unearthed in the settlement, the only plum seed found was from a chickasaw plum and it was perforated to be used as a bead (Gilmore 1931).

Table 4. Archeological finds of plums from the Middle Ages.

Location	Time period	Type of plum
Mikulcice, Czech Rep. Behren-	8th-9th century	Damson, *P. domestica*
Lübchin	990-1210	St. Julien, large plums
Szczecin, Poland	10th-11th century	Damson
Gdansk, Poland	10th-11th century	Oval plums
Maus Meer, Germany	11th-12th century	Damson, sloe, round plums, egg plums
Wroclaw, Poland	12th-13th century	*P. domestica* types
Lund, Sweden	1200-1300	Damson
Prague, Czech Rep.	10th-15th century	St. Julien, sloe, *P. domestica*
Burghausen, Germany	1250-1350	St. Julien, sloe, mahaleb
Kelheim, Germany	1200-1450	Large plums, sloe, mahaleb
Kravin, Czech Rep.	13th-14th century	Damson, St. Julien, mirabelle, cherry plum
Uhersky Brod, Czech Rep.	13th-14th century	St. Julien, mirabelle, sloe
Opava, Czech Rep.	13th-14th century	St. Julien, mirabelle, Reine-Claude, egg plum
Köln, Germany	13th-14th century	St. Julien, sloe, *P. domestica*
Lübeck	13th-16th century	Damson, St. Julien
Opatovice, Czech Rep	14th century	Damson
Budapest, Disz square, houses #8 and 10	14th century	*P. domestica,* cherry plum, sloe
Hollókö, Hungary	14th century	*P. domestica*
Kereki-Fehérkö, Hungary	14th century	Damson
Olomouc, Czech Rep.	14th-15th century	Damson, cherry plum, *P. domestica*
Ostrava	14th-15th century	Damson
Bad Windsheim	1400-1500	Damson, egg plum
Neuss, Germany	15th-16th century	Damson, sloe, egg plum
Brüggen, Germany	1500	Damson, sloe, St. Julien
Ivancice, Czech Rep.	16th-17th century	St. Julien, sloe
Pécs, Hungary	16th-17th century	*P. domestica*
Gyöngyöspata, Hungary	18th-19th century	*P. domestica*

B. Anti uity

Written evidence concerning plums surfaces in the Greek and Roman literature. Surányi (1985) interpreted Herodotus's (484-430 B.C.) and Xenophon's (431-355 B.C.) references to plums to be about cherry plums. According to these Roman writers, there were many cherry plum trees in the mountains populated by Scythians and Armenians. The European plums were mentioned first in Archilochus's *Pollux* (7th cent. B.C.). In Rhodos, the word brabüla was used for designating damsons. Rhodos was also the location of extensive damson production (Surányi 1985). Publius Valerius Cato (201 B.C.) wrote about propagation of plums and Vergil (Publius Vergilius Maro, 70-19 B.C.), in his Georgica (IV.145), remarked that sloe was grafted with plum. He also wrote about a "thorny plum" and recommended that it be planted alternately with "obelisks of box" (Georgica IV). Horace (Quintus Horatius Flaccus, 65-8 B.C.) mentioned plums in his letters (1.16:8). Ovid (Publius Ovidius Naso, 43 B.C.-17 A.D.) gave a more detailed description of black and yellow plums. Vergil also wrote (2:53) about yellow plums, which probably belonged to the green-gage group. Plinius (23-79) and, following him, Lucius Junius Moderatus Columella (1st century) wrote about several kinds of plums: *cereolum* (cherry plum), *damasci* (Damascus plum), and *onychium* (mirabelle). Plinius also wrote about the damascene plums introduced earlier into Italy from Syria. In Herculaneum, destroyed by the eruption of Mount Vesuvius in 79, Reine-Claude *(Regina-Claudia)*-like spherical plums were painted on the north side of the Sannitic House, and in Pompeii, on the wall of the tabino on the left of the entrance of Trebio Valente's house, mirabelle-like violet plums are painted in two different views: one showing the suture, the other the perpendicular rim cavity (Pompeiana 1950). Thus, plum culture was unquestionably established at the time of the Romans. Yet, according to Hedrick (1911), the plum culture was probably not widespread, because there were no seeds found in Pompeii that could be traced to the time when the city was destroyed. Hedrick estimated that plums should have been marketed in Pompeii at the time of destruction (August 1479) and their absence must mean that plum production was limited in southern Italy. Apparently the Romans planted more plums in the territories than on the mainland of Italy. Emperor Gaius Aurelius Valerius Diocletianus (245-313), who was of Dalmatian origin, established large plum orchards on the banks of the Drava and Sava rivers (Croatia) utilizing the cultivar 'De Bosnia', from which 'Pozegaca' was developed (Ramming and Cociu 1990). That plums were in the Roman territories is also indicated if the archeological sites where plum seeds were found from Roman times are mapped (Körber-Grohne 1996). Sites with plum seed were more numerous in the area of Germany occupied by the Romans compared with the unoccupied area. There was a "tavern" at Balaca, north of Lake Balaton in Western Hungary, where a wallpainting from the 1st century illustrates a woman's head surrounded by reddishpurple plums, indicating that the Romans grew plums in Hungary also. The plum in the illustration is probably P. *domestica* (Fig. 10).

Fig. 10. Detail from a painting found at Balaca, Hungary, from the 1st century. A. The painting depicts a mask as a veiled woman's head surrounded by plums. The plums are reddish-purple. B. Close-up of the plums.

C. Ja an

Plums were taken from China to Japan quite early. Yoshida (1987) remarks that plum stones have been found from the Yayoi Era, about 300 B.C. and cultivated plums were mentioned in Japanese books from 500. Matsumoto (1977) put the time of introduction somewhat later. According to him, the use of the word *ume* (Japanese for plums) first appeared in 751, in a collection ofJapanese poetry written in the Chinese style. By the early 800s, *ume* was used frequently as a subject in poetry. From this, Matsumoto (1977) concluded that the introduction of plum to Japan must have been in the mid 700s. The introduction of plums to Japan is traced back to at least two sources. Wani, a naturalized Japanese, was supposed to have brought the plums from the Korean peninsula. Alternatively, plums were introduced to Japan by a Chinese monk of high standing who brought plum trees as a gift to the Emperor (Matsumoto 1977). When considering the situation in Japan, we find that the same problem exists about the use of the word "plum" as in China. *me* is derived from *P. mume*, a species closer to apricots than to plums. Yoshida (1994) remarked that the mume is often called "Japanese apricot" or "Japanese plum," but its common name is "ume" in Japan. Therefore, because the information above is pertinent to the species *P. mume,* we are not certain when the introduction of plum *(P. salicin*a) took place in Japan.

bai (smoked and dried "plum") had long been used as medicine by the Chinese and was well known to the Japanese before the introduction of plum to Japan. *bai* was prepared by burning tree roots and straw to change the plums into a dry, black form. These smoked plums could be stored longer and were more palatable because some of the sourness was lost in the drying process. The Japanese also pickled plums and apricots for medicine, calling them *umeboshi.* The oldest record of *umeboshi* is dated 984 and subsequent dictionaries listed the word, so that it is almost certain that *umeboshi* was used in the 11th and 12th centuries (Matsumoto 1977). Salted plums were popularly known as a medicine that could be used to prevent running short of breath. Hideyoshi Toyomi, famous for his military leadership in Japan, used salted plums to motivate his soldiers. He would shout, "There is a Japanese plum grove over the mountain " This encouraged soldiers and hastened their marching (Matsumoto 1977). It must be emphasized again that this information is likely to be about *P. mume* and not about the true plum species.

The Japanese plum, *P. salicina,* was imported into the United States in 1870 by Mr. Hough of Vacaville, California. The cultivar 'Kelsey' was selected from this import, which was followed by another import in 1884. Dreyer (1985) presents evidence that Luther Burbank imported 210 seedling trees of 12 cultivars from Japan in 1885. From these, Burbank selected 'Satsuma' and 'Burbank'. In his plum-breeding activities, Luther Burbank used *P. salicina,* and this species is in the parentage of almost all of the so-called California Japanese plum cultivars. The interrelationships between the various species in California Japanese plums are described by Li et al. (1997).

D. Euro e

In the early 9th century, Charlemagne included plums in his list of fruit to be grown (Roach 1985). The plant list of al-Biruni from 1050 gives us an idea of which plants were included in the Spanish Islamic gardens. In the middle of the 11th century, essentially the whole range of temperate-zone fruits, including plums, were planted in these gardens (Harvey 1975). The Islamic garden had a principal canal with constantly flowing water that was dissected at right angles by smaller channels. Along the canals, cypress and fruit trees were planted, among which plum was used essentially for shade (Hobhouse 1992). Persian miniature paintings that date from about 1396 illustrated many stories and give us excellent information about the Islamic gardens. Fruit trees were often painted as part of the landscape of these miniatures, and plum was one of the trees pictured (Hobhouse 1992).

Plums were important in practically all parts of Europe. In his book *Physico* (1151-1158), Hildegard described red plums and garden plums. His reference to garden plums was interpreted by Körber-Grohne (1996) to damsons. The Westminster Abbey Customary required the who was the gardener to supply the monastery with plums, among several other fruits. Although plums were cultivated in some monastery gardens, the majority of people still relied on wild plums, bullaces, and sloes. The inclusion of plums in William Longland's *Piers Plowman* in 1362, and in Chaucer's translation of the *Roman de la Rose* in 1372 indicates their importance (Roach 1985).

In the 16th century, several horticulturists were concerned about plums. In the *Grete Herball* of 1526, an English translation of *Le Grand Herbier,* a French work from the press of Peter Treueris, two kinds of plums are mentioned: "blacke and reed." In 1575, Mascall regarded damson as the best type. He advised gathering the fruit when ripe and drying them in the sun or in a hot bread oven to keep them for a long period of time. Hyeronymus Bock (1546) wrote about a large black plum, a small green plum, arid a yellowish-brown plum. Fuchs (1543) was concerned about the shallow root system of plums, and Konrad Gesner (1565) wrote about the early-ripening plums being small.

Early in the 14th century, Pietro de' Crescenzi produced a book describing the establishment of mediurn-size gardens, including orchards, for kings and princesses. He recommended that these gardens be surrounded by hedges. In warm places, a hedge of pomegranates could be used and in cold places, a hedge of nuts or plums. His book was completed in 1305 and Charles V (1337-1380) commissioned its translation into French in 1373. It is likely that this book greatly influenced the establishment and design of the royal garden at Saint-Pol. Charles V, the king of France from 1364 to 1380, established an 8-ha garden at the Hotel de Saint Pol in Paris. The garden deteriorated after the death of the king and was later destroyed. Fortunately, there is a complete inventory of the trees planted in the garden and plums were included (Hobhouse 1992). Pietro Crescenzi's book, *Liber ruralium commodorum,* long read in manuscript form but actually printed in Italian in 1471, also influenced the development of the Italian Renaissance gardens. In 1460, Bartolomeo Pagello of Vicenza, Italy, fulfilled his desire to build a garden where he could grow many apples, pears, pomegranates, damascene plums, and vines (Hobhouse 1992). An inventory, taken at Villa Lante, north of Rome, after the death of Cardinal Gambra in 1587, describes the fruit orchards and reports that the walls were covered with plum, medlar, pomegranate, and quince (Hobhouse 1992).

The superior plum 'Reine-Claude' was named to honor Queen Claude, the wife of Francis I, French king from 1494 to 1547, the period during which the plum was introduced to France (Hedrick 1911). 'Green Gage', the common name for the 'Reine-Claude', derives from the fact that the Gage family of England procured a number of plums from the monastery of Chartreuse at Paris. When the plums arrived, all had labels except one, which was 'Reine-Claude'. When the unlabeled tree started to produce fruit, the gardener simply called it green gage. 'Reine-Claude' apparently was taken to England soon after its establishment in France. 'Green Gage' seeds were recovered from the wreck of the *Mary Rose*, the flagship of Henry VIII, which sank in 1545 and was raised in 1982. The wreck revealed a basket containing the remains of more than 100 plums. 'Green Gage', 'Catalonia', mirabelles, and myrobalan were identified in the basket (Roach 1985).

In Hungary in 1552, the existence of the Hungarian plum 'Besztercei' was mentioned in a Latin language document, *" na libra pruni Besztercei* . .. ," and in 1558 the production of dried prunes made from the fruit of this cultivar was described (Toth and Surányi 1980). The quality of Hungarian plums also interested Maximilian II (1527-1576), emperor of the Holy Roman Empire, who sent a letter to Antal Verancsics, archbishop of Esztergom, Hungary, dated March 18, 1573, asking for grafting material from plums, especially of four cultivars: 'Large Duranci', 'Katalan', 'White-and Black Horseye' (Rapaics 1940).

Aldrovandi (1522-1605), in his *lconographia Plantarum,* illustrates 9 plum cultivars: (1) *Pruna Damascena rotunda minora* (2) *Pruna Damascena viridia maiora et oblunga rubia, amethystina et viridia* (Fig. 11); (3) *Pruna Gregola vulgo dicta purpurei coloris* (4) *Pruna Lutea (5) Pruna lutea Augustana* (6) *Pruna maxima* (7) *Pruna maximilianis congenera* (8) *Pruna purpurea. Prune seu Prugne Bon Succino ltalis (9) Prunorum oblungorum luteorum due differentie* (Baldini 1990).

La Quintine, the gardener of Louis XIV, established the royal fruit and vegetable garden between 1677 and 1683 (Tukey 1964). The garden covered 8 hectares and had 29 separate walled enclosures. Enclosure number 20 was planted with dwarf espaliered plums.

Fig. 11. *Pruna damascena viridia maiora* from Aldrovandi's *Iconographia Plantarum.*

We estimate that as many as 200 plum trees were planted in the orchard.

In England in 1597, Gerard remarked that he had 60 of the best and rarest cultivars of plums in his garden and every year he received new ones not previously known. He commented that the dried damson prunes were more astringent than those produced in Spain, which were sweeter. Prunes produced in Hungary were long and sweet and those of Moldavia were the best (Roach 1985). He also commented that potatoes are good with plums: "doe boyle them with prunes, and so eate them." Parkinson in 1629 described 61 cultivars of plums and emphasized the role of John Tradescant in bringing new ones to England.

In 1664, János Lippai, gardener of the archbishop of Pozsony (Bratislava), in his book, *Posoni (Pozsonyi) kert*, devoted an entire chapter to plums. He described nutritional needs, propagation methods, cultivars, and diseases.

Batty Langley (1729), a London nurseryman, listed 'Reine-Claude' and 'Green Gage' separately (Fig. 12 illustrates Reine-Claude). In 1731, Philip Miller described 'Green Gage' as one of the best plums of England. Switzer (1724) considered the available plum cultivars excellent and recommended 'St Catherine', 'Reine-Claude', 'Maitre Claud', 'Drap-d'Or', 'Jeanne Hative', 'Mirabelle', 'La-Royal', 'Blue Perrigon', 'Orleance', 'Red Fotheringham', 'Black' 'Damascene', 'Marocco', and 'St Julian'. Fifty years later, John Abercrombie (1779) recommended plum cultivars, some of which were the same as recommended by Switzer (1724) earlier. His list included: 'Black Damask', 'Orleans', 'Queen-Claude', 'Green Gage', 'Perdigon', 'White Magnum Bonum', 'Fotheringham', 'St Catherine', 'Mirabelle', 'Muscle', 'St Julian', 'Damascene', and the cherry plum.

In 1800, Jervaise Co , a gardener at Bury St. Edmunds, Suffolk, introduced a new plum named 'Co 's Golden Drop'. He believed the 'Golden Drop' grew from a stone of 'Green Gage' pollinated by 'White Magnum Bonum'. It turned out to be an excellent late-season dessert plum that could be stored for the winter (Roach 1985).

Many of the important cultivars of plums were introduced to England at the beginning of the 17th century and no new cultivars were described until the 19th century. The Royal Horticultural Society encouraged breeding to produce new cultivars. Thomas Andrew Knight tried his hand at plum breeding with limited success. In 1823, he introduced a cultivar that had only medium quality. His work, however, encouraged others to develop new plum cultivars. Thomas Rivers introduced 'Early Rivers' in 1820 and 'Precoce de Tours' in 1834. In 1843 he produced a seedling that was introduced in 1875 under the name of 'Czar', named after the Czar of Russia, who had visited England that year.

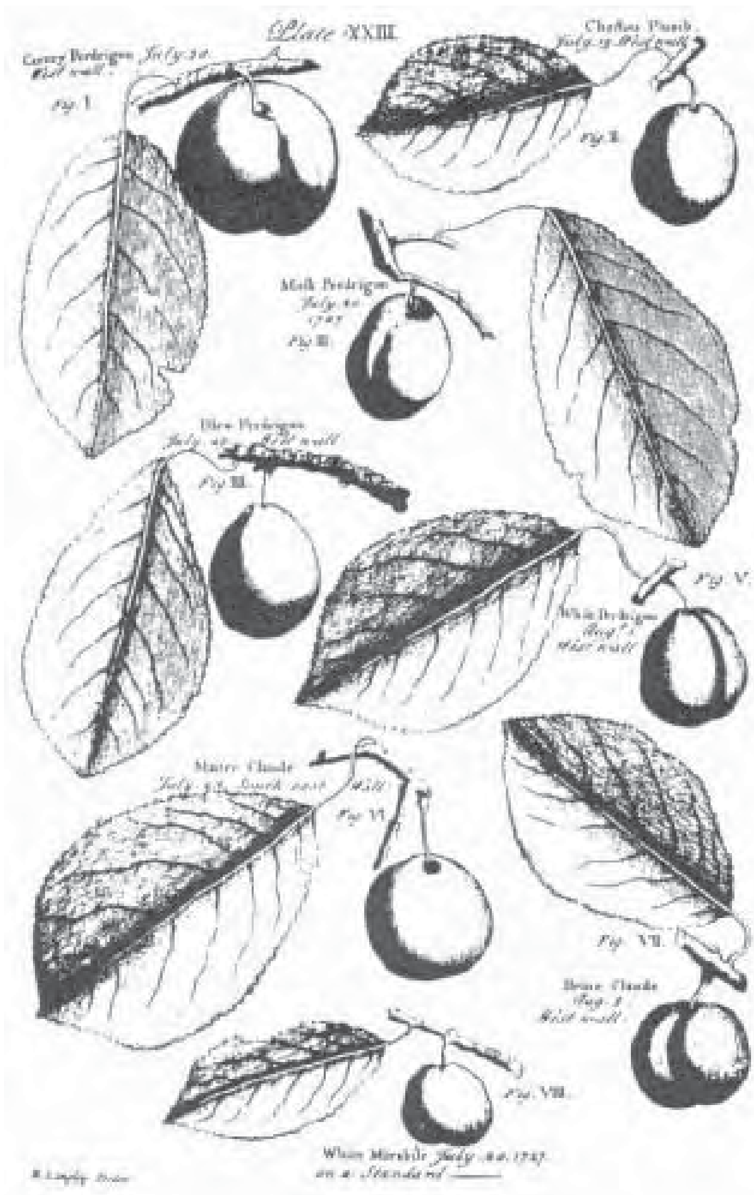

Fig. 12. Illustration of plums from Langley's Pomona, 1729.

Rivers introduced several other cultivars, which included the 'Golden Gage' and 'Late Transparent Gage', 'Monarch', 'President', and 'Wyedale'. The most important English plum cultivar, 'Victoria', was introduced in 1840. 'Victoria' was found as a seedling in a garden at Alderton in Sussex. The seedling became known as 'Sharp's Emperor' and was sold to a nurseryman, named Denyer, who in turn again sold it as 'Denyer's Victoria' and its name was finally simplified as 'Victoria'. As a self-fertile, heavy-cropping, dual-purpose cultivar, it was widely planted on farms in Kent and most other areas of plum production. Particulars of the improvement in English plums are detailed by Roach (1985).

During the 19th century, plums were improved at many diverse locations. Gallesio in 1839 published and illustrated high-quality cultivars (Fig. 13) in his *Pomona Italiana* (Baldini and Tosi 1994). 'Gullins Gage' was a chance seedling found in France at Coligny and introduced by M. Massot, a nurseryman near Lyon, sometime before 1856. 'Count Altham', a cultivar raised in Bohemia, was introduced between 1850 and 1860.

E. America

1. Nati e S ecies and Culti ars. In 1621, Edward Winslow mentioned that in Massachusetts plums were used by the Pilgrims, which, according to Sturtevant's notes (Hedrick 1919), was likely a reference to the beach plum *(P. maritima).* The native American plum *(P. americana)* was planted by the New England Indians from the early times and the western Indians collected large quantities for drying (Pickering 1879). Plum improvement in America started in the early 19th century with the selections of native American plums, and a great number of cultivars were introduced during the last two decades of the 19th century. The first American plum named 'Miner' *(P. hortulana)* was found on a Chickasaw Indian reservation in Alabama in 1813. It was soon followed by the most important cultivar among the native American plums. In 1820, a seed of *munsonina* plum was found in the craw of a goose and planted by M. E. McCance, Nashville, Tennessee. The resulting tree, named 'Wild Goose', produced exceptional fruit and achieved the largest early distribution among American plums.

A hybrid of *P. cerasifera,* the Marianna plum, was introduced in 1884 by Charles Eley, Smith Point, Texas. The originator considered Marianna to be a seedling of Wild Goose, one of the Munsoniana plums, probably fertilized by *P. cerasifera.* Marianna is a good rootstock for plums. It can be propagated by cuttings but unfortunately produces root sprouts (Yoshikawa et al. 1989).

There were a few individuals who were instrumental in the improvement of American plums. In 1857, H. A. Terry (1826-1909) established a nursery in Crescent City, Iowa. He was greatly interested in American plums and during his lifetime introduced over 50 cultivars of *P. americana, P. hortulana,* and *P. munsoniana* types. C. G. Patten, another private breeder and a contemporary of Terry, attempted to improve native plums at Charles City, Iowa, in 1867, but his only introduction was 'Patten', a *P. americana* species that was classified by Hedrick (1911) as a plum of minor importance. J. W. Kerr, who operated a nursery beginning in 1870 at Denton, Maryland, was also interested in American plums. He introduced three cultivars-'Sophie', 'Choptank' and 'Maryland'-and popularized American plums (Cullinan 1937). Hedrick (1911) described many important cultivars of American plums (Table 5.).

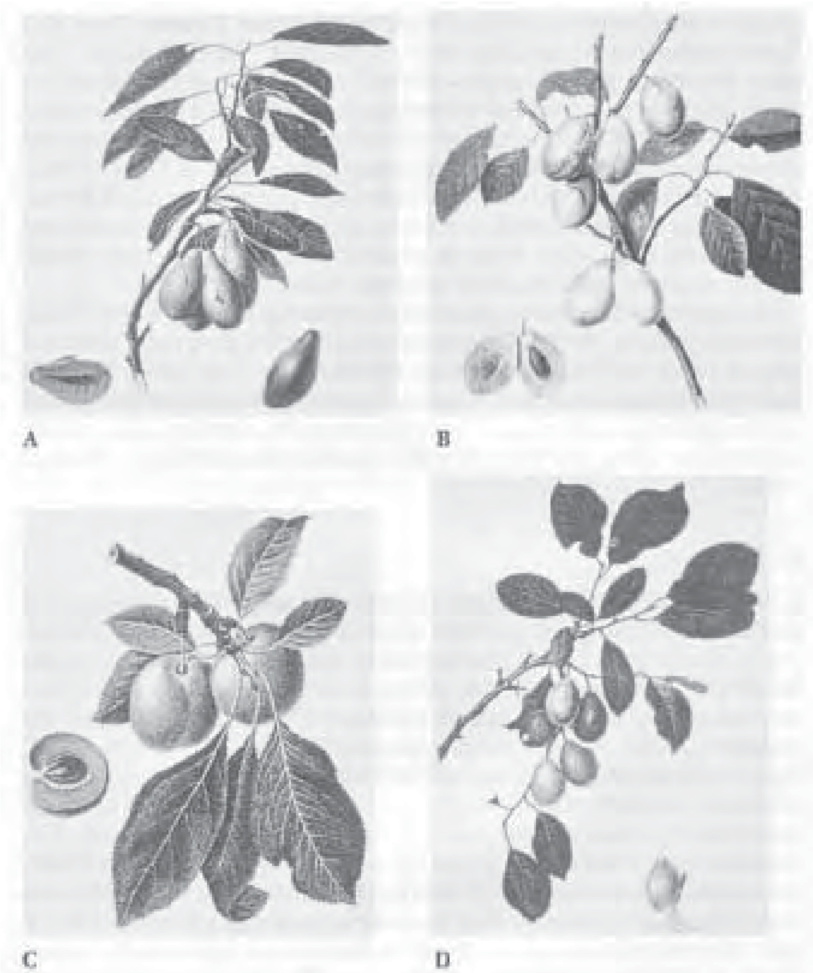

Fig. 13. Plum illustrations in *Pomona Italiana* by Giorgio Gallesio, 1839. A. 'Basaricatta', fruit is yellow, flesh is yellow. B. 'Verdacchia', fruit is green, flesh is yellow. C. 'Claudia', fruit is greenish-yellow, flesh is green. D. 'Damaschina d'Estate', fruit is yellow with red overlay.

Cullinan (1937) gives a complete description of State Experimental Stations involved in the early improvement of plum cultivars. The improvement of native American species continued at least until the 1960s. Okie and Weinberger (1996) list the introductions involving American species hybrids. Improvement of native American species took on importance in the North, where the hardiness of the native species was needed.

Table 5. Time of major activity when native American plum species were improved and new cultivars introduced. Year after the name indicates the time of introduction.

Hortulana culti ars
'Forest Garden' 1862; 'Golden Beauty' 1874; 'Wayland' 1875; 'Forest Rose' 1878; 'Moreman' 1881; and 'Maquoketa' 1889.
Americana culti ars
'Rollingstone' 1852; 'DeSoto' 1853-54; 'Garden King' 1853; 'Gaylord' 1854; 'Orem' 1878; 'Hawkeye' 1882; 'Blackhawk' 1899; 'New *Im'* 1890; 'Gale' 1890; 'Cherokee' 1892; 'Deep Creek' 1892; 'Craig' 1900; and 'Golden Queen' 1905.
Munsoniana culti ars
'Robinson' 1835; 'Pottawattamie' 1875; 'Pool Pride' 1885; 'Downing' 1885; 'Sophie' 1899; 'Freeman' 1893; and 'Flemming' 1901.
Nigra and Angustifolia culti ars
'Caddo Chief 1887.
Mixed s ecies
Hybridized by N. E. Hansen, American plums with Japanese plums and with *P. Bessey, simoni,* and *cerasifera.* 'Cheresoto', 'Cistena', 'Ztopa', 'Hanska', 'Inkpa', 'Kaga', 'Opata', 'Sapa', 'Wakapa', 'Wohanka', and 'Yuteka', among others introduced between 1808-1810.

Centers in the United States that improved native species were located at Brookings, South Dakota; Mandan, North Dakota; and Excelsior, Minnesota; and in Canada at Brooks, Alberta; Brandon and Morden, Manitoba; Rosthern and Saskatoon, Saskatchewan; and Ottawa, Ontario. The introduction of native American species hybrids continued until about 1960. After this time there were only occasional introductions and the improvement of native American species essentially ceased.

The native American plums also made their mark on large-scale production. Many species of plums were native to Texas and several of the early horticulturists were enthusiastic about the opportunities for commercial plum growing there. In the 1880s, Gilbert Oderdonk considered using the native chickasaw plum *(P. angustifolia)* for production for local markets. T. V. Munson introduced the 'Munson' cultivar, an excellent plum, but because ofits yellow color, soft texture, and susceptibility to brown rot, it never gained importance. In 1877, A. L. Bruce began crossing Japanese plums with the native chickasaws. By 1900 he had released 14 cultivars. The most remarkable of all was named 'Bruce'. 'Bruce' was pollen sterile, but interplanting it with native plums and providing pollinators assured its fruitfulness. Commercial plum growing in Texas was based on 'Bruce' (Brison 1976). In 1904, plum production in Georgia numbered 900,000 trees, based mostly on 'Wildgoose', but it slowly changed to the new Japanese hybrids (Starnes 1904).

2. Im orted Culti ars. In 1629, Francis Higginson recorded that the governor of Massachusetts planted a vineyard and fruit trees, including plums. According to John Josselyn (1865), writing of a voyage to New England in 1663, damsons were the only plums cultivated at that time. Importation of plums to America was also made by the French in Nova Scotia, Prince Edward Island, and the Island of Montreal in the St. Lawrence River (Hedrick 1911). In his history of North Carolina, written in 1714, Lawson noted that damsons, 'Damazeen', and a

large round plum were grown in that state. John Bartram was the first person in Pennsylvania to grow plums, which he located in the Bartram Botanical Garden near Philadelphia in 1728. He had the 'Great Yellow Sweet Plumb', 'Crimson Plumb', 'Chicasaw Plumb', 'Beach or Sea-Side-Plumb', and 'Dwarf Plumb' listed in his garden. In a separate part of the list of the "Catalogue of American Trees and Herbaceous Plants" grown in John Bartram's garden, *Prunus americana, P. chicasaw,* and *P. maritima* were mentioned (Reveal 1996). Plums were also introduced to Florida in 1763 at the colony at New Smyrna. In 1730, Robert Prince established his famous fruit tree nursery on Long Island, New York, and started to propagate fruit trees. His catalogs mention plums for the first time in 1767, and yet his 1774 advertisement does not mention them. Charleston, South Carolina, had nurseries that distributed plums to the southern states in 1786. The Prince nursery started to offer named cultivars of plums in 1794. In 1797, Samuel Deane, in his book, *The New England Farmer* or *Geological Dictionary*, speaks about the horse plum with a pleasant taste, the pear plum that had a distinct pear shape, the wheat plum that had a furrow in the middle, and the green-gage plum that was generally preferred among all the plums.

In 1773, Thomas Jefferson made the first notation about plums in his garden book. He noted that he sent Patrick Morton several "slips" of fruit, including a 'Green Gage' *plumb.* He made additional notes from 1778 to 1814. Among the plums he had were 'Mogul', 'Egg plum', 'Magnum Bonum', 'White Imperial', 'Horse', 'Cherokee', 'Chickasaw', 'Damson', and 'Green Gage' (Baron 1987).

The improvement of imported plums began soon after their introduction. William Prince (1828), the third proprietor of the Prince nursery, recorded in his *A Short Treatise* on *Horticulture* that his father planted 25 quarts of seeds of 'Green-Gage' in 1790 and the seedling trees produced fruit of every color. Cultivars, well known at that time, that came from this progeny were the 'White Gage', 'Red Gage', 'Prince's Gage', and perhaps the 'Washington'. By 1828, the Prince nursery offered 140 cultivars of plums. Even though the successive owners of the Prince nursery promoted plums, the greatest impetus of plum growing in America, according to Hedrick (1911), was created by William Robert Prince (1795-1869), the fourth proprietor of the Prince nursery, whose writings were characterized by a clear, vigorous style and by accurate statements as he disseminated information about plums. Other nurseries also promoted plums. The Mount Hope Nursery in Rochester, New York, commissioned the best botanical artist at the time to produce lithographs of fruits, including plums, that their salesmen could use when making presentations to customers (Fig. 14).

In 1858, Joseph Zettel of Switzerland acquired a farm on Door Peninsula, Wisconsin. He established the first commercial orchard there. His high yields and good-quality fruit aroused the interest of Emmett S. Goff and Arthur L. Hatch, who planted an orchard of cherries, apples, and plums in 1892 (Klingbeil 1976).

The largest orchard in South Dakota was planted by Mrs. Hurley in 1870. The 52-ha orchard consisted primarily of apples, but also included plums. In 1891, Professor T. A. Williams discovered and collected seed from several superior wild plums in the Badlands of South Dakota. Professor N. E. Hansen was appointed head of horticulture at South Dakota

Fig. 14. Plums painted by America's premier botanical illustrator, Joseph Prestele. A. Chicasaw plum, lithograph, completed in 1850 for the planned but never completed work of Asa Gray, *The Forest Trees of North America.* Color of fruit is red. B. Nebraska Seedling Plum (1) and Thompsons Golden Gem Plum (2). Lithograph. Issued by Mount Hope Nursery, Rochester, New York. Fruit color is yellow with red overlay on the sunny side. C. Mc Laughlin Plum. Lithograph. Issued by Mount Hope Nursery Rochester, New York, in 1871. Fruit is yellow, overlayed with red. D. Lawrence's Favorite. Unsigned lithograph. Attributed to Gottlieb Prestele, son of Joseph Prestele. Fruit color is dull yellowish-green covered with green bloom.

State University in 1895 and began his plum improvement program, using native species, which lasted for over two decades (Peterson 1976).

Indiana had about 700,000 plum trees in 1900 (Tukey 1976). In Iowa, there were sizable plum orchards near Sioux City between 1880 and 1935 (Nichols 1976). In Colorado, the first plantings of plums were made by W. Lee in 1862 east of Golden along Clear Creek. A flood in 1864 washed out all the trees. In 1870, a new shipment of 15,000 trees from Iowa arrived and were planted. By 1877 good crops were being produced, but some plum cultivars and chestnut trees did not survive (Ure and Binkley 1976).

In the early days of California, native plums *(P. subcordata)* were frequently cultivated and, before the introduction of standard European cultivars, attempts were made to improve the fruit of this species by selection. The early Mission plantings (1769-1823) included European cultivars, a few of which were able to survive the abandonment of the Missions in 1834. One cultivar found at Mission Santa Clara was grown and marketed as "Mission prune" as late as 1870. The introduction of improved plum cultivars dates back to 1851, when the first grafted fruit trees were brought to California from Oregon by Seth Levelling. The first importation of prune scions from France by the United States Patent Office in 1854 did not reach California. Two years later, Pierre Pellier, a sailor, brought scions from the famous prune district of Agen in France with him to San Francisco. The scions were grafted in Pellier's brother's nursery in the Santa Clara Valley upon a site that is today the city of San Jose. The prune industry was established in the Santa Clara Valley. In 1863, the first California-grown and cured prunes were exhibited at the State Fair in Sacramento and commercial-scale plantings started in 1870. There was disappointment over the fact that the prunes of 'Agen' were smaller than the prunes marketed by the French. Because of the small size of Pellier's introduction, they christened that cultivar "petite prune d'Agen," and the question was raised whether they had the real prune of 'd'Agen'. California growers tried several other larger fruited cultivars, including 'Pond', which was unsatisfactory because of its low sugar content. The dispute finally was settled in 1878 when W. B. West of Stockton visited France and determined that the California cultivar was the real prune of 'd'Agen' (Wickson 1914). For about a decade, plantings were increased, and in 1881 several growers produced 5 to 6 tons of cured fruit. The introduction of the French cherry-plum, myrobalan *(P. cerasifera),* as a rootstock greatly increased the productivity of the orchards. As time progressed, the prune industry increased. In 1870, there were 260 ha of plums produced for prunes. By 1900 the number had increased to 36,000 ha and by 1926 to 77,400 ha, the all-time high in the prune industry. The production area slowly decreased to 32,000 ha by 1960 and fluctuated around 30,000 ha in the 1970s. At the head of the list of cultivars was the 'Prune d'Agen', the originally introduced French prune, which proved itself to be well adapted to various conditions and was widely planted in the area. However, there was an interest in large fruited cultivars before 1940. The non-French cultivars comprised 16.7% of the production in 1940; their proportion decreased to 4.4% by 1978. Mechanical harvesting favored 'French Prunes' because the fruit of this cultivar could be harvested by machines without injury and the tree required no thinning. The large fruited cultivars required hand thinning, which slowly increased the cost of production to an uneconomic level. By 1981, the prune industry became essentially a onecultivar industry based on the 'French Prune' (Chaney 1981). Japanese plums were introduced to California in 1870 by Mr. Hough of Vacaville. John Kelsey of Berkeley, California, produced the first ripe fruit of Japanese plums in 1877 and 1878. The first wide distribution of Japanese plums fruited by John Kelsey was made by W. P. Hammon & Co. in 1884, which named the fruit after Mr. Kelsey. About the same time, Luther Burbank (1849-1926) started to operate in Santa Rosa, California. Burbank purchased a small farm there and established his breeding activities in 1875. Before Burbank started to improve Japanese plums, only two cultivars, 'Kelsey' and 'Chabot', were available. Burbank produced hundreds of thousands of plum seedlings using practically all plum species under cultivation and selected a dozen or more excellent types. Howard (1945) lists over 100 plum introductions by Burbank, some of which he imported from Japan, but the majority of which were produced by his own hybridization or from open pollination. In 1885, Burbank imported a cultivar with the help of Isaac Bunting, an export-import merchant in Yokohama. It was one of the plums Burbank read about in a travel book by a sailor. It was known as the 'Blood Plum of Satsuma', because the entire inside of the fruit was red. The name later was changed to 'Satsuma' (Howard 1945). Burbank introduced 'Santa Rosa' in 1907, the most important cultivar of this century. 'Santa Rosa' is a complex hybrid purportedly containing *P. salicina, P. simonii,* and *P. americana,* with the *salicina* character predominating. One of its likely ancestors was 'Satsuma' because 'Santa Rosa' acquired its reddish flesh from some of its parents and 'Satsuma' was the only plum carrying this character at that time. In 1914, Burbank regarded 'Santa Rosa', 'Formosa', 'Beauty' and 'Wickson' as his greatest introductions. Several other breeders continued the work of Burbank. Okie and Weinberger (1996) list the breeders involved in the improvement. In contrast to prune production, where cultivars did not change, plum cultivars changed as new cultivars became available (Table 6). With the exception of the month of August, at least one or more cultivars ripen weekly, which assures an extended marketing season for plums. Production of Japanese hybrids maintained a planting level of 10,000 ha between 1945 and 1970. Beginning in 1970, the Japanese plum production increased to 14,000 ha and remained at that level through the mid-1980s.

Table 6. Major plum cultivars in California from 1945 to 1994.

1945		1955		1965	
Santa Rosa	36	Santa Rosa	35	Santa Rosa	31
Beauty	14	Beauty	14	Laroda	10
President	10	Duarte	12	EI Dorado	10
Duarte	10	President	9	L.Santa Rosa	10
Wickson	5	L.Santa Rosa	4	Nubiana	6
Tragedy	4	Wickson	3	Beauty	6
Giant	4	Late Duarte	3	President	4
Kelsey	3	Kelsey	3	Burmosa	4
Burbank	2	EI Dorado	3	Duarte	3
Formosa	2	Burbank	2	Queen Ann	4
1975		**1988**		**1994**	
Santa Rosa	20	Friar	18	Friar	20
Casselman	14	Red Beauty	12	Blackamber	12
Laroda	10	Santa Rosa	10	Angeleno	10
L.Santa Rosa	9	Blackamber	8	Santa Rosa	7
Red Beauty	6	Casselman	6	Red Beauty	7
El Dorado	6	Angeleno	5	Simka	5
Simka	5	Queen Ann	4	Laroda	4
Nubiana	5	Simka	5	Casselman	4
Royal Diamond	3	Black Beauty	5	Black Beauty	
Friar	3	El Dorado	3	Kelsey	2

During this period, the percentage of 'Santa Rosa' decreased from 36 to 7% and large black plums, such as 'Friar' and 'Blackamber', gained consumer acceptance. Johnson and LaRue (1989) compiled the changes in plum cultivars between 1945 and 1988 and Okie and Weinberger (1996) listed those in use in 1994. Their lists of cultivars are presented in Table 6. The new cultivars lengthened the harvest season, extending it to 16 weeks from the fourth week of May to the third week of September.

IV. CONCLUSIONS

From the developmental point of view, we conclude that two major species provided the basis of the present plum industry. These two species emerged on separate continents-*P. domestica* in Europe and P. *salicina* in Asia. Neither species has wild progenitors and both entered into human use remarkably highly developed. The time period during which these species emerged is relatively recent. Archeological data indicates the widespread use of plums during the Neolithic period, but these were the small damsons or cherry plums, adequate only in rudimentary conditions. The garden plum and the Japanese plum emerged about 300 B.C. as important species. Why and how these plums were selected ten thousand miles apart at about the same time continues to baffle the imagination.

Fruits are important to mankind as a source of delicious food and have become admired for their beauty. They have become part of our cultural heritage. Among the stone fruits, peaches and cherries were used in names of localities and artists used them as the subject of their art. There are decorations of codices, frescoes, paintings, and floors produced since the beginning of the Roman empire involving not only the blossoms but also the fruit of these species (Faust and Timon 1995; Faust and Surányi 1997). Many other fruits such as apples, pears, quinces, and pomegranates are used in cornucopia as an expression of abundance. Plums have been the subject of artistic expression in much fewer cases. Prunes are excellent for health because they help promote digestive regularity. The mention of prunes even today is met with a response of muffled hilarity in the United States. Yet, at the same time, the virtues of plums are recognized in the use of the term to signify the best of everything or a bonus, such as in the saying that someone has a "plum" job.

The kinds of plums that are eaten is also a complicated manner. Even though some of the native American plums are yellow and many of the plums of the 19th century were yellow (Ravenswaay 1984), yellow plums are not marketed in America. Today, plums in America are mostly blue, black, or dark red, with a few bright reds becoming popular. In Europe, the yellow or green Reine-Claude gages or Mirabelles are accepted and sometimes even preferred over the blue or red prunes. In Asia Minor, the red or yellow colors of cherry plums are completely acceptable. One must raise the question then as to what was enticing to the American public about the dark colors. Was it a conscious selection by the people or was the dark color merely the preference of Luther Burbank, who was very successful at breeding plums and whose legacy has influenced the American plum culture. Black plums, especially the cultivars 'Friar' and 'Blackamber', became successful because they produce large fruit, are very productive, and do not show bruises, as the yellow plums or red plums that have yellow shoulders do.

Although the garden plum was used for drying in Asia Minor and Central Europe, the rate of drying never came close to the level achieved in apricots. A major change occurred when prunes entered California and processing by sun drying began. Today, a very high percentage of the world production of dried prunes (76%) is produced on the west coast of the United States, especially in California.

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Origin and Dissemination of Almond

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I. INTRODUCTION

The almond differs from the other *Prunus* crops both botanically and horticulturally and the combinations of these differences have had widespread consequences on its role in human history and the role of humans in its dissemination. Botanically, the consumed part is a nut rather than fruit, representing a durable propagation source for expanding plantings as well as a concentrated, desirable, and relatively non-perishable food item which made it a readily fungible commodity even in ancient times. The wild almonds traded and consumed by early human communities were represented by over 30 species of diverse quality, morphology, and geographic origin. Early dissemination of this genetically diverse commodity followed the trade routes of emerging civilizations from Central Asia westward to the Mediterranean. Almond's widespread desirability and easy transportability appear to have made it an important commodity in prehistoric trade in Asia, North Africa and Europe, apparently leading to the establishment of an evolving market standard as well as a new species: the cultivated sweet almond or Greek nut, [*Prunus dulcis* (Mill.) D. A. Webb L., syn. *Prunus amygdalus* Batsch., *Amygdalus communis* L., *Amygdalus dulcis* Mill.] possibly selected by prehistoric societies from an interspecific hybridization. The subsequent, rapid reverse dissemination of these Greek nuts from the early Greek and Persian civilizations eastward into centers of almond's origin and beyond, including India and China, is an indication of the extent of global commerce at this time. Also disseminated was a rich folklore and associated culinary practices based on almonds unique horticultural characteristics of very early flowering and associated traits allowing it to thrive under harsh arid environments yet produce a sweet and symmetrical amygdaloidal-shaped kernel. The widespread adoption of the commercially more desirable Greek nut would displace previously utilized almond species, inevitably resulting in a loss of germplasm and trait diversity. The current globalization of trade is promoting even greater uniformity in commerce, leading to further reductions in genetic, ecological, and culinary diversity.

II. CLASSIFICATION

A. Botanical

As with other *Prunus* crops, almond fruit is classed botanically as a drupe with a pubescent exocarp (skin), a fleshy but thin mesocarp (hull) and a distinct hardened endocarp (shell) (Fig. 1). In almond, however, the mesocarp undergoes only limited enlargement during development, becoming dry and leathery and dehiscing at maturity. The mature endocarp ranges from hard to soft and papery. The tree, while relatively slow growing, can survive for 100 years or more, reaching heights exceeding 20 m. Almond's outlier status within the *Prunus*, however, has also confounded its botanical classification. Presently, the most widely accepted scientific name, *Prunus dulcis*, (from Latin *dulcis* for sweet) acknowledges its taxonomic affinities with other *Prunus* based on similar morphology, molecular-genetic relatedness, and reported hybridization with peach, apricot and some plums. Because it was the first to be proposed in the literature, *Prunus dulcis* has superseded the scientific name *Prunus amygdalus* (*amygdalus* is Latin for almond) commonly still found in the European literature. In its Central Asian center of origin and diversity, the taxonomic experts most familiar with almond species in their native ecosystems, have preferred to classify them in a separate genus, *Amygdalus communis* (Browicz and Zohary 1996) arguing that their evolution of specialized botanical structures and development patterns in these often extreme environments justify a separate genus.

Fig. 1. Nut, flower, shoot and fruit of cultivated almond, *Prunus dulcis.*

Conversely, the molecular genetic structure and composition of almond is very similar to peach, suggesting that both belong to the same species (Mart nez-Gómez et al. 2007). This view is further supported by absence of any formidable barriers to their hybridization and subsequent gene introgression (Gradziel et al. 2001; Mart nez-Gómez et al. 2003). Cultivated almond also readily intercrosses with wild almond relatives (Fig. 2) which represent a wide range of morphological and developmental forms as found throughout western and central Asia (Komorov et al. 1941; Browicz and Zohary 1972; Browicz 1996; Denisov 1988; Grasselly 1976a; Grasselly and Crossa-Reynaud 1980, Kester et al. 1991). Some of the more than 30 species described by botanists may represent subspecies or ecotypes within a broad collection of genotypes adapted to the wide range of ecological niches in the deserts, steppes and mountains of central Asia.

A classification into five sections was proposed by the German botanist Spach (1843) (Grasselly and Crossa-Raynaud 1980; Kester et al.1991) (Table 1). More recently, Browicz (1974) separated almond species into two subgroups: *Amygdalus* (leaves conduplicate in bud and 20-30 or more stamens) and *Dodecandra* (leaves convolvulate in bud and fewer than 17 stamens. The most northeasterly group located in western China and Mongolia includes *P. mongolica*, *P. pedunulata* and *P. tangutica (P. dehiscens)*, the latter probably in Section *Chamaeamygdalus*. The remainder occupies a more or less contiguous area in west central Asia (Fig. 3). Those with the most northern range include species in Section *Chamaeamygdalus* and extend from the Balkan Peninsula to the Altai Mountains. The most southern and xerophytic groups includes species in the Spartiodes Section, which developed leafless, slender shoots, and the Lyciodes (*Dodecandra*) Section, which are very dwarfed and thorny. A third Section (*Euamygdalus*) resembles cultivated almonds and includes many species extending from central Asia to southern Jordan and parts of Europe.

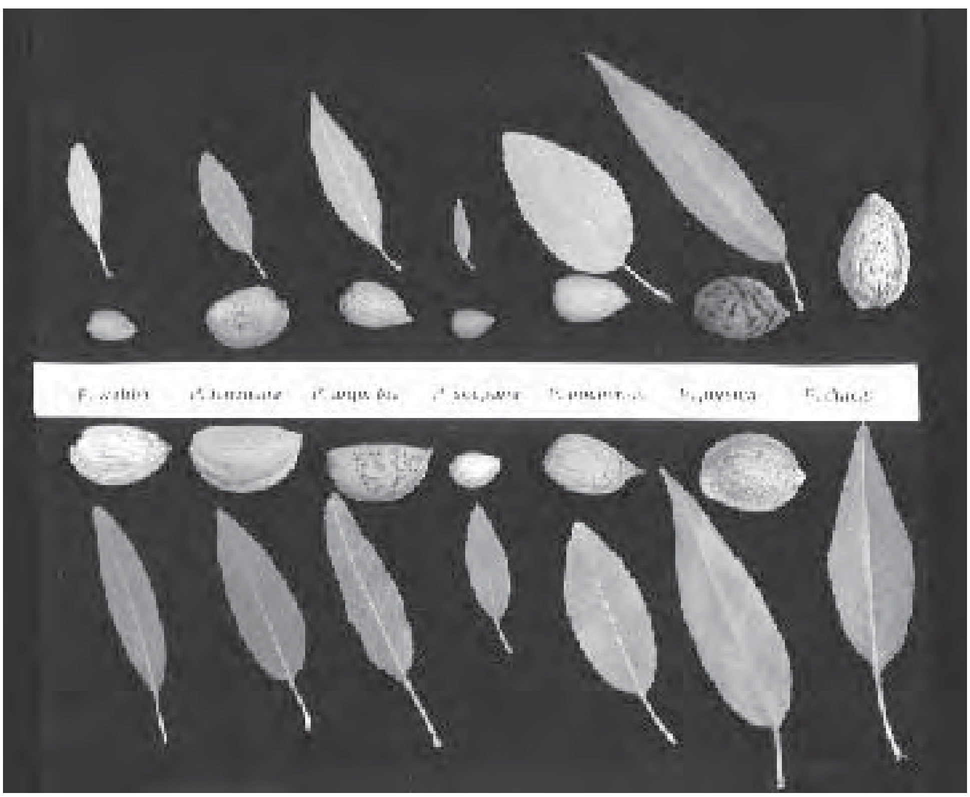

Fig. 2. Leaf and nut morphology of parent species (top) and hybrids with cultivated almond *P. dulcis* (bottom). Leaf and nut typical of cultivated almond at right

Table 1. Botanical relationship of *Prunus* species in Subgenus *Amygdalus.*

Almond rou
Section Euamygdalus S ach
Prunus dulcis (Miller) D.A.Webb
P. bucharica Korshinsky
P. communis (L) Archangeli
P. fenzliania Fritsch
P. kuramica Korchinsky
P. orientalis (Mill.), syn. *P. argentea* (Lam)
P. kotschyi [Boissier and Hohenm. (Nab,) and Rehd.]
P. korschinskii Hand-Mazz.
P. webbii (Spach) Vieh.
P. zabulica Serafimov
Section S artioides S ach
P. scoparia Spach
P. spartioides Spach
P. arabica Olivier
P. glauca Browicz
Section Lycioides S ach
P. spinosissima Franchet
P. turcomanica Lincz.
Section Chamamygdalus S ach
P. nana (Stock)
P. ledebouriana Schle.
P. petunnikowi Lits.
P. tangutica Batal.(syn. *P. dehiscens*) Koehne
Peach rou
P. persica (L.) Batsch.
P. mira Koehne
P. davidiana (Carriere) Fransch.

The cultivated almond as well as most almond species expresses gametophytic self-incompatibility, though self-compatibility is present in some *P. bucharica* and *P. webbii* populations . Gametophytic incompatibility prevents self-fertilization (Socias i Company, 1992), favors cross-pollination, (Weinbaum et al. 1985) and maintains genetic variability within seedling populations (Socias i Company and Felipe 1992). This trait would have contributed to almond's extensive genetic diversity that insured wide adaptation and wide distribution of these species in the wild. The chromosome number of *Prunus dulcis (P. amygdalus), P. fenzliana, P. nana (P. tenella), P. bucharica, P. kotschyi, P. scoparia* and peach (*P. persica*) is $2n = 16$ (Darlington and Ammal 1945; Grasselly 1977), which is the same as many other *Prunus*.

The taxonomic closeness of almond with peach (Fig. 4) led Watkins (1979) to suggest that both originated from the same primitive species but evolved separately following the mountain upheavals of the Central Asian massif approximately 10 million years ago. Thus peach evolved in the east, spread over several regions of China, in a more humid and uniform climate and at lower elevations, whereas almond evolved in the west, in arid steppes, deserts, and mountainous regions, under severe and erratic conditions. The often highly variable nature of these environments may have encourages almond's evolution towards self-incompatibility as it would enforce out-breeding and so promote greater genetic diversity to cope with changing environments.

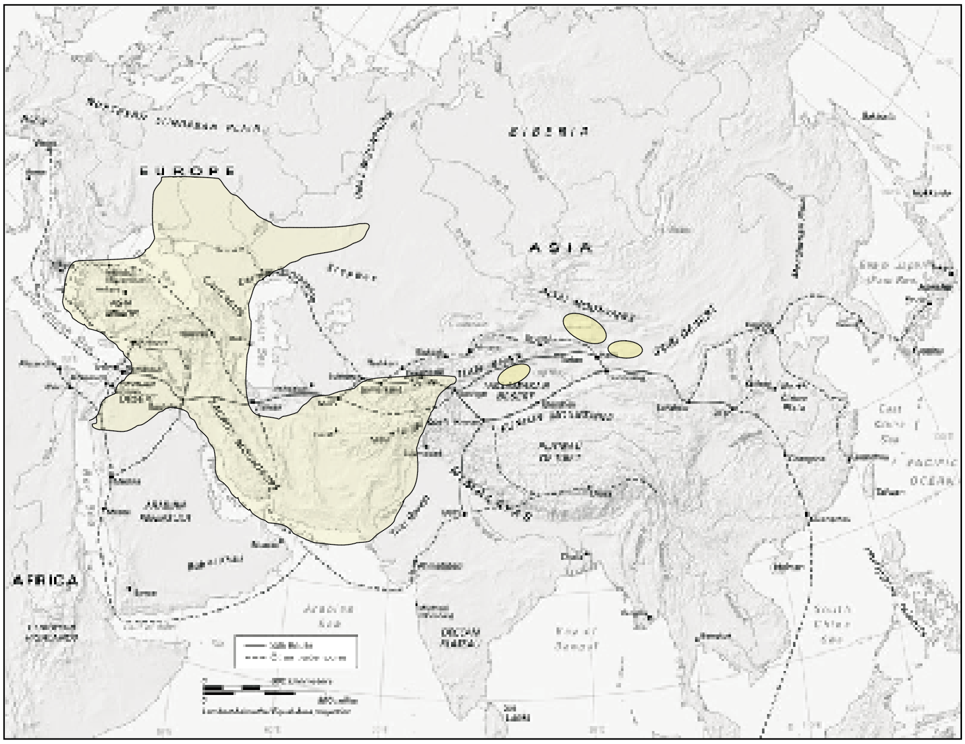

Fig. 3. Physical map of Eurasia showing distribution of wild almond species of the subgenus Euamygdalus (dashed outlines) and major ancient trade routes.

Fig. 4. Peach and almond stones, of natural size, viewed edgeways. 1. Common English Peach. 2. Double, crimson-flowered Chinese Peach. 3. Chinese Honey Peach. 4. English Almond. 5. Barcelona Almond. 6. Malaga Almond. 7. Soft-shelled French Almond. 8. Smyrna. Source: from Darwin 1868.

The fruit of different almond species and cultivars vary in size, shape, pubescence, shape and retention of the pistil remnants and suture line, all of which can be useful in identification. The pattern by which splitting occurs in the hull also differs and can be described by specific classes. Wood (1925) showed four basic types: (1) ventral split, opening on one side, (2) ventral and dorsal split, (3) four-way split and (4) dorsal split. The thickness and weight of the mature hull may also differ significantly. Some hulls are thin and dry and constitute only a small portion of the entire fruit. Others are thick and fleshy and provide a relatively large proportion of the final weight. In California, hulls of cultivated almond are used for livestock feed and the food value is better with larger hulls (Aguilar et al., 1984).

Shell hardness is the most important characteristic of the endocarp and is associated with the total amount of lignin deposited during nut development. Shelling proportion (dry weight of kernel weight of in-shell nut) is used to obtain a quantitative measure of shell hardness and is utilized in commercial activities to calculate final yield of kernels from whole nuts. Shelling percentage has an exponential relationship to hardness but is subject to considerable variation due to non-genetic factors. Markings on the outer shell are unique and identify specific species as well as cultivars. Within *Prunus dulcis*, the markings or openings (pores) tend to be mostly circular, though sometimes elongated and sometimes a mixture of both. Among species, pores may be large or small, many or few. Other species have smooth and thin shells as in *P. bucharica*) or are distinctly grooved (scribed) as in *P. kuramica* (Fig. 2). The shell consists of an outer and an inner layer separated by channels through which vascular tissues develop (Fig. 1). As the hull dehisces and separates from the nut, the outer layer may remain attached to the hull and separate from the inner shell layer. The latter type is associated with high shelling percentages but often poor seal.

Kernel size is established during the first growth phase of nut development in the spring and is completed by late spring. There is a strong environmental and seasonal component on size, including crop load, vigor of tree, soil moisture, and environment. Crop density has a strong inverse relationship to average size. Kernel mass is determined during the last accumulative phase of almond nut growth and increases continuously until maturity (Labavitch 1978).

Native almond species predominantly have bitter kernels because of high levels of the glucoside amygdalin which hydrolyzes to benzaldehyde and cyanide when exposed to the enzyme emulsin (Conn 1980; Sánchez-Pérez 2008). Both substrate and enzyme are present in the seed and come together when the cells are injured. This trait has adaptive value in the wild by discouraging seed predation by birds and rodents but would discourage human consumption since the cyanide would first have to be processed-out using heating, grinding or leaching practices similar to those used by hunter-gatherer societies to detoxify certain wild roots and legumes (Alexander-Essers, 1994). Plants producing sweet almond kernels have appeared from mutations and subsequent seedling segregation within various almond species, including *Prunus bucharica*, as well as other *Prunus*, such as peach and apricot (*Prunus armeniaca* L.) (Bailey and Hough 1975). Seed bitterness is determined by the genotype of maternal parent and not the embryo. Bitterness is inherited as a simple recessive (*ss*) in cultivated almond (Dicenta and Garcia 1993; Dicenta et al. 2007; Heppner 1923, 1926). Sweetness is dominant, transmitted from homozygous (*SS*) parents as 100% sweet and segregates from heterozygous seed parents (*Ss*) at a ratio of either 3 sweet:1 bitter (if both parents heterozygous) or 1 sweet:1 bitter (if the heterozygote is pollinated by a bitter (*ss*) almond tree (Spiegel-Roy and Kochba 1974). Trace amounts of amygdalin in genetically sweet-kernel trees may account for flavor differences and the distinct flavor characteristics claimed for some Mediterranean produced almonds (Horoschah 1971; Socias i Company et al. 2007).

B. Horticultural

Horticulturally, almonds are classified as a nut, in which the edible seed or kernel is the commercial product. The kernel includes an embryo surrounded by the pellicle, which is derived from the seed coats and remnants of nucellus and endosperm (Fig. 1). The almond is the earliest deciduous fruit and nut tree to bloom in spring due to its relatively low winter chilling requirement and quick response to warm growing temperatures in the spring (DiGrandi-Hoffman et al. 1994; Tabuenca et al. 1972). In nature, the almond growth cycle is well adapted to a Mediterranean or desert climate where plants are dormant during winter precipitations and associated low temperatures. Blooming and vegetative growth occur in late winter or early spring when temperatures become mild (Egea et al. 2003; Tabuenca et al. 1972). Growth ceases in late spring as the moisture in the ground is depleted and a dormant condition develops during the hot, dry, rainless summer (Denisov 1988). When almonds are irrigated during the growing season, however, growth continues through the spring and summer and production can be increased many times over that of non-irrigated almond trees (Asai et al. 1994; Micke 1994) Almond trees require some winter chilling and many cultivars do not grow well in areas of little or no winter chilling.

The early-flowering habit of almond also made it very susceptible to spring frost in more temperate growing regions and limited its plantings to more moderate, almost subtropical climates. In addition, a general susceptibility of the almond foliage to fungal diseases limited tree survival to those regions free from appreciable summer rainfall. Excessive moisture in the root zone is also deleterious (Kester and Grasselly 1987) and can result in tree losses due to crown rot or asphyxia. Consequently, the range of almond production has been limited to relatively mild winter areas. Fall freezing is a hazard because almonds tend to respond to warm temperature and accessible moisture even in late fall by growing and delaying the normal acquisition of hardiness. During the winter when trees are fully dormant, cambium and buds reportedly can withstand temperatures of 2°C (Grasselly and Crossa-Renaud 1980). Flower buds may be injured by temperatures of 15 to 20°C particularly in late winter after the normal rest period has been fulfilled (Cociu 1985; Ristevski 1992).

III. THE WILD BADAM

The kernels of a geographically wide range of Asian almond species represented a nutritious, compact, and relatively non-perishable food source that is also appetizing even when eaten in quantity or over a period of time. These qualities combined with its presence throughout the range of early plant domestication by humans ensured that it was among the first tree crops to be domesticated probably during the third millennium BCE (Spiegel-Roy 1976).

The natural range of the various almond species from northwestern China to the northern Indus Valley in the east, to Mesopotamia and southern Europe in the west (Fig. 2), overlapped areas important in the transition of humans from hunter gatherers to more permanent settlements. These cradles of civilization were also inherently cradles of plant domestication, which undoubtedly involved selection within the numerous wild almonds. The edible kernels of wild almonds and related species were thus important food staples from ancient times. Stone tools used for the apparent cracking of almond shells supports the harvesting of wild almonds in northern Israel by our human ancestors as early as 780,000 years ago (Goren-Inbar et al. 2002; Martinoli and Jacomet 2004; Weiss et al. 2004). Around 11,000 BCE, almonds, pistachios, and lentils were being utilized at Franchthi cave in southern Greece, indicating that the farming of legumes and nuts preceded that of grain in Greece and possibly the rest of Asia Minor (Farrand 1999; Hansen and Renfrew 1978; William, 1999). In addition to wild almond, kernels of wild apricots, plums and possibly peaches, also present in various Western and central Asian ecosystems, would have also been consumed regardless of fruit quality, as they are to this day. The term *badam,* which when used alone refers to almond in a wide range of Asian languages (Turkish, Persian, Arabic (either badam or *loz*) Urdu, Hindi, Punjabi, Telugu Kashmiri, Kannada, Marathi, Gujarati, Tamil, and Chinese (either *badam*, *bwa-dam* or *x ng rén* the later also referring to apricot seed) can also refer to the edible kernels of other *Prunus,* for example *tao ze badam* refers to peach kernel in western China, and *khasta badam* to apricot kernel (sometimes called poor man's almond) in India. Thus, in the absence of well preserved endocarp remnants for species identification, it can be difficult to know which *Prunus* species was present in archaeological reports. Other distinguishing characteristic of almond species, however, are the symmetrical amygdaloidal (from amygdala or αμυγδαλη) kernel shape (versus the more ovate peach and apricot kernel) and a flowering time among the earliest of all temperate trees and where the flowers emerge well before the leaves. This explosion of life towards the end of an otherwise barren winter has apparently captured the imagination of ancient observers as it does now, contributing to a rich and varied folklore.

Almonds are mentioned in the earliest Sumerian culinary texts in a list of banquet menu items (Rosengarten, 1984). Biblical references to the almond show it was common in Palestine (where it can bloom as early as January) by at least 1700 BCE (Goor and Nurock 1968; Janick 2007). A reference to almonds in the book of Genesis 43:11 documents its high value: *their father Israel said unto them, if it must be so now, do this take the best foods in the land in your vessels, and carry down to the man a present, a little balm, and a little honey, spices, and myrrh, nuts and almonds.* The man, in this case was the governor of Egypt, from whom they were soliciting food aid in their time of famine, suggesting that almonds were also valued in Egypt but possibly not grown there.

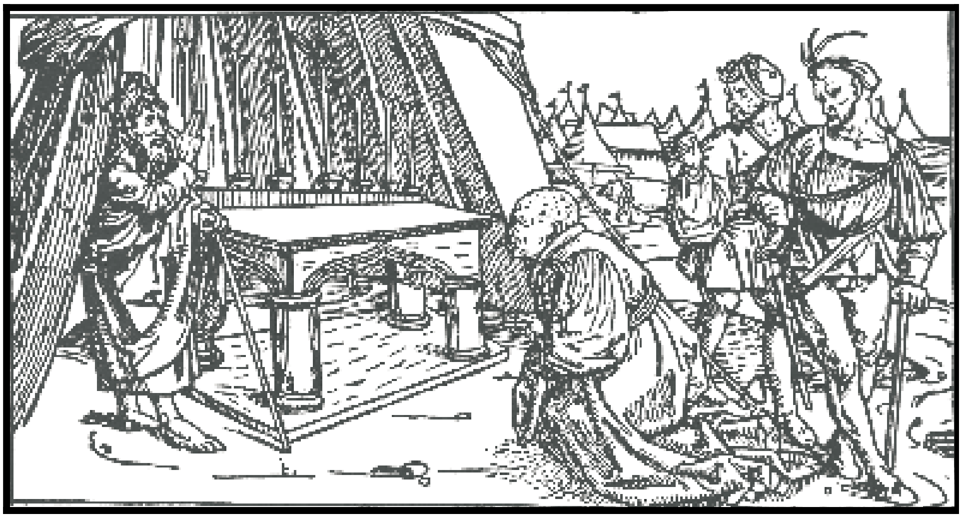

Fig. 5. Flowering of the almond staff of Aaron at the Jewish Tabernacle during the Exodus. Source: Rosengarten 1984.

The Hebrew name for almond is (שׁקד) or *shaqed*, which has its roots in an ancient Semitic term, as seen in the Akkadian *iqdu* and Ugaritic *thaqid*, as well as in old Ethiopic language. *Shaqed* may also be translated as watchful , symbolizing God's watchfulness over His people; as in Jeremiah 1:11 12, *And the word of the Lord came to me, saying Jeremiah, what do you see And I said, I see an almond branch. Then the Lord said to me, You have seen well, for I am watching over my word to perform it.* An early biblical reference, Numbers 17: 8, describes how the staffs of the 12 princes of Israel were placed into the Tabernacle after the Exodus. Only the staff of Aaron of the house of Levy, which was almond, flowered (Fig. 5). This was interpreted as a sign of divine favor to Aaron, of God's watchfulness over him and his descendants (Rosengarten 1984). According to tradition, the staff of Aaron bore sweet kernels on one side and bitter kernels on the other, symbolizing sustenance if the Israelites followed the Lord, but bitterness if they were to forsake of the Lord. (While an almond staff could flower if cut just prior to bloom, and even continue to flower for many days if placed in water, the cut branch would soon collapse well before fruit development.) The almond blossom also supplied a symbolic model for the menorah or ark which stood in the Holy Temple, *Three cups, shaped like almond blossoms, were on one branch, with a knob and a flower and three cups, shaped like almond blossoms, were on the other...on the candlestick itself were four cups, shaped like almond blossoms, with its knobs and flowers* (Exodus 25:33 34; 37:19 20). That the golden candlesticks for the Tabernacle should have almond shaped bowls may explain why ornamental pieces of crystals attached to candlesticks are sometimes still called almonds. Interestingly, in areas of Pakistan, Western China, and India, the prayer cap or *topi* is often adorned with paisley-like patterns said to represent almond blossoms (Fig. 6). In Arabia and other Muslim areas, almond's early flowering on leafless branches is seen as a symbol of hope (Rosengarten 1984). The early flowering habit of almond appears to have also made it symbolic for watchfulness or insight in ancient Greek mythology (Fig. 7). The symbolism derived from the Mycenaean Bronze Age (ca. 1200 BCE) myth of Phyllis of Thrace who grieved so much when the her lover Demophon did not return from Troy that the gods transformed her into an almond tree, thereafter called Phylla by the Greeks. Upon Demophon's return, he embraced the tree which burst into blossom. A more ominous interpretation of almond bloom, (perhaps alluding to the rather sudden whitening of a man's hair as he approaches old age and death), is given in Ecclesiastes 12:5: *when men are afraid of heights and of dangers in the streets when the almond tree blossoms and the grasshopper drags himself along and desire no longer is stirred. Then man goes to his eternal home and mourners go about the streets*. A similarly ominous significance appeared to be held by the Bronze Age Phrygian culture of Anatolia, in present day Turkey, whose rites of worship to their main goddess Cybele were so savage that they were eventually banned. According to legend, the almond tree sprang from the blood of Cybele and played prominent roles in the creation of lesser gods. Besides symbolizing Cybele for her devotees, the almond was also regarded as the Father of Everything according to Rawlinson (1917).

The symbolic importance of almond in these early cultures may have referred to its dramatic, life-reaffirming early bloom or to the amygdaloidal kernel shape. The almond shape symbolized the female genitalia in the East, while in Europe it often represented the womb. In early Christian art, Christ is sometimes shown surrounded by almonds or an almond-shaped mandorla (from the Italian *mandorlo* for almond) representing the womb (Fig. 8). In other parts of Europe, particularly central Italy, the almond symbolized the Virgin Mary. Consequently almond nuts have often been associated with fertility. Romans showered newlyweds with almonds as a fertility charm. An old Romanian contraceptive measure was to carry roasted almonds on the person, perhaps because the roasting counteracted the nuts traditional powers on fertility. It is still a modern European custom to give female guests at weddings a bag of 5 sugared almonds representing children, happiness, romance, good health, and fortune (Fig. 9). In Greece, almond cookies remain a popular wedding food. In Britain, their traditional Mothering Sunday Simnel cake is covered with almond paste in a possible reference to motherhood. The traditional almond paste and royal icing of British wedding cakes symbolizes the intermingled sweetness and bittersweetness of the couples new life together. Even in ancient China, almond's amygdaloidal shape is considered a symbol of female beauty as well as enduring sadness (perhaps because the symmetrical *amygdalus* or *mandorla* is the product of overlapping circles or perhaps it refers to the inevitable bitterness present in the occasional bitter kernels).

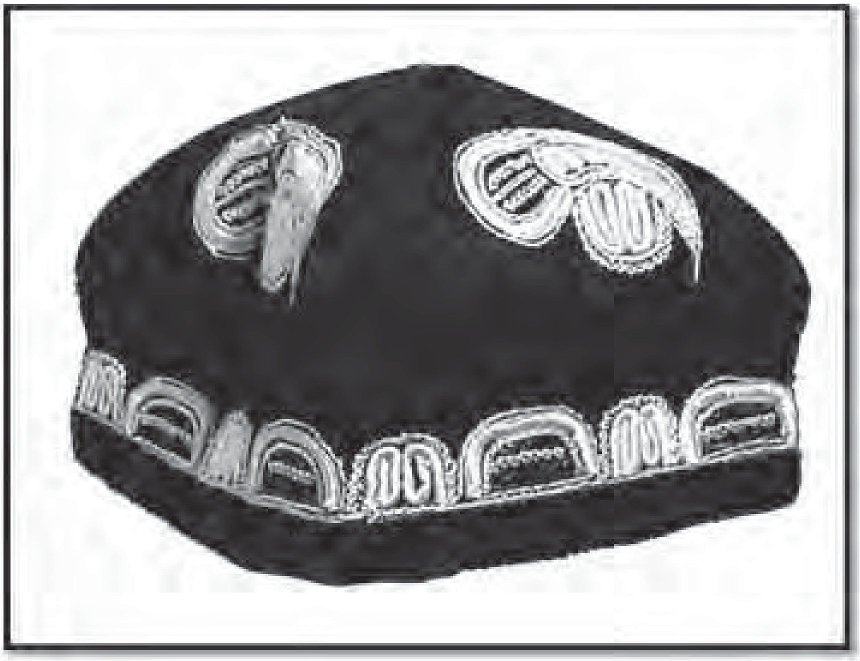

Fig. 6. A prayer cap, or topi, adorned on top with paisley-like patterns said to represent single almond blossoms.

Fig. 7. Greek vase from 450 BCE showing the Oracle at Delphi holding almond branch in right hand. Source: www.talariaenterprises.com.

Fig. 8. A medieval Christian artistic convention in which an almond-shaped area or mandorla, surrounds Jesus. Source: wikipedia.org wiki Aureola.

In the wild, almond species usually produce cyanogenic and bitter seed; however, individual trees producing sweet and edible nuts have been reported in native populations of many almond and related species (Denisov 1988; Vavilov 1930; Werner and Crellar, 1997). Although relatively rare, these individuals can be readily identified by consumption of their seed by native rodents and birds. Human gatherers from early times to present, would mark such trees for recurrent annual harvest as has been documented in present-day hunter gather groups in Asia and Africa (Alexander-Essers 1994). The mutation for sweet kernel is expressed in all seed of the parent tree and, unlike most other cyanogenic plants, including apricot and peach, is dominant in almond (Dicenta et al. 2007; Negri et al. 2008; Werner and Crellar 1997). Consequently, not only will all seed in a selected tree have sweet kernels but the majority of seedlings derived from those seed will also have sweet kernels. Domestication of sweet kernel genotypes would have been advanced by the propagation of these selected individuals, either through the germination and growth of harvested seed, through relatively simple propagation techniques such as rooted-cuttings developed during these prehistoric times, or through the weeding out of bitter almonds within a wild grove and thus promoting greater growth by the selected sweet types (Zohary and Spiegel-Roy 1975). In addition, birds of certain species such as the Western Scrub-Jay *Aphelocoma californica* will systematically bury or cache single sweet almond seed at several thousand distinct sites for later retrieval and consumption (Pravosudova et al. 2006). It is not unusual for many of these seed to germinate and, if the site is appropriate, to grow into productive trees.

Fig. 9. A bomboniere, or Italian party favor, containing 5 symbolic almonds. Note the almond flower design in this example.

Toxins in bitter seeds can be removed through various basic processing methods. Bitter almonds possess the almond's nutritional quality and long storage life, as well as a natural protection against undesired feeding by mammals, birds, and insects. Nutritionally, almond represents a compact, readily stored, and high energy food (Table 2). Both the edible, immature fruit as well as mature kernel contain the amino acid linolenic acid which is essential but not naturally synthesized in humans. Recent studies have also indicated that moderate consumption of almond kernels, can suppress hunger. An exceptional postharvest stability of almond kernels of over 2 years when stored dry and in shell, would further contributed to almonds value as an easily transportable, high-quality food source in early human transmigrations and commerce. The same traits would also facilitate the establishment of widely dispersed almond stands through the accidental or deliberate planting of seed.

Table 2. Nutrient composition of the almond kernel per 100 g fresh weight of edible portion.

Nutrient	Value
Energy	578 kcal
Protein	21.26 g
Carbohydrate	19.74 g
Fiber, total dietary	11.8 g
Glucose	4.54 g
Starch	0.73 g
Calcium	248 mg
Magnesium	275 mg
Phosporus	474 mg
Potassium	728 mg
Sodium	1 mg
Folate, total	29 mcg
Vitamin E	25.87 mg
Saturated Fatty Acids	3.88 g
Monounsaturated fatty acids	32.16 g
Polyunsaturated fatty acid	12.21 g

Source: Adapted from Socias i Company et al. 2007.

IV. THE CULTIVATED REEK NUT

Although the kernel of native almond and even apricot and peach species continue to be harvested today much as they were in antiquity, evolving market factors, particularly during the great flourishing of trade associated with the Achaemenian Dynasty of Persia (559 334 BCE), resulted in a market standard that appears to have become widely known in ancient times as the Greek nut and in more modern times as the cultivated sweet almond. Several hypotheses have been advanced concerning its origin. Russian scientists Kovalev and Kostina (1935) suggested that the cultivated almond emerged by selection from within the species listed initially as *Amygdalus communis* L. whose range may have extended across Iran, and eastern Turkey, into Syria, Lebanon and Jordan (Browitz 1974). Two natural sweet kernelled *A. communis* populations have been reported on the slopes of the Kopet Dagh Mountains in central Asia between present day Iran and Tadjikistan and on the slopes of the Tian Shan Mountains between Uzbekistan and western China (Vavilov 1930; Denisov 1988) (Fig. 3). This species was reported to be adapted to mild winter and dry hot summer conditions by traits of low chilling, early bloom, rapid early shoot growth, deep penetrating root systems and high tolerance to summer heat and drought. Its phenotypic range closely resembles that of present day cultivated almonds.

Another hypothesis originated by Evreinoff (1958) is that the cultivated almond arose by hybridization among *P. fenzliana*, and possibly *P. bucharica*, *P. kuramica*, and other species. This view, which has recently been support by molecular analysis (Zeinalabedini et al. 2009), holds that the cultivated almond originated through human intervention and is not a natural species. Grasselly (1976b) reported that *P. kuramica*, whose range includes Afghanistan and northern Pakistan, somewhat resembles cultivated almonds and coexists with it in many farming areas. *P. kuramica* grows on the more xerophytic sites, *P. dulcis* being a mesophytic species. Different almond species, particularly those of the same Section cross readily and considerable natural hybridization between cultivated almond and nearby wild species takes place (Grasselly, 1976; Denisov, 1988). Introgressive hybridization and exchange of genes thus can take place whenever ranges overlap. Many of the more than 30 named almond species may not be true species but products of such interspecific hybridization events. The previously described Kopet Dagh and Tian Shan sweet kernelled populations are proposed to be more recent feral populations of cultivated almonds or their natural hybrids (Browicz and Zohary 1996). *Amygdalus communis* thus represents feral populations of *P. dulcis* (*A. dulcis*) rather than a native species. Furthermore, as almond cultivation expanded, new hybridizations introgression would have occurred, as with the wild species *P. webbii* (Spach) Vierh. (Godini 1977; Socias i Company 2002), and cultivated almond populations found along the northern shore of the Mediterranean sea from Greece and the Balkans to Spain and Portugal. Godini (2000) showed that *P. webbii* from the Italian region of Puglia was self-compatible and that it probably contributed this trait to local cultivated almond landraces since many almond orchards were made up of seedling plantings during prehistoric times to the present. Molecular analysis has recently shown this proposed interspecific introgression of self-compatibility from wild *P. webbii* to cultivated *P. dulcis*, to be correct (Certal et al., 2002; Mart nez-Gómez et al., 2007). Zohary and Hopf (1993) proposed that the area of initial domestication was the eastern part of the Mediterranean basin. However, the wild populations and species found in the eastern Mediterranean appear genetically more distant from the cultivated almond than the wild populations and species of the Caucasus and Zagros Mountains of eastern Asia Minor and Persia (Sorkheh et al. 2007). Both regions, however, were then part of the Achaemenian Dynasty of Persia (559 334 BCE) which actively encouraged both commercial and cultural exchange among its diverse regions (Fig. 10). The Achaemenian kings, including both Cyrus the Great (c. 600 530 BCE) and Darius the Great (ca. 549 486 BCE), took a special interest in plant collection and cultivation. The Spartan mercenary Lysander, who joined the Achaemenian Persian king Cyrus the Younger in 401 BCE, reported to Xenophon of Athens how the Persian kings excelled not only in war but also in creating protected gardens or *pairidaeza* of plants, especially fruit bearing trees, collected during their foreign expeditions. Xenophon (who was a supporter and chronicler of Socrates), went on to write, in his *Oeconomicus* (Economics 399 BCE) *The Great King...in all the districts he resides and visits...takes great care that there are paradises* (from Greek form *paradeisos*) *as they call them, full of all the beautiful things the soil will produce.* (Eduljee, 2009). One of the earliest pairidaeza may have been the mythical Hanging Gardens of Babylon purportedly built by King Nebuchadnezzar (605 562 BCE) to placate his homesick Median wife, Amytis, by copying the lush gardens from her childhood home on the slopes of the Zagros Mountains. Several wild almonds are common species in the Zagros Mountains, suggesting their possible inclusion in the Hanging Gardens of Babylon. One of these species, *P. fenzliana*, from which cultivated almond was probably derived, may have also been present at an even earlier *paradeisos* as recent archeological research has identified an areas within the native habitat of *P. fenzliana* in the Caucasus mountains, as a possible site of the mythical Garden of Eden (Eduljee 2009).

Fig. 10. Map of the Achaemenian Empire at about 500 BCE showing overlap with both time and locations of documented early almond plantings (see text).

V. OLD WORLD DISSEMINATION

It is known that the introduction of cultivated almond in the eastern Mediterranean area took place by the second millennium BCE, because cultivated almond remains have been found in the tomb of Tutankhamen who was buried in 1323 BCE (Zohary and Hopf, 1993). Almond cultivation appears to have existed in Greece long before the creation of the Greek myths to explain its incorporation into them (Graves 1955) and there is evidence of extensive almond trade in the eastern Mediterranean in the fourth century BCE (Cerdá 1973) and possibly much earlier (Farrand 1999; Hansen and Renfrew 1978). The wide dissemination of modern almond and its cultivation has been separated into four phases: Asiatic, Mediterranean, Californian, and Southern Hemisphere (Kester et al. 1991). Often concurrent with the spread of cultivated almond is a dissemination of a surprisingly similar folklore, including medical and culinary uses, suggesting spread was through well established and interconnected trade routes (Albala 2009).

A. Asiatic Stage

The Asiatic stage included the initial domestication and the subsequent spread throughout central and southwestern Asia. The Greek naturalist Theophrastus described almond, which he called ‘amugdalai’ in his treatise on the history of plants about 300 BCE. During the early Roman expansion, Marcus

Porcius Cato (circa 236 149 BCE), referred to almond as the Greek nut , suggesting its dissemination via Greece. Pliny (23 79) in his Natural History, also listed almond as *prima omnium* or first of all . Within a few hundred years the range of known almond cultivation includes the regions now known as Turkey (Ayfer 1975; Dokuzogus 1975), Iran (Grigorian 1976), Syria (Thompson 1983), Israel (Spiegel-Roy 1976), and east to the Xinjiang province of China (Gustaffson et al. 1988), northern Pakistan (Thompson et al. 1989) and northwest India (Singh and Uppal 1977; Singh et al. 1977). In Kashgar in Xinjiang province, cultivated almonds were reported to originate from Central Asia across the Tian Shan mountains to the west (Gustaffson et al. 1988). Kashgar is on the old Silk Road connecting China to India and the West, as were most other sites of eventual domestication. The extent and sophistication of this prehistoric trade was recently documented with the discovery of the wreck of the Kyrnenia, dating from around 350 BCE in which both vessel and cargo remain remarkable intact (Fig. 11). In addition to cultivated almonds, the ship was carrying amphorae of wine and olive oil, grain millstones, coins and iron blooms. Using presumed and sometimes known origins for this cargo, the vessel's probable trading route was deduced, showing that an advanced commerce had already been well established by this time (Albala 2009). Such archaeological finds, as well as parallels in the associated folklore, support a central role of prehistoric Greco-Persian culture and commerce in advancing the cultivation, utilization and dissemination of the modern almond. As a traded commodity, the range of almond extended to the edge of the known world (Fig. 3).

In Far-east China, it was initially described in the *Yu yan tsa tsu* as a flat peach from Persia. The meat is bitter and acrid, and cannot be chewed; the interior of the kernel, however, is sweet, and is highly prized in the Western Regions and all other countries (Albala 2009). The Persian the name for almonds *badam*, or in Old Persian *vadam* became the Old Chinese *p o-tam* or *bwa-dam*. It also entered Tibetan as *ba-dam*. A later document, *Pen ts ap kan mu* by Li Si-cen identifies the origin of almonds as the land of the Mohammedans and occurs everywhere West of Gansu, the province bordering Xinjiang (literally New Frontier). Because the more temperate and humid climate of eastern China limits its cultivation, almonds were imported, especially in the T'ang Dynasty (618 907), a period of rich cultural exchange between East and West. Fragments of Chinese pharmacopoeias survive including the seventh century works by Meng Shen which mention almonds and a number of Western foods grown in imperial gardens (Simoons, 1991).

Later, the Hsin *T ang* shu (New T'ang History) describes plants grown in Western Asia, including almonds, grapes and figs from Persia (Albala 2009). In the 16th century, Li Shizen in his *Bencao Gangmu*, (a classification of materia medica) reports: It comes from the lands of Hui people and is now in all the lands of the west.

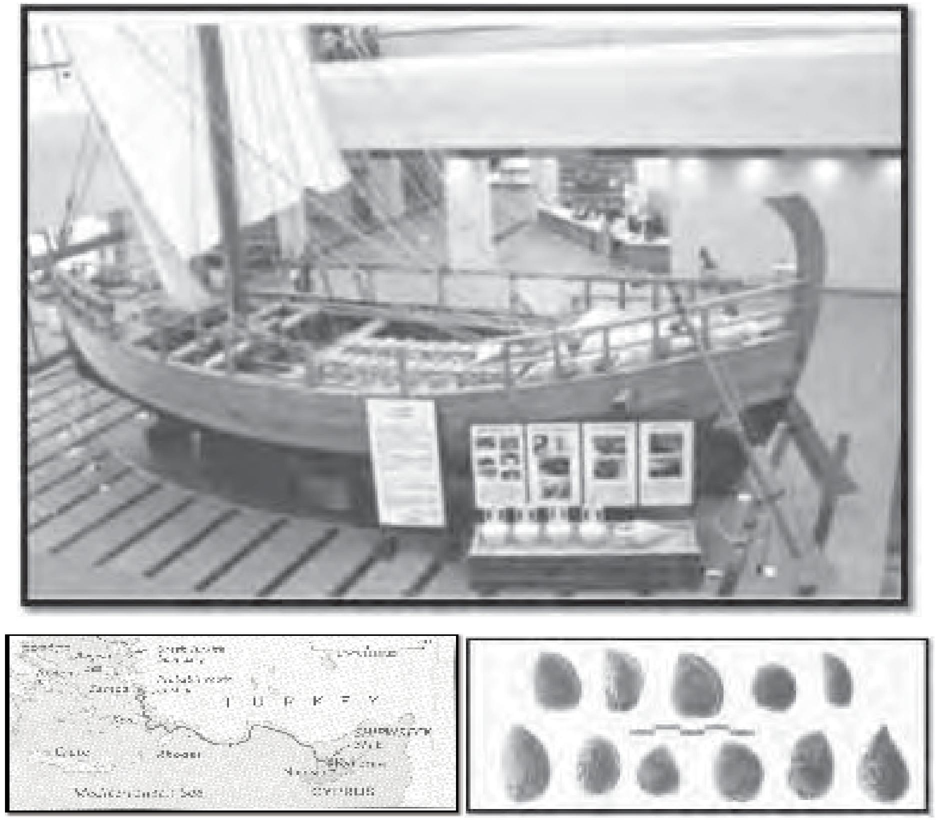

Fig. 11. The Kyrenia II replica of the almond carrying Greek cargo vessel sunk off Cyprus about 350 BCE (top). Proposed last route of the Kyrenia suggesting extensive commerce in the region (lower left). Samples of the 10,000 almond found with the Kyrenia wreckage (lower right).

The tree is like an apricot but its leaves are smaller; the fruit is pointed and small, the flesh thin. Its kernel is like a plumstone, the skin is thin and the almond is sweet and nice. It is eaten for tea, its taste is similar to that of the hazelnut. The people in the west consider it a local specialty (Métailié 2001).

In India, where almonds can be cultivated in the more Mediterranean climates of the northern provinces of Jammu and Himachal Pradesh, descriptions of almond and it's often medical and culinary uses appeared during the same period and also suggest a Greco-Persian origin (Peregrine and Melvin 2003). Almonds in Hindi are called *badam* which comes from the Sanskrit *vatama*, in turn from Persian *badam* or old Persian *vadam*. As early as the 3rd century BCE (around the time of voyages of the Kyrnenia), the classic Indian medical texts *Caraka Samhitā* and *Susruta Samhitā* characterized sweet almond (*v t ma* or *b d ma*) as heavy, hot in potency, unctuous, sweet, strength promoting, alleviator of *Vata* (wind spirit air), nourishing, aphrodisiac and aggravator of *Kapha* (phlegm) as well as *Pitta* (bile). Although the *Caraka Samhitā* and *Susruta Samhitā*, which are ancient Indian Ayurvedic texts on internal medicine, are an early source of medical understanding which was is believed to be independent of ancient Greece, Albala (2009) has recently pointed out the strong similarities between medical (and culinary) uses of almond as initially described in Greece with subsequent uses in Persia and its trading partners, including India and China. He proposes that apparent Greek origin of much of the traditional folklore associated with cultivated almond is evidence for a Greek origin or major role in the dissemination of the cultivated form of almond (*P. dulcis*).

The ancient Greek physician Hippocrates, (ca. 460 370 BCE) considered the father of Western medicine, founded the humoral or Unani doctrine of medicine. Unani medicine is based on the concepts of the four humors: phlegm (*balgham*), blood (*Dam*), Yellow bile (s*afrā*') and Black bile (*saudā*'). [The word Unani refers to Ionian Greek, meaning the Greek populated west coast of Asia Minor, in what is now Turkey. Thus the term Greek during this period of history refers not only to the Greek islands but much of the eastern Mediterranean, which at that time was also strongly networked with Persian culture (Fig. 10).] Hippocrates was among the first to record the medical uses of almonds. He reports that *Almonds are burning but nutritious burning because they are oily, and nutritious because they are fleshy* (Jones 1967). In the Greek system of humoral physiology, this means that almonds would have been categorized as a hot and dry food, one that stimulates choler or energy in the body. Diocles of Carystus, a follower of Hippocrates, adds: *almonds are nourishing and good for the bowels, and are moreover, calorific because they contain some of the properties of millet. The green are less unwholesome than the dry, the soaked than the unsoaked, the roasted than the raw* (Bottero 2004). Soaking almonds would activate seed digestive enzymes and facilitate removal of the bitter brown seedcoat. Roasting make them more easily digested. Although green almonds would have been unknown outside their area of cultivation, soaking or blanching was a common practice in both Indian and Chinese medicine (Achaya 1998). Although medical philosophies differed, the goal appears to be the same for each: to reduce their tendency to heat the body (Albala, 2009). Because of its classification as a hot food which scours the body's passages, Hippocrates and his followers recommended almond to relieve coughs, for weight gain and as an aphrodisiac (Albala 2009). The Persian *Al- anun fi l-tibb* or Canon of Avicenna (980 1037), became the standard medical text in medieval Europe, and was the primary means of Greek humoral medicine reaching Arabia and Asia, particularly in Indian Unani medicine, (where the Canon is still the principal authority) (Achaya 1998; Bottero 2004). Almond's medical values were described in a manner very consistent with the earlier view of Hippocrates: *Almonds are more slowly digested and thus less likely to convert to choler and sweet almonds comfort coughs and spitting of blood they open clogs of the liver and spleen on account of their bitterness. They even open clogs occurring in the extremities of the veins and if eaten fresh with the peel, clean humidity in the stomach* (Albala 2009).

The *Yin-Shan Cheng-Yao* dietary by Szu-Hui, of the Chinese Mongol Era, dating from 25 CE, also describe almonds in a similar fashion: Almonds control coughing and bring down ch'i. They disperse impeded pressing of the chest and abdomen (Buell et al. 2000). The Greco-Persian view of health as a balance of humors thus finds its parallel in the Chinese idea of *ch i* or the balancing yin and yang forces, which can also be described as cold and hot. In the Indian ayurvedic medical system, almonds, in addition to the previously listed attributes of cough relief and aphrodisiac, are also classified as a hot food. In Ayurvedic medicine, as in Greek medicine, health consists of a balance of elemental forces, or *doshas*, which are not exactly humors but energy principles that regulate physiological functions. Almonds are said to enhance the *kapha dosha*, which maintains the structural integrity of the body, but they also suppress an excess of the *vata dosha*, which is the principle of movement and transportation in the body. Thus, low weight gain in a thin overactive body in which nourishment dissipates quickly can be treated with a regimen including almonds (Albala 2009). In the associated *Rasayana* approach to health and longevity, almonds provide vital energy, or *ojas*, a belief comparable to the Chinese concept of *ch i* and the Greek concept of *pneuma* (Albala 2009).

Almond kernels, in addition to being a high-quality food source are also source or high-quality oil. The oil, which can constitute more than 50% of the kernel by weight, is primarily composed of oleic acid (approximately 65%) and linoleic acid (approximately 30%) which results in good flavor and nutritional value as well as stability in storage (Abdallah et al. 1998). These qualities encouraged its use as a base for various ointments in both ancient and modern cultures. The most extensive use of almonds in ayurveda is in the form of oil, used for various skin ailments and to warm the body in massage and other therapies. Almond oil is used in various *vata* disorders, chronic constipation, dry cough, semen disorders, leucorrhoea, and dysmenorrhoea. It is a good aphrodisiac, galactogogue, and health tonic (Albala 2009). In addition to the similar medicinal uses of almond in disparate Asian cultures, there were also a number of culinary dishes which appear to have a Greco-Persian origin. An ancient Baghdad cookbook, the *Kitab al-Tabikh*, records a number of sweet recipes, among which are *lauzinaj*, *faludhaj* and *samal wa-aqras* (Albala, 2009; Bottero, 2004). (The Arabic word for almond is *lauz* or *loz*, whose occasional use in the Old Testament documents its use in antiquity). The *lauzinaj* recipe begins with finely pounded sugar and pounded almonds, kneaded together with rose-water. This is essentially marzipan (see Fig. 19), and also comes with various flavorings such as camphor or musk. These are ancestors of a number of dishes of India, such as *badam barfi*, *halwa*, and similar almond sweets found throughout central Asia and as far as China. The term lozenge is also derived from the Arabic *lauz* perhaps in reference to its almond shape (Albala 2009).

B. Mediterranean Stage

The westward dissemination of cultivated almond into the Mediterranean had two stages. Almonds were first brought into the Peloponnesian Peninsula and Greek Isles (Stylianides 1976), becoming well established by 300 to 400 BCE (Fig. 3). Gradually almonds were introduced to all adapted areas of the Mediterranean, including Italy, southern France, Spain, Portugal, North Africa, and the Madeira Islands. These introductions may have come from the early ocean trading Phoenicians of Asia Minor (Egea and Garcia 1975) and or from the Greeks while establishing colonies in Sicily, Europe, and North Africa, and from other groups as extensive trade routes were well established by this time. Cultivation was typically limited to within 50 miles of the Mediterranean coast extending onto the slopes of river valleys and the interior plateau of Spain. Further introductions came from about 500 to 600 with the conquest of North Africa by the Arabs who brought almonds into Tunisia (Jaquani 1976) and Morocco (Laghezali 1985) and then into Spain and Portugal (Egea and Garcia 1975). One of the ancient Silk Road caravan routes also crossed north-central Africa, through Timbuktu into Morocco, thus representing an even earlier route of possible dissemination to north Africa and western Europe (Evreinoff 1952, 1958). Remnants of such pre-Arabic introductions may yet exist in the diverse germplasm only now being documented in the geographically isolated Atlas Mountains in Morocco and Tunisia (Laghezali 1985; Lansari et al. 1994).

Archeological studies at the site of the Mount Vesuvius eruption that occurred in the year 79 indicated that almond was a common food of the Campenians of southern Italy by the first century, though almonds appear to be well known much earlier in Rome's history, being described by Marcus Porcius Cato as the Greek nut as early as 200 BCE. In Latin it was called *amandola*, derived from the Greek αμυγδαλη (amingdola) (*cf* Amygdala). The Latin *amandola* appears to be the root for the term used for almond in Italian (*mandorla*), German (*mandel*), Swedish (*mandel)*, Russian (*mindal*), Croatian (*mandula*), French (*amande*), Spanish (almendra) and Portuguese (*amendoa*). Interestingly, in the etymologically more isolated Romani language, almond is *migdala* and so probably derived from the Greek. It has been widely postulated that the *al* prefix as in the Spanish *almendra* and English *almond* resulted from its fusion of the Arabic article *al* with the Latin *amandola* (and dropping the initial a as done with the Italian *mandorla*), which represents an etymological and cultural legacy of the 800-year control of Spain by the Arabic speaking Moors.

There is no doubt that Roman knowledge of almond was strongly influenced by the Greeks. Pliny the Elder (23 79), the ancient Roman nobleman and historian, reiterated earlier Greek ideas that almonds act as a diuretic and emmenagogue. They provoke sleep and sharpen the appetite, are also useful against headache and fever, the latter presumably from their purging qualities to drive out the fever rather than counteract or cool it (Albala 2009). Galen of Pergamum (129 200), a highly influential Greek physician serving several Roman Emperors, believed that although bitter almonds were not very astringent, they cleansed and attenuated and thus purged, and act towards the expectoration of moist matter from the lungs and chest. The very bitter cut through thick and viscous matter. But they are also oily, so not as useful for purging the stomach, and bitter almonds unlike the sweet afford little nourishment for the body (Grant 2000).

Rosengarten (1984) describes an almond-based cold cream used by fashionable French women in the 17th century. This Ninon de Lenclos ointment contained four ounces (112 g) of almond oil, 3 ounces of hog's lard

(104 g), and one ounce (28 g) of spermaceti (a waxy component of sperm whale oil). These ingredients were melted, lemon juice added, stirred until cool and then scented with rose water. Almond oil continues to be an important oil-base for cosmetics and other pharmaceuticals to the present. Additional medicinal uses of almond ointment included the treatment of pattern baldness and as a soothing ointment for burns. The continuing practice in parts of Asia is the application of almond oil to the heads of babies, as it is believed to promote their subsequent intelligence. Salves containing concentrations of oleic and related fatty acids may also help control of head lice (Socias i Company et al. 2007) which might further explain the application of almond to the scalps of children.

While bitter almonds and almond oil were used primarily as medicine, sweet almonds and oil of bitter almond (an alcohol-based extract of bitter almond essence, being primarily benzaldehyde) were used as both food and medicine. Both also found culinary uses. One of the oldest surviving Roman cookbooks, Apicius (fourth or fifth century CE), describes a dish called *apothermum* which is boiled wheat with pine nuts and almonds that have been soaked, skinned and whitened with silver chalk (*creta argentaria*) to which is added raisins and raisin wine, with pepper over the top (Bottero 2004). As pointed out by Albala (2009) this recipe bears a striking resemblance to a rice dish in Persian cookery, and which in turn finds its way to India and China and ultimately to England and the West as rice pudding. A similar soup made with ground almond, rice and sugar was used for sore throats in the Ch'ing court in China (1644 1911) (Simoons 1991). In modern China, a popular dish to combat colds and sore throats is made with apricot kernels powdered and mixed with rice congee (Simoons 1991). A traditional Christmas desert in Sweden and parts of northern Germany is cinnamon-flavored rice pudding into which a single almond has been hidden; the one who finds the almond will have good fortune for a year.

A renaissance in European cuisine which involved spices, as well as almond and other foods from Asia, appears to have occurred from the 10th through the 13th centuries following the spread of Islam. Evidence for an even earlier almond plantings in France can be found in the charter granted by King Chilperic II (716) and in an edict of Charlemagne in 812 (Rosengarten, 1984). An inventory of the household goods of the Queen of France in 1372 listed only 20 pounds of sugar but included 500 pounds of almonds. Almonds appear to have been relatively inexpensive and generally available to the emerging middle class even in areas such as England where the climate would make a local production more difficult. Rosengarten (1984) estimates an average price of approximately two to three pence per pound between the years 1259 and 1400. The almond trade appeared substantial by the 14th century with Venice becoming an important center of commerce. To capitalize on this extensive commerce, the Knights Templar levied tithes on almonds, honey and sesame seed in 1441.

The Arab conquest of North Africa and Spain, introduced Middle Eastern cuisine which included almond and sugar-based confections similar to the previously described marzipan, as well as more staple fare such as *harisa*, a popular dish of 10th-century Baghdad, which consisted of meat and vegetables served with a sauce thickened with powdered almonds (Rosengarten, 1984). Similarly, almond milk, which could be used as a milk substitute for direct consumption or in cooking, was made by soaking in water pulverized almonds from which the outer seed coat had first been removed. Almond milk became a more frequent ingredient in Mediterranean cuisine than in the Middle East. For example, the grand medieval European dish, *blancmanger*, was typically chicken stewed in almond-milk. The comparable and popular Persian dish, *isfidhabaj* (white stew), used almond milk in some recipes though many recipes contained no reference to almonds at all. Religious and medical views have played roles in the emergence of almond in European cuisine. For example, almond milk could be conveniently substituted for dairy milk, whose consumption was forbidden on Fridays by the Roman Catholic Church.

In addition, physicians from the 12th to the 16th century continued the belief that the nature of the food consumed was a critical component of health. Echoing ancient Greek beliefs, foods such as almonds, chicken, and rice were viewed as moderately warm and moist in their characteristics and so compatible with the healthy human body. The prevailing view among the upper class was that such moderate foods were more ideally suited for consumption and had the added value of moderating foods perceived as being too hot (ginger), too cold (many vegetables), too dry (turnip) and too wet (watermelon) (Albala 2009). Even more extensive culinary uses of almond were eventually brought to Europe by the returning Crusaders, many of whom had developed a preference to more exotic Middle Eastern cuisine compared to the more bland European diet of the time. As an example, a recipe from the *Forme of Cury*, dating back to 1390 (homecooking.about.com od foodhistory a almondhistory.htm), uses ground almonds in a gravy for oysters that is still fashionable.

A rich folklore, including extensive medical and culinary uses of almond, also can also be found in Spain, particularly southern Iberia which was under Moorish control the longest. The origin of this folklore is often uncertain though, since, during the Dark Ages, the Muslim Arab kingdoms were the main repository and disseminator of the earlier Greek and Roman knowledge. Paella, the national dish of Spain, or at least the Valencia region, has its equivalent in the Persian dish of *dan-pukhtak* also known as *biryani*, with almonds often being included in both (Albala 2009).

A bit of mythology often credited to Aristotle (but probably not disseminated by the abstinent Arab Muslims), was this proposal of Roman author Pliny the Elder: It is said that if five bitter almonds are taken by a person before sitting down to drink, he will be proof against inebriation. Plutarch (ca. 42 BCE 37 CE), likewise says that Drusus, brother of Tiberius, who was a prodigious drinker, used almonds this way. The logic here is that the almond, on account of its bitterness and diuretic properties, speeds the alcohol through the system before it has a chance to send vapors up to the head (which was believed to cause inebriation). The *Herbal* of John Gerard (1597) states that five or six (almonds) being taken fasting do keepe a man from being drunke and may have become the forerunner of the cocktail nut of today (Rosengarten 1984). Purported protection from inebriation may have also contributed to previously cited popularity of almonds in weddings. In traditional Greek weddings, slightly bitter sugar-coated almonds called *koufeta* are placed in little bags in odd numbers and served on a silver tray. Odd numbers are indivisible, symbolizing how the newlyweds will share everything and remain undivided. Tradition holds that if an unmarried woman puts the almonds under her pillow, she will dream of her future husband. Five (often sugar-coated or Jordan almonds), signify five wishes (health, wealth, happiness, fertility, and longevity) are common in traditional Italian weddings, and other special occasions. These almonds decorate each place setting as favors, tucked into pretty boxes or tulle bags called *bomboniere* that are often personalized with the couple's names and date (Fig. 9). A different and new type of favor is the Favor Cake or *Torta Bomboniera* which are made using little boxes forming one or more tier of a cake. Inside each box there are the sugared almonds and a card printed with the data of ceremony. Sugar-coated almonds are also traditional in Middle Eastern weddings and are considered by some to be aphrodisiacs.

In southern Europe, almonds also symbolized good luck, as well as long life and happiness. The heartening capability of a dormant almond shoot in winter to quickly flower when cut and brought into warmer temperatures is frequently alluded to in European art and literature from Medieval times to the present (Figs. 12, 13, 14). In the legend of Tannhauser, made famous by Richard Wagner's 1845 opera, the knight was informed by the pope that he was as likely to have his sins forgiven as the pope staff was likely to bloom (Rosengarten 1984). The staff, which was made of almond, did indeed bloom but tragically, Tannhauser died before his pardon arrived.

The almond's seemingly magical flowering ability may have also contributed to the preference for a wand made from almond by professional magicians during the Middle Ages, as well as the use of almonds in Tuscany for making dowsing rods for the divination of underground water or other hidden items of value [reminiscent of the almond branch of the Oracle at Delphi (Fig. 7)].

Fig. 5. Lithographic reproduction of an Almond twig from the *1517 Herbal* by Johanes Niger. Source: Avanzato, and Vasssallo 2006.

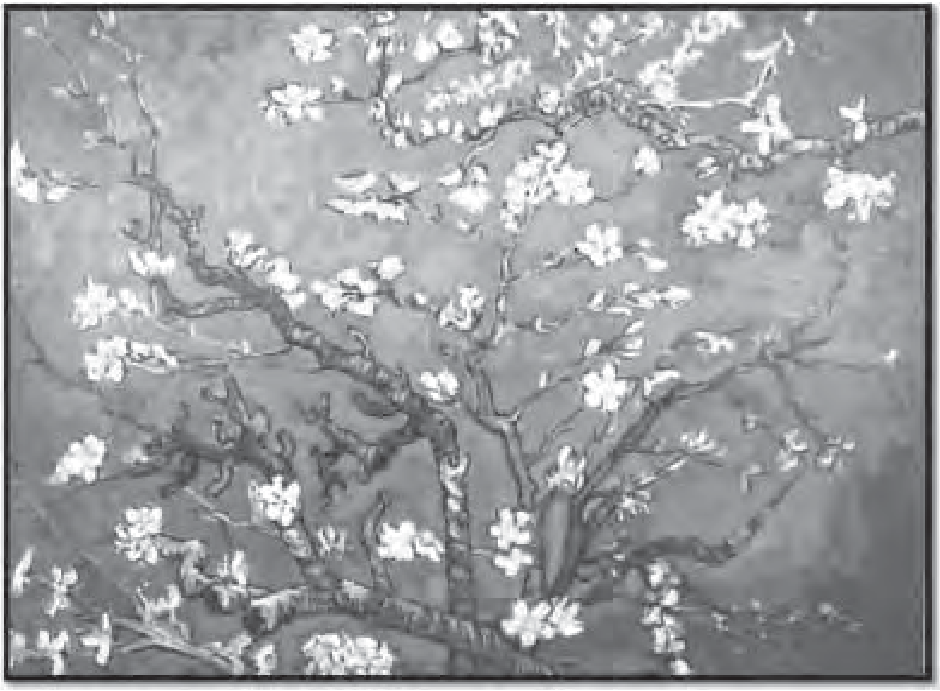

Fig. 13. Almond Blossom by Vincent Van Gogh (1853 1890) for his newborn nephew as a symbol of a budding life.

Almond was also well suited for cultivation in the Mediterranean climate with its traditional low input-moderate return dry-land cropping systems. Easy propagation by seed, rapid development of the tree, and adaptation to marginal soil, summer drought and heat, combined with its food value, made the almond well adapted to the subsistence form agriculture predominating in early Mediterranean culture. High root tolerance to drought but high susceptibility to excessive soil moisture placed almonds in a mixed culture system with olives, carob and other drought-tolerant crops. Almonds were usually found on well drained slopes at higher elevations of valleys to escape shoot damage from frosts and root damage from excessive soil water. A traditional culture system evolved which minimized inputs of labor, fertilizers, and use of supplementary water. Some trees producing bitter nuts were often tolerated in local seedling orchards since bitter seed were mixed in small quantities with sweet kernel to produce the distinctive amaretto flavor. Because sweetness is the dominant trait, genes for bitterness may still be present in sweet-kernel trees, allowing the occasional recombination of bitter seedling trees. The Italian naturalist Scribonius Largus documented this distinction in the first century CE by naming bitter almonds as *Amygdali amari*. Bitter forms of the cultivated almond are sometimes classified as *Prunus dulcis* (Mill.) D. A. Webb var. amara (DC.) Buchheim (Fig. 15). Bitter almonds are also commercially cultivated for their oil which is used to extract benzaldehyde for the amaretto essence, known to bakers and chefs as almond extract or oil of bitter almond but known to many consumers as the cherry flavor in cherry colas, drinks and confectionaries. The presence of excessive trees producing bitter or otherwise undesirable seeds in segregating seedling populations would be an incentive to use the undesired bitter trees as rootstocks for topworking with scions from the more desirable trees. Grafting was widely used in antiquity and is found in writings of Hippocrates, Theophrastus, Cato, Varro, Columella, and Pliny. Two thousand years of continuous almond culture in the Mediterranean basin concentrated production to specific regions where well-defined seedling ecotypes and local cultivars evolved (Grasselly 1972, 1976b; Grasselly and Crossa-Raynaud 1980). These highly selected regional cultivars and landraces represent a rich genetic, horticultural, and culinary diversity (Tables 3 and 4). Dryland, seedling orchards remained the major almond culture system in the Mediterranean Region for centuries, persisting to recent times in such areas as Sicily, Sardinia, Majorca, Madeira Islands, Greece, Turkey, and Morocco.

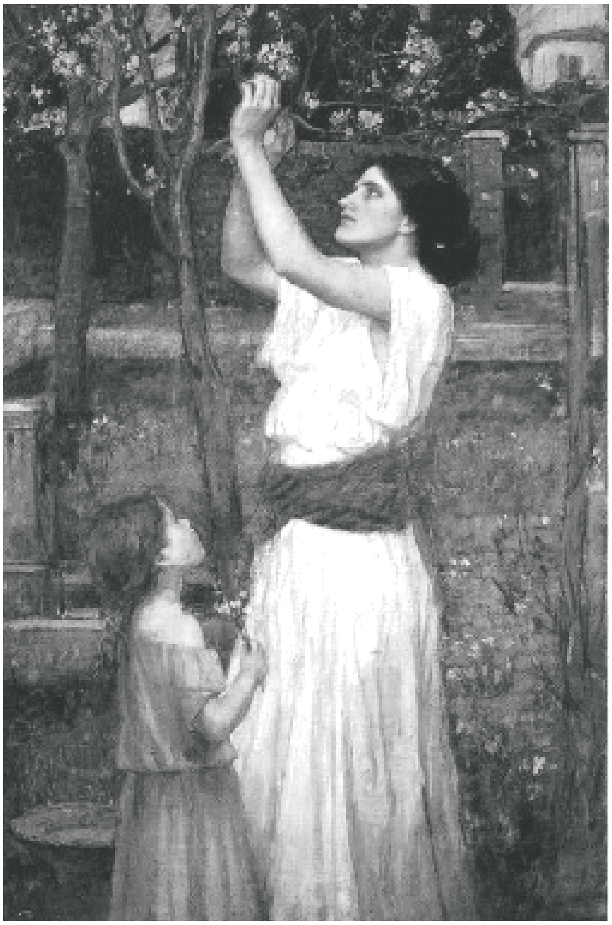

Fig. 14. *Gathering Almond Blossoms* (1916) by John William Waterhouse.

By the middle of the 19th century, cultivars of specific Mediterranean countries were recognized by nurseries by name (Fig. 16) and were introduced into California as early as 1843. By the turn of the 20th century, most of the almond countries of the Mediterranean region and the United States had identified local cultivars that were seedling selections which, while representing the germplasm of the region, were often of unknown origin. Italy became a major almond growing area and many cultivars have been described in Puglia (Fanelli 1939; Grasselly and Crossa-Raynaud 1980), Sicily (Bianca 1872; Spina 1958) and Sardinia (Milella 1959; Agabbio et al. 1984; Chessa and Pala 1985). Puglian cultivars were predominantly late blooming, had hard shells with a kernel nut ratio of 25% to 30%, with high percentages of double kernels. Sicilian cultivars tended to be early blooming, very hard shelled and more or less round in shape. Several Italian cultivars were also self-compatible.

Spain has a long history of almond culture with almonds being grown in most provinces (Felipe 1976; Gardner and Lee 1979). Principal concentrations are in coastal provinces (Tarragona, Valencia) along the Mediterranean coast (Murcia) and the Ebro valley (Lerida) although the range extends to the southeastern border with Portugal and into the interior (Murua et al. 1993). 'Marcona' and 'Desmayo Largueta', both of unknown origin, have been the most widely grown cultivars. Both have very hard shells, are highly productive, have well recognized eating and cooking qualities such that they are marketed by name. Many other named cultivars of local origin (Vargas 1975; Felipe 1984; Garcia et al. 1985, 1988) have evolved from localized ecological niches that occur in different valleys that extend inland from the Mediterranean coast.

France is an old almond-growing country with areas in the southern Rhone valley and the surrounding foothills (Grasselly and Crossa-Raynaud 1980). Cultivars originating in Provence and the foothills of the Alps tend to be late blooming. Cultivars associated with the Languedoc region nearer the center of the Rhone valley ('Ai', 'Princesse', 'Languedoc', 'Pistache', 'Ardechoise', 'Fournat de Brezenaud', 'Rabasse') show a range of tree and nut characteristics from hard to soft shelled and large to small kernels.

Portugal has two principal areas of production, the Algarve region in the south and the Alto Douro in the north. Each region has cultivars specific to the region (Grasselly and Crossa-Raynaud 1980). Similar situations exist in other traditional almond growing countries, such as Tunisia, Greece, and Canary Islands.

Fig. 15. Bitter almond [*Amygdalus communis* L. var. *amara* (syn, *P. dulcis* var. *amara*)] from 1926 *Textbook of Pharmacognosy* by T.C. Denston showing similar morphologies to cultivated sweet almond despite distinct botanical classification.

The traditional almond production system of the Mediterranean and Asian regions, however, began to fail in the 1940s and the French almond industry essentially went out of production by the 1950s (Grasselly and Crossa-Raynaud 1980). By the 1970s production could not keep pace with the world demand for almond products because the most productive land was used for high value crops such as peach and grape. Italy, historically the leading almond producer of the world, experienced a sharp decline in production (Federation Italiani 1973; Godini 1977; Bacarella 1993), and began to import almonds (Bacarella et al. 1991). Spain expanded its area and production but the scarcity of productive irrigated land has made production increases relatively modest (Abdelwahed and Albisu 1993; Murua, 1993; Murua et al. 1993). In addition, supplemental honeybee pollination is not widely practiced (Felipe and Socias y Company 1992; Godini 1977b; Godini et al. 1992) significantly reducing final yield potential. Declines in production relative to other higher value tree crops also took place in the Asiatic regions of cultivation, where in many areas almonds continue to be grown under conditions similar to those used thousands of years ago. The genetic, horticultural, and culinary diversity which initially made these selections highly adapted to their production regions proved inconsistent with the new kernel ideotype of an increasingly global and so increasingly standardized market.

Table 3. Characteristics of important new almond cultivars from selected breeding programs.

Cultivar	Description [z]
SPAIN	
CITA of Aragón (Zaragoza)	
Blanquerna	‘Genco’ OP, SC, mid-blooming, hard shell, large kernel of excellent quality, early ripening
Cambra	‘Ferragnès’ × ‘Tuono’, SC, late blooming, hard shell, medium ripening
Felisia	‘Titan’ × ‘Tuono’, SC, very late blooming, medium-hard shell, small kernel, very low alternance, early-medium ripening
Belona	‘Blanquerna’ × ‘Belle d’Aurons’, SC, late blooming, hard shell, large kernel with an outstanding composition, medium ripening
Soleta	‘Blanquerna’ × ‘Belle d’Aurons’, SC, late blooming, large kernel with an outstanding performance when roasted, medium-late ripening
Mard a	‘Felisia’ × ‘Bertina’, SC, extremely late blooming, disease tolerant, early-medium ripening
CEBAS - CSIC (Murcia)	
Anto eta	‘Ferragnès’ × ‘Tuono’, SC, late blooming, hard shell, high vigor, spreading with dense, very early ripening
Marta	‘Ferragnès’ × ‘Tuono’, SC, hard shell, high vigor, upright, late blooming, early ripening
Penta	S5133 × ‘Lauranne’, SC, extremely late blooming, hard shell, intermediate vigor and branching, early ripening
Tardona	S5133 × R1000, SC, extremely late blooming, hard shell, small kernel, intermediate vigor with dense branching, medium ripening
IRTA - Mas de Bover (Reus)	
Constant	(‘Ferragnès’ × ‘Ferraduel’) OP, SC, late blooming, mid ripening, vigorous, mid branching
Marinada	‘Lauranne’ × ‘Glorieta’, SC, very late blooming, mid ripening, mid vigor, mid branching
Tarraco	(‘Ferralise’ × ‘Tuono’) × Anxaneta, SI, very late blooming, mid ripening, mid vigor, large kernel, mid branching
Vairo	(‘Primorskij’ × ‘Cristomorto) × ‘Lauranne, SC, late bloomig, early ripening, high vigor, mid branching
FRANCE	
INRA (Avignon)	
Lauranne	‘Ferragnès’ × ‘Tuono’, SC, medium-hard shell, medium vigor, late blooming, early-medium ripening, some double kernels
Steliette	‘Ferragnès’ × ‘Tuono’, SC, semi-hard shell, medium vigor, late blooming, early ripening, some double kernels
Mandaline	‘Ferralise’ × ‘Tuono’, SC, late blooming, medium ripening, hard shell, medium to upright growth
ISRAEL	
Shefa	‘Tuono’ × local cross, SI, vigorous, early blooming, highly adapted to Israel conditions, soft shell, large kernel, early ripening
UNITED STATES	
University of California (Davis)	
Avalon	Probably ‘Nonpareil’ OP, SI, medium kernel, early blooming, paper-shell, harvest approx. 8 days after ‘Nonpareil’
Kahl	Chance seedling in a ‘Nonpareil’, ‘Davey’, and ‘Mission’ planting, SI, mid- blooming, large kernel, semi-soft-shell, harvest 14 days after ‘Nonpareil’
Morley	‘Mission’ × late blooming almond seedling, SI, late blooming, medium kernel, semi-soft shell
Savanna	‘Nonpareil’ × late blooming almond seedling, SI, late blooming (2 weeks after ‘Nonpareil’), large kernel, semi-soft shell, harvest 14 days after ‘Nonpareil’
Sweetheart	SB3,54-39E [‘Lukens Honey’ peach × ‘Mission’ × ‘Nonpareil’] × Sel 25-26. SC, mid-blooming, large ‘Marcona’-type kernel, harvest approx. 10 d after ‘Nonpareil’, semi-soft shell, high kernel oil and roasting quality, resistant to post-harvest worm damage
Winters	‘3-1’ (‘Peerless’ × ‘Harpereil’) × ‘6-27’ (‘Nonpareil’ × ‘Jordanollo’), SI, early blooming, large Carmel-type kernel, paper-shell, good bloom overlap with early ‘Nonpareil’ bloom, harvest 3 weeks after ‘Nonpareil’

[z] OP: open pollinated; SC: self-compatible; SI: self-incompatible.

Table 4. Characteristics of the new rootstocks for almond from selected breeding programs.

Rootstock	Description
SPAIN	
CITA de Aragón (Zaragoza)	
Felinem	‘Garfi’ almond × ‘Nemared’ peach, red leaves, easy propagation, nematode resistant, good vigor, adapted to replanting and to poor and calcareous soils
Garnem	‘Garfi’ almond × ‘Nemared’ peach, red leaves, easy propagation, nematode resistant, good vigor, adapted to replanting and to poor and calcareous soils
Monegro	‘Garfi’ almond × ‘Nemared’ peach, red leaves, easy propagation, nematode resistant, good vigor, adapted to replanting and to poor and calcareous soils
EE Aula Dei - CSIC (Zaragoza)	
Adafuel	Natural hybrid selection (probably ‘Marcona’ seedling), easy propagation, very vigorous, adapted to calcareous soils
Adarcias	Natural hybrid selection, easy propagation, low vigor, adapted to calcareous soils
ITALY	
University of Pisa	
Sirio	‘INRA GF 557’ OP, low vigor, poor vegetative propagation, good root system
UNITED STATES	
California	
Atlas	Interspecific cross to *Prunus blireiana,* vigorous, upright
Hansen 536	Almond × peach hybrid, vigorous, deep rooting, resistant to drought
Nickels	Almond × peach hybrid, vigorous, deep rooting, resistant to drought, soil fungi.
Marianna M40	*P. cerasifera* × *P. munsoniana*, improved anchorage, fewer suckers
Viking	Interspecies cross to *P. blireiana,* vigorous, upright, tolerant wet soils

Similarly, attempts to extend the range of cultivated almond into continental areas, e.g., Yugoslavia (Ristevski 1992), southern Russia (Richter 1972), Romania (Cociu 1985), Bulgaria (Serafimov 1975, 1976) and Hungary have met with only partial success. This has been due to almond’s susceptibility to winter cold, and spring frosts as well as flower and foliar disease which is exacerbated by summer rains in these regions.

Fig. 16. Illustrations representing different heirloom almond varieties from the Genova region of Italy.

VI. NEW WORLD DISSEMINATION

Almond dissemination to the New World followed early colonization by European and Asian settlers, eventually resulting in commercial plantings in North and South America, Australia, and South Africa. Successful cultivation typically occurred only after a series of failures as early settlers, not recognizing the degree of almond's vulnerability to winter cold, spring frosts and summer rains, tested different growing regions and germplasm until suitable combinations were found. Almonds introduction into California, which began as an extension of the Mediterranean culture utilizing a limited range of European germplasm (Wood 1925) is representative of the New World stage from 1850 to the present. California production, however, inevitably broke from the traditional methods of almond growing utilized in the rest of the world. Key adaptations included: (1) selection of specific vegetatively propagated cultivars and rootstocks to maximize production; (2) standardization of markets based upon cultivar; (3) selection and optimization of growing sites; and (4) development of new cultural and management techniques, including increased mechanization, agrochemical inputs and supplemental pollination. The impact of these changes has been to maximize yield and to promote modern industrial and marketing techniques (Kester et al. 1991; Micke 1994). Commercial cultivars introduced to California from the Languedoc area of southern France from 1850 to 1900 included 'Princess', 'Languedoc', 'Gros Tendre', 'Sultana', and others that ultimately provided the germplasm from which the California almond industry evolved (Wood 1925). Originally these were grown primarily in solid plantings and considered to be shy-bearing (because almond is self-sterile and needs pollenizers), nonadapted, and susceptible to frost and disease (Chappelow 1893; Wickson 1910; Dargitz 1910). The eventual combination of highly adapted and rootstocks and multiple interplanted cultivars, the use of honey bee hives to maximize cross-pollination at flowering

(Thorp and Roper 1994), favorable soil and climate, and abundant water and effective management has resulted in the highest productivity in the world and the domination of world markets (Kester et al. 1991; Micke 1994). Yields per hectare continues to show upward trends with yield as high as 4,500 kg ha not unusual.

An important initial step towards maximizing output was the (1900 to 1925) selection of four cross-compatible cultivars (‘Nonpareil’, ‘Mission’, ‘Ne Plus Ultra’, and ‘Peerless’) that established the basic industry cultivar pattern in the orchard and the marketplace. Shifts to more productive soil areas, changes in management, and the change to peach rootstocks brought about changes (1925 to 1955) that resulted in a shift from what was initially a subsistence enterprise to a major, dedicated agricultural industry. This change reflected the contributions from many sources, including research and extension from the University of California, Davis, a progressive nursery industry, innovative growers and industry leaders, and governmental policies that promoted the development of irrigation and marketing. In the period of 1955 to 1965, the management patterns and world economic and marketing trends began to change and the industry entered an explosive growth period. Expansion occurred into all areas of the central valleys of California, increasing five-fold in area and ten-fold in overall production. As a result California production came to dominate world production (Fig. 17).

Almond cultivars and cultural management methods were introduced to Australia, Chile and Argentina from California and different Mediterranean areas in the early to mid-19th century. In Australia, chance seedlings from this material resulted in selection of cultivars which have become more or less standard such as ‘Chellastan’, ‘Johnston’, ‘White Brandis’, ‘Bruce’, and ‘Boxendale’ (Quinn 1928). More recently, the list has been supplemented by new introductions from California. South Africa grows limited almonds following introduction about the turn of the century. The principal cultivars are from California but a local selection, known as ‘Britz’ was important in establishing the early industry (Davis 1928).

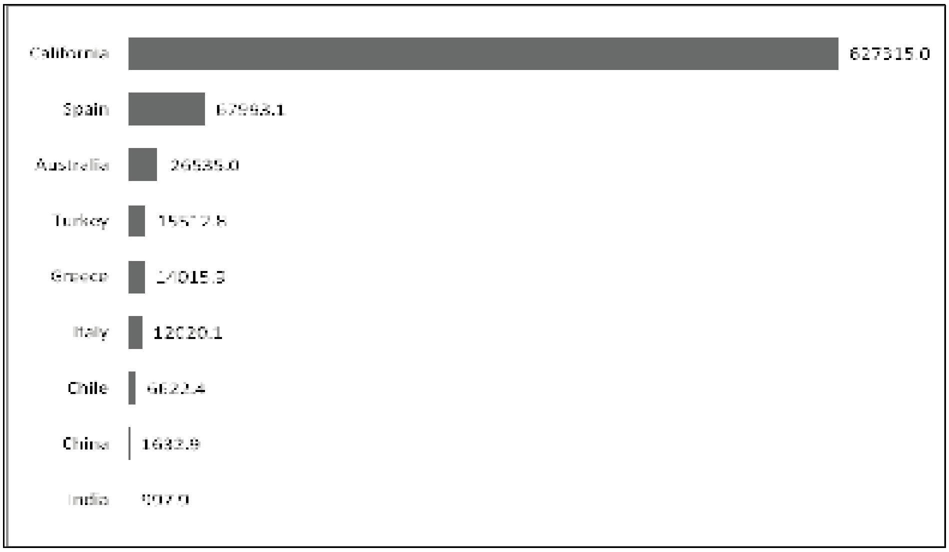

Fig. 17. Commercial almond production (million tonnes) in 2007 2008. Source: ABC 2008.

VII. LOBAL COMMERCE

A. Production

Global commercial production was approximately 772,468 million tonnes (Mt) in 2007 2008 with California accounting for approximately 80% with a 2008 production of 627,315 Mt (Fig. 17) from 261,076 ha (bearing). Spain, the second leading country, produced approximately 8% of world production but utilizes a cultivated area of over 436,500 ha (Murua et al. 1993). The remaining world production comes from about 20 countries including Australia (3%), Turkey (2%), Greece (2%), Italy (1.5%), Chile (1%), China (0.2%), and India (0.1%) (ABC 2008). Limited almond production for both local and export markets also occur in other areas of the Mediterranean, including Portugal, Morocco, Tunisia, Algeria; areas of the Balkan Peninsula including Bulgaria, Romania and Hungary; and central and southwestern Asia including Syria, Iraq, Israel, Iran, Ukraine, Tajikistan, Uzbekistan, Afghanistan and Pakistan. Almond growing in much of this area is in a relatively archaic state although modern production areas exist in Portugal, and in some parts of Ukraine and Iran. Despite falling production in most traditional almond producers, global production has actually more than doubled in the last 20 years from a 1998 crop of 354,259.3 Mt. Most of the increase in production has occurred in California where a 5-fold increase in crop area combined with a more than doubling in yields per hectare resulted in an almost 10-fold increase in production over the last 30 years. This combination of increased plantings coupled with increased cropping efficiency has made almonds the largest export crop for California (Fig. 18) and has resulted in expanded research on production efficiency, as well as phytonutrient value and culinary uses of almond (ABC 2008).

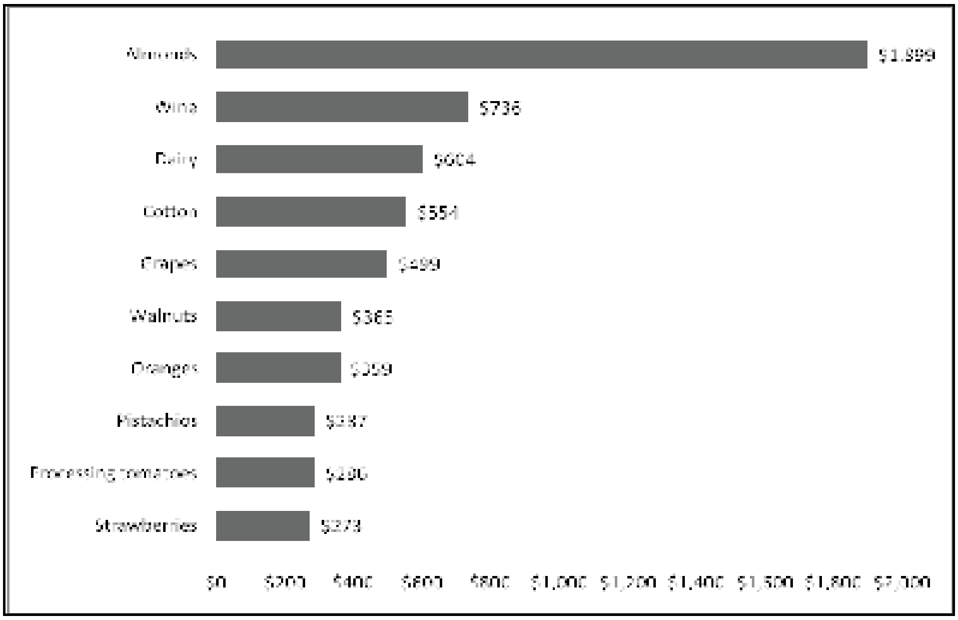

Fig. 18. Value (in millions of US dollars) of major California export crops in 2006
2007. Source: ABC 2008.

B. Consum tion

Consistent with its Mediterranean and Asian culinary origins, almond continues to show great versatility with its distinctive culinary heritage, as with marzipan paste (see Fig. 19) in addition to its more traditional role as a convenient and nutritious snack nut (Table 5). At 0.6 kg, the per capita consumption of almonds in the US has increased by over 20% over the last four years. Similar increased demand has occurred in traditional European and Asian markets (Fig. 20). Expanding markets have increased the food and even industrial utilization’s of almond (such as hand creams) well beyond its traditional use. As in the past, the perceived culinary and medicinal value of almonds remains a driving force for market expansion. Recent medical studies have documented health benefits from almond consumption for a range of areas, including protection from cancer, obesity, and heart disease (see recent review by Socias y Company et al. 2007). The widespread availability and relative low cost of almonds relative to other nut crops have also encouraged its expanded use (Fig. 21) either in combination or as replacements for other nuts in confectioneries, cereals, and baked goods. A highly developed international marketing system has emerged to distribute the billion-dollar-per-year almond crop (Alston et al. 1993; ABC 2008). In addition to ensuring product quality and availability, these advanced marketing systems are also important in ensuring food safety, particularly the prevention of product contamination by fungal toxins such as aflatoxin or microbial contamination as with *Salmonella* spp. (IPM 1995). Global market requirements for product consistency, however, have moved beyond food safety and food quality concerns. The increasing sophistication of culinary and food service uses are progressively demanding more standardized kernel type for industrialized handling, as in slicing and slivering (Table 5). Even in the making of food products emphasizing the natural amaretto almond flavor, processors will often prefer using a more consistently bland cultivar as the basic nut to which they can add either limited bitter nuts or almond extract as needed. In California, ‘Nonpareil’ (Fig. 22) has become the cultivar most widely planted, partly because it satisfies most of these market needs for consistency combined with a relatively long and elliptical kernel which further facilitates its processing. Approximately 37% of the current California crop area is planted to ‘Nonpareil’ with an additional 15% planted to do similar market type ‘Carmel’. The remaining cultivars are primarily planted as pollenizers to ensure high fruit set. Thus, the anticipated introduction of self-fruitful ‘Nonpareil’-type cultivars in the next decades would further and probably dramatically promote greater crop uniformity and compatibility with expanding international markets. These global market pressures towards more uniformity in the almond crop would consequently lead to continued and perhaps accelerated loss of native genetic diversity, and so genetic options against emerging pests and diseases. Considerable losses in germplasm have already been documented in traditional Mediterranean and Asian growing areas as new market-orientated cultivars are brought in to replace the traditional, locally adapted cultivars and land races established over hundreds to thousands of years.

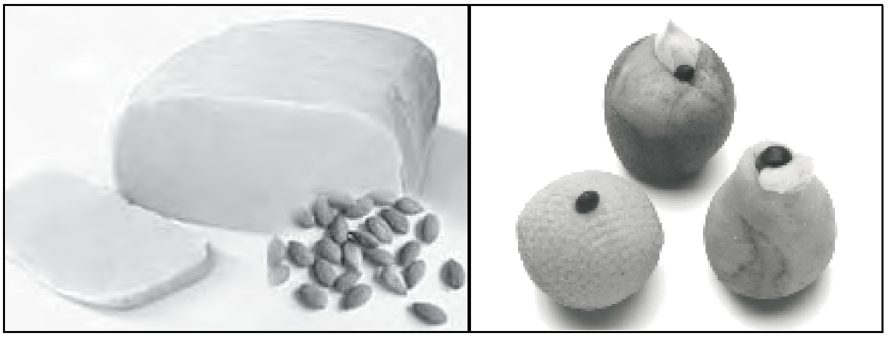

Fig. 19. Almond paste (left) which is commonly called marzipan but known by regional names throughout Europe, Asia, and North Africa, is a confection consisting primarily of sugar and almond meal. The incorporation of bitter almonds, which constitute approximately 5% of the total weight, gives it its distinctive flavor. It is often made into sweets, glazes for cakes, or as a cake ingredient, as in stöllen. In addition, it can be consumed directly, in many regions after being shaped into small figures as a traditional treat for New Year’s Day (right).

Table 5. Commercial almond products and applications.

Common products	Benefits	Applications
Natural almonds whole; and whole & broken	Provides color contrast to lighter foods; adds visual appeal nutritional value and texture; stronger flavor than blanched products	Roasting, flavoring, snack foods; complementary ingredients for confectionery, cake, bread, cookies and cooking, etc.
Natural or blanched sliced almonds	Increases almond recognition; adds flavor, visual appeal and nutritional value; provides texture contrast	Cake, bread and cooking garnish; cereal additive ingredients
Natural or blanched diced almonds	Adds almond flavor and characteristics, nutritional value. and visual appeal	Cake and confectionery fillings; additive ingredients for cooking
Blanched almonds whole & broken	Complementary flavor, high quality, garnishing, visual contrast and nutritional value	Ingredients for mixed dried fruits and nuts retail packing, and blanched manufactured products; cookie and cake garnish
Blanched slivered almonds	Adds crunchy, complementary flavor, and nutritional value.	Ingredients for cake, cookie, bread, snack, and cereals; additive ingredients for cooking.
Natural or blanched almond meal	Adds color, flavor, richness and nutritional value.; fat replacement and binding agent	Cake and confectionery fillings; ingredients for fortified breads and cereals
Roasted almonds	Strengthen flavor and color and nutritional value	Fillings and garnish for dairy products, e.g. ice cream; ingredients for energy and chocolate bars.
Oil	Stability, low rancidity, high oleic acid content and nutritional value..	Base for cosmetics, ointments, skin creams and other pharmaceuticals
Hull	High carbohydrates & nutrients, adds flavor	Dairy cattle feed

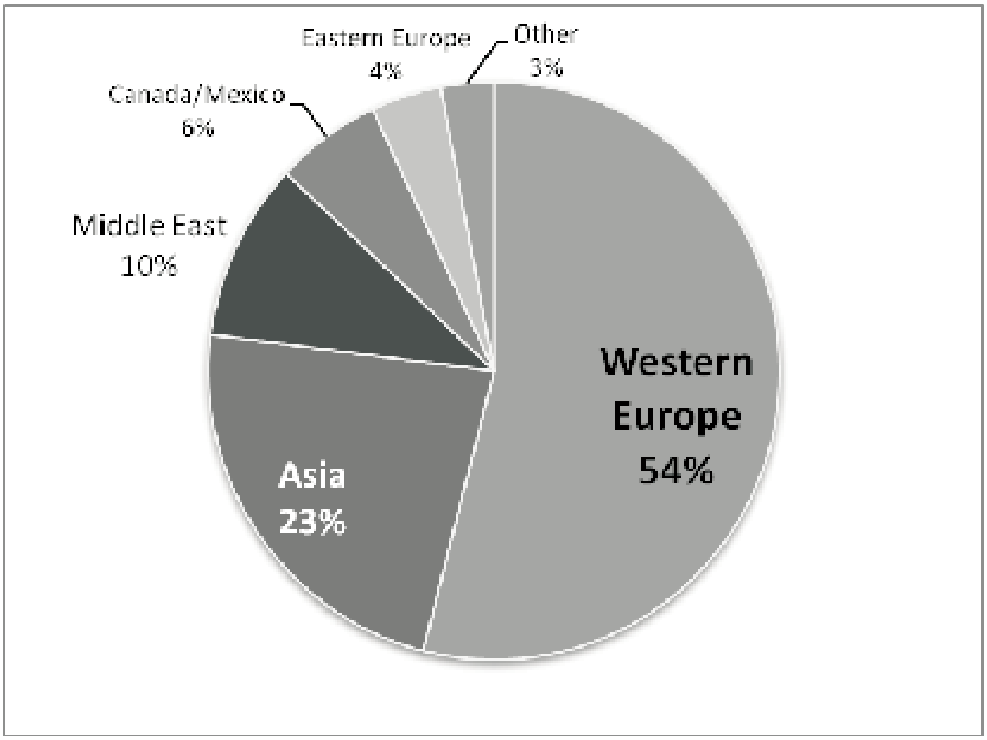

Fig. 20. California export markets in 2007 2008.

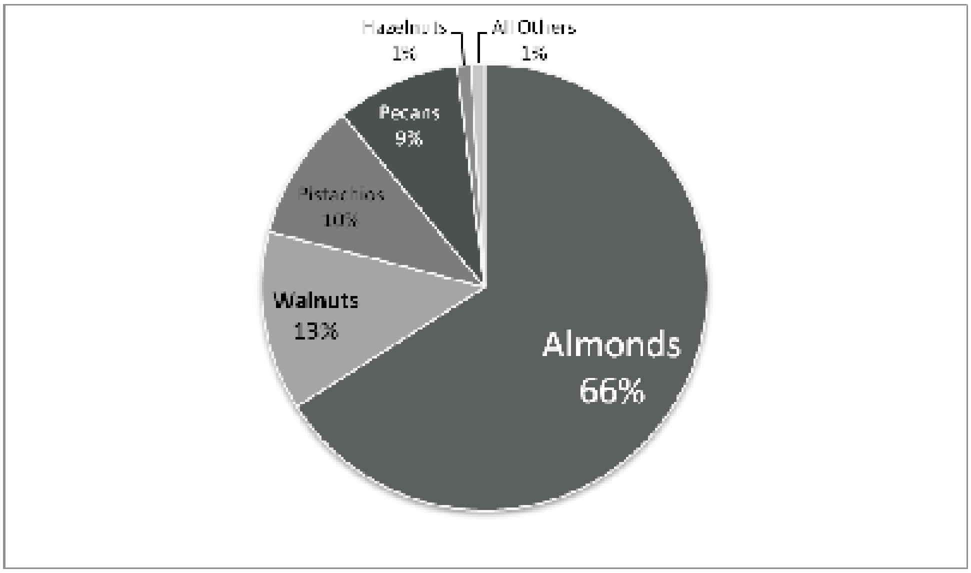

Fig. 21. World commercial use of various tree nuts by proportion (2007 2008).

Fig. 22. 'Nonpareil'-type paper shell and uniform, amygdaloidal kernel which is becoming the market standard in world commerce.

VIII. EVOLVIN RE UISITES FOR COMMERCIAL ALMOND

Recognizing the genetic, environmental and management deficiencies of the traditional almond industries, most almond producing countries are pursuing almond research with emphasis on germplasm evaluation and cultivar and rootstock improvement. These activities followed a pattern that included: (1) surveys of local cultivars and seedling populations within the traditional almond growing areas; (2) establishment of cultivar collections and test planting to evaluate local and introduced almond cultivars; (3) establishment of germplasm collections for maintenance of local and introduced cultivated almond as well as related species; and (4) develop controlled breeding methods to incorporate desirable new traits into locally adapted material and so generate new cultivars and rootstocks to optimize regional performance. Some traits, such as self-fruitfulness and certain disease resistances, were not readily available in cultivated almond and required introgression from related species. Crosses of *Prunus dulcis* with other almond species in Sections *Euamygdalus* and *Spartiodes* are generally easily accomplished (Denisov 1982, 1988, 1989; Kester et al. 1991; Gradziel et al. 2001). Hybridization with Section *Lycioides* is somewhat more difficult and even more so with *Chameamydalus* and *Leptopus* (Denisov et al. 1983; Denisov 1988; Chepinoga 1990). Crosses with peach (*Prunus persica*) can be made easily although some types of sterility may sometimes occur in the progeny (Ryabov 1969; Kester and Gradziel 1996). Crosses with plum are possible but difficult (Grasselly et al. 1992). Crosses with apricot are very difficult but have been reported (Jones 1968). The extent of new germplasm incorporation, as well as general breeding approach, however, varies by region (Table 6).

A. Mediterranean

Modern cultivar improvement had its start with the beginning of cultivar collections at Bordeaux in 1951 and in 1961 at Nimes under the direction of Dr. Charles Grasselly (1972). A survey of the germplasm potential throughout the Mediterranean region was followed by collecting trips to Iran, USSR and Afghanistan (Grasselly and Crossa-Raynaud, 1980) and 450 accessions from 10 different countries were collected, evaluated and described. This study provided the basis of the concept of local ecotypes in different almond growing districts (Crossa-Raynaud 1977, 1981) and the collection is the base of an almond Germplasm Repository at Montfavet, France. Controlled crosses begun in 1961 in France produced valuable inheritance data (Grasselly 1972) and resulted in new cultivars and rootstocks. Initial objectives were to combine late bloom, high production and improved nut and kernel quality. The first releases (Grasselly 1975) from this program, ‘Ferragnes’ and ‘Ferraduel’, were cross-compatible and when planted in combination shifted the blooming date approximately two weeks later than prevailing cultivars. This combination quickly became the basis for new orchard plantings both in France and the rest of the Mediterranean. These cultivars arose from crossing representatives of two ecotypes, ‘Cristomorto’, an Italian cultivar from Puglia, which was late blooming due to a high chilling requirement for bloom, and ‘Ai’, a cultivar from France which was late blooming due to a high heat requirement. Later disease resistance from the French cultivars ‘Ardechoise’ and ‘Mandaline’ were incorporated into the program as well as late bloom from ‘Tardy Nonpareil’ (Grasselly 1978; Duval 1999). Almond improvement programs were developed at Zaragoza, Spain by A. Felipe (Felipe and Socias i Company 1977a, 1985, 1992), at Reus, Spain by F. Vargas-Garcia (1975a,b), Barraquer and Vargas-Garcia (1975) and Vargas and Romero (1993), and at Murcia, Spain by Egea and Garcia (1975), Garcia et al., (1988) and Dicenta et al., (1993). Genetic improvement programs were initiated in Tunisia by El Gharbi (1977) and Jaquani (1976) and in 1970 at Rome, Italy by F. Monastra (Monastra and Fideghelli 1977; Monastra et al. 1982, 1985). Almond improvement programs were initiated in Greece in 1960 by D. Stylianides (1977).

Table 6. Objectives of modern almond improvement programs.

Problem	Trait	Objective	Country
Spring frosts	Late bloom; blossom resistance	Avoid early and late spring frosts	U.S., Ukraine, France, Greece, Spain, Italy, Romania, Turkey, Bulgaria
Winter freezing	Hardy buds and wood	Avoid loss of dormant flower buds; avoid tree damage	Ukraine, Romania, Bulgaria
Low winter chilling	Low chilling requirements	Grow in subtropical area	Israel, Tunisia, Australia, Morocco
Moisture stress	Drouth tolerance	Grow with deficient irrigation	Spain, Italy
Lack of or reduced bee populations	Self-fertility	Eliminate or reduce need for bee pollinizers	France, Greece, Tunisia, Italy, Spain, USA
Disease and pests	Resistance to fungus and bacterial diseases, and insects.	Eliminate or reduce need for chemical sprays	USA, France, Spain, Italy, Turkey
			USA, France, Spain, Italy
	Virus and viruslike organisms	Clean propagation sources	USA, Spain, Italy
High management costs	Modified tree size, shape, branching, growth habit	Efficient orchard management; adjust orchard density; pruning; shaking	USA, Spain
Difficult harvest and handling	Optimize time of maturity, ease and completeness of nut removal, hulling	Extend harvest period; efficient and complete harvest	All programs
Shell character	very hard shell	Kernel protection and storage; prevent worm infestation	Spain, France, Italy.
	semi-soft to soft	Higher shelling percentages	USA, Ukraine, France
	well sealed	Kernel protection	USA, all programs
Inconsistent yields	Improve tree: precocity, productivity, regularity of bearing,	Early production; high yield, no alternate bearing.	All programs
	Nut quality	Increased kernel yield and reduced damage	All programs

Israel began a crossing program in 1966 which involved early bloom, low chilling and improved nut and kernel quality (Spiegel-Roy and Kochba 1977). Parental material included ‘Marcona’ crossed with local cultivars ‘Greek’ and ‘Poria’ (Spiegel-Roy 1985). Rootstock surveys of local seedling populations resulted in discovery of nematode resistant almond clones, known as the ‘Alnem’ series (Kochba and Spiegel-Roy 1975).

Turkey began a program of selection among seedling populations for late bloom and frost resistance for interior Turkey (Ayfer 1975) and in southwest

Turkey for late bloom, adaptation and improved quality (Dokuzogus and Gulcan 1973, 1977; Dokuzogus 1975; Gulcan, 1977). Crossing programs were begun in 1990 (Gulcan et al. 1992).

Surveys of local germplasm also occurred in Turkey (Dokuzogus 1975; Kuden et al. 1993), Sicily (Barbera et al. 1988) and Sardinia (Agabbio et al. 1984; Chessa and Pala 1985). Evaluations of unique North African germplasm in the local seedling populations were carried out in Morocco (Barbeau and El Baudami 1977; Laghezali 1985; Loussart et al. 1989). These populations are considered to have good potential for germplasm exploration (Lansari et al. 1994). In virtually all of these areas destruction of many local groves and so loss of traditional germplasm has already occurred.

The Groupe de Recherche et d'Etude Mediterraneen Pour l'Amandier (GREMPA) was formed in 1974. This group organized almond researchers into an informal association whose purposes were to provide a forum to exchange information and plant materials and to coordinate breeding and testing efforts (Crossa-Raynaud 1975; Socias i Company 1998).

B. California

Beginning in the mid-1950s, the major source of new cultivars was the population of almond seedlings found throughout California either along roadsides and near commercial orchards or in orchards from unbudded almond seedling rootstock escapes. Since 1957, many selections from this source were patented and introduced by individual growers as commercial cultivars through commercial nurseries (Brooks and Olmo 1997). Most, including 'Merced', 'Price', 'Carmel', and 'Fritz', were used to provide cross-pollination to 'Nonpareil'. Others, such as 'Thompson' and 'Livingston', were later blooming and were combined with 'Texas'. A cooperative breeding program initiated in 1923 at Davis, CA, between the U.S. Dept. of Agriculture and the University of California was an outgrowth of early pollination and variety evaluation studies (Wood 1938). This program was separated in 1948. The USDA program was continued until 1975. The University of California program has continued and resulted in the release of a number of cultivars and rootstocks (Kester et al. 1996).

C. Eastern Euro e and Asia

After California, the second oldest continuous breeding program for almond has been at the Nikitski Botanical Garden at Yalta, Crimea in the former USSR (now Ukraine) under the direction of A.A. Richter (Richter 1969, 1972) and Yadrov (1993). These began with the research of N. Vavilov (1930) and were based on extensive species and cultivar collections. Other programs have been in progress in the Asiatic Republics (Denisov 1988). The primary objectives have been to develop hardiness to winter cold and spring frosts and to investigate the breeding potential of wild almond species.

Hardy, late blooming cultivars were introduced for commercial production in southern USSR during the 1950s (Denisov, 1988), into Bulgaria in 1956 (Serafimoov 1975, 1976) and later into other Mediterranean countries (Guerriero et al. 1974; Grasselly and Crossa-Raynaud 1980; Garcia et al. 1988;

Vargas and Romero 1988). Additional almond cultivars have been introduced by Yadrov in a continuation of this program.

Research has been carried out by other Asiatic republics including Turkmenistan, Tadjististan (Mizgireva 1973) and Uzbekistan (Komarov et al. 1941). This research involves populations of the Kopet Dagh populations of *P. communis* (Denisov 1977ab; Saparov 1978) and many wild species (Denisov 1982; Eremin and Denisov 1984; Chepinoga 1990). In Romania, selection of local cultivars has resulted in improved commercial plantings and a breeding program has introduced new cultivars (Cociu 1981).

The foothill districts of northern India, including the Kashmir, provinces of Jammu and Himachal Pradesh (Uppal 1977a,b; Singh et al. 1977; Singh and Uppal 1977) as well as northeastern Pakistan (Thompson et al. 1990) have historically had many seedling almond orchards. Studies of promising seedlings and introduced almond cultivars have been undertaken (Kumar and Uppal 1990; Kumar et al. 1989).

Several almond species and commercial cultivars exist in the Xinjiang province of western China (Gustafson et al. 1989) near the ancient cities of Kashgar and Sache on the ancient silk route. A program of almond improvement has been carried out by Prof. Zhu Jing Lin at the Xinjiang Academy of Forestry since 1970 with the objectives of cold hardiness and dwarfing rootstocks.

IX. CONCLUSIONS

The wide dispersion of almond and its wild relatives in the often severe environments from Central Asia to the Mediterranean was largely possible because of the genetic and associated developmental physiological diversity promoted by this typically self-sterile, yet inter-species fruitful genus. Even today, evidence of species-mixing of the traditional Asian badam is evident in many rural bazaars by the presence of shell patterning characteristic of other species (Fig. 2). The cultivated Greek nut which appears to have gained wide prominence in prehistoric Greco-Persian commerce, may well have originated from an interspecies cross with *P. fenzliana*, and owes its existence and eventual commercial ascendancy to human selection. Gene transfer between wild and cultivated almond continued to be important in the early dissemination of this crop, as evidenced in the transfer of self-compatibility from wild *P. webbii* to the old cultivated land races in southern Italy. 'Tuono', an old Italian cultivar selected from these land races, is currently the most important source for self-compatibility in Mediterranean and Asian breeding programs (Table 3). However, despite its historical wide acceptance throughout the Mediterranean, 'Tuono', as well as many of the regional heirloom cultivars, are largely being replaced by new orchards designed to maximize production (Fig. 23) of a more globally standardized market quality. Regionally adapted (to both local culture and cultivation) cultivars are also being lost as traditional plantings are converted to other crops or to other consequences of modern development. Similar progress is also leading to the loss of native germplasm throughout the Asian and Mediterranean centers of origin and diversity (Ledig 1992). The fragile nature of many of these wild almond ecosystems, (for example the dependency on a minimum spring snowmelt for summer drought survival), make them particularly vulnerable to a range of environmental perturbations from human enterprises to global warming. Concurrent with and contributing to germplasm loss is the rapid expansion of almond cultivation to satisfy an escalating global demand. The extensive commodity standardization associated with these complex, international markets has been largely achieved by dependence on a few standard cultivar types, as with 'Nonpareil' 'Carmel' type in California (Fig. 22) which is also increasingly grown in many international plantings. And with a 2007 2008 California production of over 225,000 Mt, the 5% sub-standard-sized nuts which might normally be considered rejects, can effectively compete with markets normally utilizing smaller, lower-value nuts. Even when found to be poorly adapted locally, these market standards are often used as breeding parents to combine desired market quality with local adaptability (Tables 3 and 6). For example, virtually all of the other commercially important California cultivars are progeny of 'Nonpareil' by 'Mission' crosses (Kester et al., 1991, 1996), with the few exceptions being cultivars developed by University programs (Table 3). Recent history has demonstrated the dangers of too great a dependence on a limited germplasm, including significant economic losses from disease, pest, and climate change (Tanksley and McCouch, 1997). A similar danger also exists in the loss of the extensive medical and culinary legacy of the current diversity of almond germplasm at a time when we are just beginning to understand their unique contributions. Inevitably, the modern marketing folklore that uniformity is good may be found to be myth.

Fig. 23. High input, high yield monoculture cropping system typical of 2007 California production.

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