cultivars are being released. All of the subspecies used in cultivar development are tetraploid ($2n = 36$) and crosses among them have been fully compatible. (The diploid status of *L. boczkarnikovae* prevents its use in breeding with the other subspecies.)

In the past several years, blue honeysuckle selection programmes, using Russian plant materials, have been initiated in Romania, Czech Republic, Latvia, Sweden and Oregon (USA). In the 1970s, selection work began in Hokkaido, Japan, using the locally available subspecies, *emphyllocalyx*. In addition to 'Yufutsu', several selections have been distributed to farmers who have developed a small industry of fresh and processed products. This subspecies is notable for having the longest dormancy; in Oregon, plants bloom 2–4 weeks later than Russian forms and are, therefore, much more adapted to moderate climate regions. Recently, in north-eastern China where wild berries (ssp. *edulis* and *boczkarnikovae*) have long been harvested, there is increasing interest in selecting elite forms for commercial production to augment the supply for the already-established processing plants.

Major characteristics sought in new cultivars are high production, large fruit, self-fertility, traits to facilitate mechanical harvesting such as upright plants with flexible shoots, and retention of ripe fruit on plants or simultaneous fruit maturity. Fruit skin and flesh must be firm for the fresh market and for mechanical harvesting berries should have moderately firm attachment. Other characteristics include a superior flavour and a high content of nutritional components, especially vitamin C and antioxidant compounds (polyphenols). To extend cultivation into regions of moderate climate, cultivars must remain dormant through fluctuating temperatures in autumn and winter. For severe climates where plants remain dormant due to continual low winter temperatures followed by abrupt spring warmth, early fruit maturity is desired. Maxine M. Thompson

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Sambucus spp. elderberry

The American elderberry (*Sambucus canadensis*, *Caprifoliaceae* = *Adoxaceae*) and European elderberry (*Sambucus nigra*) are the primary cultivated species of this genus, which contains about a dozen species.

Fruit of the cultivated types are very dark purple, nearly black, but the various species range from bright red to blue and dark purple. The mild-flavoured fruit ripen in mid- to late summer. For commercial harvest, the entire cluster is picked and the entire crop is processed into juice or purée. Elderberry bark, roots, stems, flowers and fruit have been used by Native American cultures as drugs, foods and to produce toys and tools. In Europe and America, especially in rural areas, the fruit have been gathered from the wild and used to make wine, juice and jams/jellies; they are often blended with more strongly flavoured fruit. Flowers are picked, coated with batter and fried or infused in water and citrus juice to make an aromatic, refreshing drink. Elderberries are purported to have tremendous nutraceutical value as antioxidants and as a treatment for colds and the flu.

Botany

Elderberry is a large deciduous shrub or small tree (4–6 m). The large, pinnately compound leaves are typically dark green although ornamental selections have been identified that are variegated, lime green and dark purple and have become very popular plants for landscaping. Hundreds of small, white hermaphroditic flowers are borne in flat umbels in the two commercial species but may also be borne in panicles in other species in the genera. The flower clusters are typically produced on shoots from apical or near apical buds. The flowers are insect pollinated. As with the flowers, the fruit are individually small (0.3–0.6 cm) but collectively the hundreds of fruit produce very large fruit clusters.

Ecology

Sambucus spp. are primarily native to the northern hemisphere, although it has become naturalized throughout much of the temperate and subtropical regions where humans live. They prefer full sun or partially shaded exposures on

moist soils. Because the fruit are highly desirable to birds, elderberry rapidly colonizes moist areas along railways, roadways, forest edges and fence lines.

Horticulture

Commercial elderberry production is concentrated in Oregon in the USA and in Denmark, Italy and Austria in Europe. In addition, wild harvested fruit is sold commercially in a number of areas particularly the Midwestern USA. In Kansas, commercial processors, particularly wineries, that have relied on wild harvested fruit are now driving the establishment of commercial plantings. While European and US production practices are similar, Europe relies on cultivars derived from *S. nigra* and the USA on cultivars derived from *S. canadensis* and *S. nigra*. Most of the botany, plant and fruit development are similar for these two species, however, *S. nigra* tends to be a single or few-trunked large shrub whereas *S. canadensis* can have many canes.

Elderberry is adapted to a wide variety of soils but needs full sun for maximum yield and quality. Plantings are established in a wide variety of configurations but plants are generally spaced from 1.5 to 2.5 m apart in rows spaced 3–4 m apart. For best production, plants are irrigated, fertilized and weeds are controlled. Once established it takes several years to reach full production. The most fruit will be produced on 1-, 2- and 3-year-old canes. Pruning consists of removing the canes older than 3 years, along with diseased or weakened canes. Mature plants can yield 6–8 kg of fruit each. Fruit ripens in late summer and the entire cluster is clipped off. Fruit may be either stripped from the umbel immediately after harvest or the entire cluster is frozen after which the berries 'shatter' from the umbel very easily.

INSECTS AND DISEASES While a myriad of insects, diseases and viruses may attack elderberry, they seldom are so serious as to cause significant yield reduction. As there are no insecticides and fungicides that are recommended for elderberry, good field sanitation is the primary control method for insects and diseases. Tomato ringspot virus, a nematode-borne virus, can be a serious problem but purchasing virus-free plants, avoiding soils with known nematode problems and not planting near wild elderberry plants can go a long way to controlling this virus.

MAIN CULTIVARS AND BREEDING A number of *S. canadensis* cultivars are grown in the USA, primarily from the New York and Nova Scotia Agricultural Experiment Stations' breeding programmes, for example 'Adams 1', 'Adams 2', 'Johns', 'York' and 'Nova'. The origin of many of the European *S. nigra* plantings is less clear, although the Danish developed cultivars 'Allesø', 'Korsør' and 'Sambu' are recommended in parts of Europe.

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CARICACEAE

Carica papaya L. papaya

Papaya (*Carica papaya*, *Caricaceae*) is a popular fruit native to tropical America. It is usually grown for its small to large melon-like fruit. It is an herbaceous perennial, bearing fruit continuously at the leaf axils spirally arranged along the single erect trunk. The papaya is also called papaw, pawpaw, papayer (French), melonenbaum (German), lechosa (Spanish), mamao, mamoeiro (Portuguese), mugua (Chinese) and betik (Malaysian, Indonesian).

Carica papaya has not been found wild in nature. Its origin is rather uncertain, but there is some agreement among botanists that it originated in the lowlands of Central America between southern Mexico and Nicaragua. Early distribution over wide geographical regions was enhanced by the abundance of seeds in the fruit and their long viability. The accounts of 18th-century travellers and botanists indicated that seeds of papaya were taken from the Caribbean to Malacca and on to India (Storey, 1941a). From Malacca or the Philippines, distribution continued throughout Asia and to the South Pacific region. Don Francisco Marin, a Spanish explorer and horticulturist, is credited with the introduction of papaya into Hawaii from the Marquesas Islands during the early 1800s. Papaya is now grown in all tropical countries and in many subtropical regions of the world.

World production and yield

The papaya is popular as a backyard tree but increasingly becoming more important in commercial planting for domestic markets for export. Major commercial production of papaya is found primarily between 23°N and S latitudes. Man has extended cultivation into regions as far as 32°N and S where it may be grown in well-protected areas at sea level. In Hawaii, at 19–22°N, papaya are grown at sea level and up to 300 m elevation. The advantage in papaya cultivation is the rapid return on investment, intensive cultivation and high yield. Fruit in the tropics can be harvested 8 or 9 months after sowing and annual yields can range from 60 to 100 t/ha for improved cultivars. The plant continuously flowers and sets fruit and harvesting takes place all year-round. Drought and high temperature can lead to poor fruit set and lead to periods of poor yields.

The global production of papaya in 2002 (FAOSTAT, 2003) was nearly 6 million t. Of this, 25% was produced by Brazil (1.5 million t), followed by Nigeria, India and Mexico at 11–12% of the world production. The most important papaya exporter in 2001 was Mexico at 74,033 t or 37.4% of the world export, followed by Malaysia (27.3%), Brazil (11.5%) and the USA (Hawaii) (4.2%). The main market for papaya in 2001 was the USA with 84,401 t or 46.2% from Mexico and Hawaii. The next largest importers were China (14.7%) and Singapore (14.5%) of the total world export. The major supplier to these markets is Malaysia. The papaya imported by Japan is from the USA (Hawaii) and the Philippines, two countries that have commercial disinfestation facilities that meet the stringent postharvest import quarantine regulations of Japan.