

# Elderberry: Botany, Horticulture, and Potential as a Food and Medicinal Crop

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## I. INTRODUCTION

Of all the small fruit species in production or harvested in the wild in the Northern hemisphere, the elderberries (elders) probably represent those with the widest range of applications. From river bank stabilization to windbreak (Paquet and Jutras 1996), from ornamental use to wildlife refuge, from versatile food source to multi-purpose medicinal, members of the genus *Sambucus* have been used for millennia. While the scientific documentation related to elderberries has increased over the last two decades, few reviews have been published. The taxonomy of the genus *Sambucus* was revised by Bolli (1994) and we refer the readers to his work for a description of the various species belonging to this genus. Martin and Mott (1997) reviewed the selection, cultivation, and management of American elder for wildlife and habitat management. More recently, the ecology of the European elder in the British Isles was thoroughly reviewed by Atkinson and Atkinson (2002). Finally, Charlebois (2007) reviewed

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the medicinal value of elderberries. Despite a well established production in many countries of Europe and an increasing interest in North America, little attention has been paid to the horticultural aspects of this genus and its potential as a food and a medicinal crop.

Recent works linking antioxidant-rich diet to disease prevention (Prior 2003; Willcox et al. 2004; Scalbert et al. 2005; Zafra-Stone et al. 2007; Seeram 2008), along with the versatility of elderberry as a crop, a food, and a medicine, have generated a renewed interest in these plants. This paper presents a review of European and American elderberry species, by far the most widely used members of the genus *Sambucus*. Additional information provided by the authors is based on many years of field experience.

## **A. Taxonomy**

The generic name *Sambucus* is apparently derived from the Greek word “σαμβυκε” or the Latin word “*sambuca*” that designate either a kind of flute that was made out of elderberry twig (Marie-Victorin 1935) or a small harp (Rich 1859). Members of the genus *Sambucus* are small trees, shrubs, or herbs (Fernald 1970). Because species of this genus are difficult to delimit, there is no clear consensus about the exact number it contains and, depending on the author, it can range from 20 to 40 (Bailey 1930; Marie-Victorin 1935; Lawrence 1951; Elias 1980; Hickey and King 1981; Stang 1990). Thus, it is not unusual to find some confusion when consulting regional floras (Bailey and Bailey 1976). This confusion, along with the fact that numerous synonyms can be found in the literature, make it difficult to get a clear picture of this genus. Fortunately, *Sambucus* has recently been the subject of an important taxonomic revision by Bolli (1994). The phylogenetic tree was simplified by bringing many species down to the rank of subspecies and emphasizing similarities within the group, with the final result that only nine species are reputed to be part of the genus (Bolli 1994). Bolli (1994) proposed giving the two most economically important members of the genus, the European elder (formerly *Sambucus nigra* L.)

and the American elder (formerly *S. canadensis* L.) the status of subspecies. Accordingly, they should now properly be designated as *Sambucus nigra* ssp. *nigra* (L.) R. Bolli (European elder) and *Sambucus nigra* ssp. *canadensis* (L.) R. Bolli (American elder). Although this reclassification is now more than a decade old, the scientific and horticultural communities have been slow to adopt the new terminology, and consequently the names *S. nigra* and *S. canadensis* are still widely used in the literature (European and Mediterranean Plant Protection Organization 2008; UDSA, ARS, National Genetic Resources Program 2008). Furthermore, it should be noted that numerous authors, such as Yatskievych (2006), disagree with Bolli's (1994) revision.

Even today, the genus *Sambucus* is most often included with the Caprifoliaceae (Guangwan et al. 2008; Hu et al. 2008). Bolli (1994) asserts that it possesses enough distinctive characteristics to warrant the recognition of a new family, the Sambucaceae. Except for some occasional cases (Gasson 1979; Gustafsson 1995), this proposal has not been pursued. Another noteworthy change resulting from the taxonomic revision of *Sambucus* was its withdrawal from the family Caprifoliaceae and its placement in the family Adoxaceae (Donoghue et al. 2003), an affiliation supported by plastid gene sequencing (Savolainen et al. 2000) but not supported by Fourier transform infrared spectroscopy analysis (Hao et al. 2007). While the exact taxonomical position of the genus *Sambucus* is likely to be debated as new methods are developed, the classification of the European and American elders may be summarized as follows:

Family – Adoxaceae; Genus – *Sambucus*; Species – *nigra*; Subspecies – *nigra* (European),  
*canadensis* (American)

The American and European elders are known in various parts of the world, leading to a plethora of vernacular names. The following table lists some of them.

	<i>Sambucus nigra</i> ssp. <i>nigra</i>	<i>Sambucus nigra</i> ssp. <i>canadensis</i>
English	Black elderberry, Elder, common elder, European elder	American elder(berry), bourtree, Canada elder, eastern elderberry, elderberry, common elder, sweet elder, pie elder, elder-blow, blackberry elder, Mexican elder
French	Arbre de Judas, Grand sureau, haut bois, sambequier, sambuquier, sampêchier, seu, seuillet, seuillon, sureau, sureau commun, sureau noir, sus, suseau, susier	Sureau blanc, sureau du Canada, sirop blanc
Afrikaans Dutch		Kanadese vlier
German	Flieder, memeine Holunder, Holunder, schwarzer Flieder, schwarzer Holunder	
Italian	Sambuco, sambuco nero, sambuco nostrale, zambuco, zambuco arboreo	
Portuguese	Sabugueiro, sabugueiro negro, sabugueiro preto	Sabugueiro do Canada
Spanish	Sáuco, canillero, cañilero, linsusa, sabuco, sabugo, saúco blanco, sauquero, sayugo, yezgo	Sauco del Canada

<http://www.tela-botanica.org/eflore/BDNFF/4.02/nn/60241/vernaculaire>

## B. Distribution

1. *S. nigra* ssp. *canadensis*. The American elder is native to eastern North America and fossilized seeds can be traced back more than 16,000 years (Kneller and Peteet 1999). It is found from Florida (25°N)(Deam 1924; Bailey 1930; Allen et al. 2002; Wunderlin and Hansen 2008) in the United States to the northern part of the Gaspé coast of Québec in Canada (49° N)(Environnement Canada 2002), which marks the northern limit of its natural distribution range. Experimental plots have been maintained in Normandin Québec (Canadian hardiness zone 2b)(The National Land and Water Information Service Agriculture and Agri-Food Canada 2000) where the wild type and some cultivars

grow well but where the fruits barely reach full maturity due to a short growing season. It can also be found in Central Mexico and most Mesoamerican countries such as Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama (Plant Gene Resources of Canada Agriculture and Agri-Food Canada 2007). It grows in scattered patches as far west as Manitoba (Hosie 1979) and Minnesota in the United States (Martin and Mott 1997; Small et al. 2004). American elder could grow up to an altitude of about 1500 m (Little 1980). Its distribution along the eastern coast of North America is probably limited by its relative sensitivity to salt (Hightshoe 1988; Griffiths 2006). It has been reported to grow in the Himalaya at an altitude of 2200 m (Mehra and Bawa 1968). From this paper, it is not clear if European elder was not mistaken for American elder or if the specimens studied had escaped from culture. European elder has long been used as an ornamental plant in North America (Marie-Victorin 1935). It is also possible that the early settlers brought with them cuttings and seeds of European elder and that some might have adapted to the North American climate. A thorough genetic analysis would however be needed in order to validate this hypothesis.

**2. *S. nigra* ssp. *nigra*.** The European elder can be found almost anywhere in Europe with an eastern limit of distribution near 55°E (Atkinson and Atkinson 2002). Its distribution goes further north than its American counterpart reaching latitude of 63°N in Norway (Lid 1979; Hultén and Fries 1986). It has been reported to grow at altitude up to 470 m (Halliday 1997) in the British Isles but probably reaches higher altitude elsewhere on the European continent and in North Africa (Atkinson and Atkinson 2002). It has been introduced in various part of the world such as North America, East Asia, New Zealand and South Australia (Hultén and Fries 1986; Kabuce 2007). A detailed distribution map can be found in Atkinson and Atkinson (2002).

The American and European elders are endozoochorous, as has been reported for *S. ebulis* L. (Czarnecka 2005). Since the fruits are eaten by a variety of birds and mammals (Stiebel and Bairlein

2008), it is expected that their dispersal can be over long distances (Czarnecka 2005) even in less favorable environments such as woodland where the light availability is not ideal for the optimal development of the species.

## **II. BOTANY AND PHYSIOLOGY**

### **A. Habitat**

American and European elder seedlings compete poorly with more aggressive species (Hayes 1987) and thrive best in full sun or partial shade (Grime et al. 1988). In fact, European elder has been shown to be relatively light demanding (Kollmann and Reiner 1996). Both subspecies are usually found in open or semi-open areas and along habitat edges (Martin and Mott 1997), where conditions are suitable for seed germination and plant growth. Examples of such areas are along streams in floodplains (Schnitzler 1997), in wooded areas where it will take advantage of openings in the canopy (Hankla 1977), in abandoned farm fields, in disturbed sites and along roadsides where it is sometimes used as a windbreak. American elder can however be found under closed canopy (Rossell and Rossell 1999). The elder does best with ample moisture and will grow in swamps, bogs and in transition zones between wetland and upland (Conner et al. 1990). In North America, elderberry is often found in roadside ditches that provide a moist environment and adequate light. It will thrive under poor drainage (Himerlick and Galletta 1990; McLaughlin et al. 2008) but will not tolerate long periods of flooding.

Elder's adaptation to a wide variety of climatic conditions has allowed it to develop an extensive distribution range. As with many plants, it is at risk in winter, after its chilling requirement has been met when warm spells trigger deacclimation and the beginning of budbreak when freezing temperatures are still common. This can result in leaf death if the plant is subjected to subsequent severe frosts (Grime et al. 1988). In the southmost part of its range, American elder grows in areas with

no definite winter season and where summer temperature can easily reach 40°C without undergoing a dormant phase.

In the northern part of its range, the winter temperature can dip as low as -40°C. All exposed parts are then susceptible to winter kill and the amount of snow cover will determine the extent of the damage. Temperatures as low as -20°C down to root level have been observed in Québec in a snow free orchard resulting in some plant death, however most of the genotypes evaluated survived with various levels of damages (D. Charlebois, unpubl.).

There is little discussion in the literature about American elder's soil requirements. However, numerous field trials by the authors (D. Charlebois, unpubl.; P.L. Byers and A.L. Thomas, unpubl.) and the size of its distribution range clearly indicate that American elder can grow on a wide variety of soils ranging from sandy to clay-loams (Stang 1990) with good growth and yield in muck soil. Similar comments can also be made for the European elder.

## **B. Description**

The American elder is a deciduous fruit-bearing multi-stemmed shrub or small tree that can reach up to 3 m tall in the northern part of its range and as tall as 4.5 m in more southerly regions (Elias 1980; McLaughlin et al. 2008). Exceptionally, it can reach a height of up to 9 m (Maisenhelder 1958; Vines 1960; Hankla 1977; DeGraaf and Witman 1979) and up to 10 m in European elder (Atkinson and Atkinson 2002). An elder seldom develops a spread of more than 3 m. American and European elders form shrubs with numerous straight canes growing closely together from the base where numerous branches arise, giving these plants their bushy appearance (Atkinson and Atkinson 2002). Certain cultivars may develop into a more treelike shape with a single trunk from which shoots emerge a few centimeters above the ground. New shoots usually appear from second or higher order branching but

can sometimes arise directly from the base as a reaction to low temperature (Barnola 1972) or removal of the above-ground part of the plant. As it reaches 20 to 30 years of age, European elder will stop producing branches from the base and assume a more tree-like shape (Bolli 1994). European elder can easily live up to 25 years (Atkinson and Atkinson 2002).

The canes are weakly lignified, with the white pith in the centre accounting for most of their diameter, and consequently are somewhat brittle; a heavy load of snow or ice may cause them to break.

Elderberry pith has long been used as an easy-to-cut support to prepare histological sections (Marie-Victorin 1935; Hickey and King 1981). The plants can spread vegetatively via rhizomes and the ability of horizontal stems to root where they touch the soil surface. Small lateral branches often arise late in the season; these usually die at the onset of winter (Metcalf 1948). Because of this natural dieback, some annual maintenance (see Pruning) is usually required in spring with a positive effect on fruit production (DeGraaf and Witman 1979). The bark is light brown, yellowish or grayish and covered with prominent lenticels (Hankla 1977; DeGraaf and Witman 1979; Foote and Joes 1989), which is more deeply furrowed and corky in European elder.

The cone-shaped buds are medium sized and slightly pendulous (Harlow 1954). The leaves are stipulate, opposite and odd-pinnately compound with 5 to 11 leaflets, usually 7 (American)(Lawrence 1951) or 3 to 9 leaflets, usually 5 to 7 (European)(Atkinson and Atkinson 2002). They range in color from bright green to medium green and yellow, are from 10 cm to 30 cm long (Vines 1960), and are nearly hairless on the upper side but hairy on the underside, especially along the veins. Selections, particularly of *S. nigra*, have been chosen for their ornamental value. They have a range of leaf colors from lime green to deep purple and a range of dissection to the leaves such that many appear similar to the finely divided leaves of *Acer palmatum* Thunb. Leaflets are short stalked, finely serrated, lanceolate to elliptical in shape, from 6 to 15 cm (American) or from 3 to 9 cm (European) in length, and from 2.5

cm to 6 cm in width; the lower leaflets are frequently tripartite (Foote and Joes 1989); the petiole reaches 3 to 10 cm (American) or 3 to 4 cm (European) in length (Vines 1960; Radford et al. 1968; Atkinson and Atkinson 2002). The roots extend into the soil near the surface at a depth of some 20 cm. They are lateral, fibrous and fasciculate and not extensively ramified. On two year old plants from cuttings, roots may attain a length of over 2 m.

Reproduction is sexual, by means of seeds that are dispersed by birds and mammals, and asexual, by root suckering. The divergent stamens tend to prevent self-pollination (Marie-Victorin 1935; Hickey and King 1981). In southern Canada, flowering begins toward the end of June, well after the leaves have appeared, and continues through the first two weeks of July. In the Carolinas, blooming starts in late April and also extends through July (Radford et al. 1968). In Missouri, the date of full flowering is usually in mid-June and a bit later, in late June, in the Pacific Northwest (Finn et al. 2008). Over its entire distribution range in North America, American elder's main blooming period probably extends from June through August (Maisenhelder 1958; DeGraaf and Witman 1979). In areas where there is no definite dormant season such as Florida, year-round flower and fruit production can be observed (Cerulean et al. 1986). A few new flower clusters occasionally appear throughout late summer and early fall (Hightshoe 1988). Because of this late flowering habit, and because they do not produce their floral primordia until shoot elongation has started in the spring (Philipson 1946), it is rare for elderberry to be affected by late spring frost, even in the northern part of its distribution range. Furthermore, if above-ground tissues in American elder are damaged or pruned, vigorous new shoots will arise from the root crown that flower a few to several days later than secondary stems, and that ripen fruit 14 to 21 days later (A. Thomas et al, unpubl.). Thus elderberry is an excellent choice for flower and fruit production.

The flower clusters, corymbs sometimes described as a cymes (Marie-Victorin 1935; Fernald 1970), can reach from only a few centimeters up to 35 cm in diameter, the largest clusters are usually found on new canes. On unpruned plants, cluster size tends to diminish as the number of clusters increases (D. Charlebois, unpubl.; P.L. Byers and A.L. Thomas, unpubl.). They are made up of small (6 mm) creamy white flowers, with up to 2,000 or more in a single cluster. Offshoots arising from old canes often bear clusters of only a few flowers. The flowers, which are faintly perfumed, are complete (pentamerous) but contain no nectar gland (Marie-Victorin 1935), however extrafloral nectaries are present in American (Radford et al. 1968; Fahn 1987) and European elder (Dammer 1890). In European elder, there are no transpetal veins (Gustafsson 1995). The ovary is inferior and may be trilocular, tetralocular or pentalocular (Bailey 1930; Marie-Victorin 1935).

When the berries appear, they are green, relatively compact, and oblong. As they ripen over a period of six to eight weeks from July to September in most of the distribution range, they first enlarge until they are spherical. The peduncles and pedicels can also turn red during the ripening process. The berries gradually become red before finally turning glossy black with a hint of purple. They remain attached to their stalks for several days after becoming fully ripe. The canes tend to sag under the weight of the ripe berries, and fruit clusters occasionally become detached prematurely from the plant, particularly in some cultivars such as 'York'. Individual berries, which may range from 4 to 6 mm in diameter, contain three to five oblong tan to yellowish seeds (Radford et al. 1968). Finn et al. (2008) reported individual ripe berry weights ranging from 46 to 135 mg with means of 81 to 90 mg across multiple locations and cultivars.

American elder is sometimes mistaken for red elder (*S. racemosa* ssp. *pubens* (Michx.) House syn. *Sambucus pubens* Michx.); the two share the same habitats in southern Quebec, but red elder ranges only as far south as Tennessee in the United States (Fernald 1970). The red elder has a much more

pyramidal inflorescence compared with the generally flat-topped inflorescence of American elder, and flowers earlier than the American elder, with flowers appearing in April and May, at the same time as the leaves. The berries of the red elder are red when ripe.

### **C. Cultivars, Forms, and Hybrids**

European and American elders are grown throughout large areas of Europe, northern Africa, eastern Asia, and North America. Their hardiness and attractiveness, as well as their ecological, ornamental and commercial potentials, have spurred interest in developing cultivars that meet the demand of consumers. It is most likely that naturally occurring forms, such as ‘viridis’ and ‘laciniata’, have probably been used in the past to develop new cultivars (European and Mediterranean Plant Protection Organization 2008). Efforts in cultivar development to satisfy the needs of the ornamental plant and commercial fruit industries (Kaack 1989) go back no further than the early 20<sup>th</sup> century (Stang 1990) with a peak in the second half of that century (European and Mediterranean Plant Protection Organization 2008). About 35 cultivars of European and American elders are described in the literature (Vines 1960; Wyman 1969; Bailey and Bailey 1976; Craig 1978; Hightshoe 1988; Griffiths 1994; Hillier and Coomes 2002). Both subspecies are about equally represented in the backgrounds of the commercial cultivars, contrary to what Stang reported in the early nineties (Stang 1990). In some cases, such as ‘acutiloba’, ‘aurea’, ‘chlorocarpa’ and ‘laciniata’, it was not always clear from the literature which of the two subspecies the cultivar was related to.

Considering the extensive distribution range of both subspecies, the information provided by nurserymen about growth, yield, and hardiness should be seen as general information and important differences are likely to be observed in the various hardiness zones.

Only a few cases of natural or induced interspecific *Sambucus* hybrids have been reported but Small et al. (2004) believe that hybridization is widespread in this genus. Most known interspecific hybrids concern European elder (Böcher 1941; Winge 1944; Chia 1975; Nilsson 1987; Simonovik et al. 2007). Such hybrids are usually sterile and therefore of limited horticultural interest. American elder has been described as a species that can vary in appearance by Deam (1924) and some rare naturally occurring variants have been reported (Schneck 1880).

#### **D. Development**

Since American and European elders occur naturally over wide areas it is difficult to describe their development using universal temporal references. Both species are among the first bushes to leaf out in spring. For example, leaf emergence in American elder can be in late February in Missouri (P.L. Byers and A.L. Thomas, unpubl.) to early April in southern Québec (D. Charlebois, unpubl.), while European elder will do so in February or March in the U.K. (Atkinson and Atkinson 2002). Similarly, flowers will appear at the end of June for the former and much earlier, in May or June, for the latter. When both subspecies were grown in the same environment in Oregon, ssp. *nigra* broke bud much earlier than ssp. *canadensis* and flowered over three weeks earlier (Finn et al. 2008). Despite widely different flowering times, fruit ripening is rather synchronous for both subspecies reaching full maturity in early August to mid-September depending on where they are grown (Atkinson and Atkinson 2002; Mathieu et al. 2007; Mathieu et al. 2008a). Little information is available about the development of elders over their entire distribution range and it is to be expected that these general patterns will vary to some extent. For example, in Florida, elders have sometimes been known to retain their leaves (Little 1980; Cerulean et al. 1986; McLaughlin et al. 2008), and to bear flowers and fruits all year round (Little 1980) thus probably impacting production. Annual variations in weather patterns will also affect the date of occurrence and the duration of the various developmental stages as described by Atkinson and Atkinson (2002). While Guilmette et al. (2007) have demonstrated that flowering is independent of

heat accumulation in American elder, full fruit maturity is likely to be delayed if unfavorable conditions occur (D. Charlebois, unpubl.).

### III. CULTIVATION PARAMETERS

The first cultivation report of American elder in North America dates back to 1761 (Ritter and McKee 1964). Either as an ornamental or as a fruit producing plant, elderberries can be used as single plants, in groups, as hedges, as living fences or as screens (Galletta and Himelrick 1990). The use of elderberry in a variety of agroforestry production systems is also promising (A. Thomas et al., unpubl.).

#### A. Hardiness

1. *S. nigra ssp. canadensis*. The American elder can be grown from hardiness zone 2 (See The National Land and Water Information Service Agriculture and Agri-Food Canada 2000 for a correspondence between the Canadian and the American Hardiness zones) to hardiness zone 10. The climate of zone 2 is harsher than that of the northern limit of its natural range, but even in this zone, American elder has vigorous vegetative growth and the bushes frequently grow to a height of more than 1.5 m (D. Charlebois, unpubl.). However, in areas where there is significant annual snow accumulation, the rather brittle canes tend to break under the weight of the snow. The plant will benefit from being carefully wrapped up with burlap or string in fall and will probably need corrective pruning in spring to remove broken canes. Fruit ripening can also be an issue in northern climates where the growing season is too short even for the most precocious cultivar to fully ripen the crop (D. Charlebois, unpubl.). Under such climatic conditions and considering the vegetative growth potential of the plant, flower production might be a better choice than fruit production.

2. *S. nigra ssp. nigra*. European elder reaches its latitudinal and altitudinal upper limits where the mean October temperature is around 7°C, which is probably limiting for seed maturation (Atkinson and

Atkinson 2002). The natural distribution range of European elderberry suggests that it is probably as winter hardy as the American subspecies *canadensis*. Both subspecies can however be cultivated in colder climates. The results reported by Finn et al. (Finn et al. 2008) could indicate that excessive heat rather than winter hardiness was responsible for the poor field performance of European elders in Missouri.

## **B. Site Selection and Preparation**

Although American and European elders are not demanding plants, care must be taken when selecting a location. For ornamental purposes, the tendency of this species to form thickets through suckering should not be overlooked and sufficient space must be available. Full exposure to sunlight is not essential but fruit production will be compromised in sites with less than full sun. For fruit or flower production purposes, select a location away from woods and other obstructions in order to allow free air movement and to reduce the incidence of disease, insect, and bird problems (Stang 1990).

**1. Type of Soil.** Although elders are adapted to a wide range of soils, a rich, well-drained soil that can maintain a relatively constant moisture level will produce excellent results. In order to determine the need for lime amendments and fertilizer prior to planting, soil analysis is recommended on potential sites.

*Texture.* Elder can be grown on a wide variety of soils. Excellent growth and yield could be expected in organic soil (muck soil). Mineral soil will also provide good conditions for elderberry production.

Drainage and compaction can however be an issue and the presence of rocks in the soil can be beneficial. Sandy soils, while capable of supporting limited growth and production, offer little nutrients and insufficient water retention.

*Moisture/drainage.* While elderberry can tolerate imperfect drainage, repeated flooding will reduce their growth and productivity. The impact of overly wet conditions will vary depending on when they occur. Damage may be minimal if the plantation is flooded during the period of dormancy; growth begins as soon as the ground thaws (in the northern part of its distribution range), and ceases with the first frosts. On the other hand, an accumulation of water during dormancy will be much more harmful if it is accompanied by alternating cycles of freezing and thawing. Ice formation can cause serious injury to young cuttings and seedlings. An excess of water during the growing season, if prolonged, may cause asphyxiation of the roots, delayed growth, reduced productivity, encourage root-rot diseases and fungi, and even death. However, an excess of water of not more than a day or two is unlikely to do much damage. Elderberry plants respond favorably to planting on berms at sites with less than ideal soil drainage.

Elders are not considered drought-tolerant species (Atkinson and Atkinson 2002). Drought will cause damage that may range from slower growth, yellowing of foliage or premature leaf fall, to the death of the bush. Mulching and proper weed management are helpful in minimizing the adverse effects of an occasional shortage of water, but irrigation is needed to meet the water needs of plants during prolonged dry periods. In Mediterranean climates such as in Oregon's Willamette Valley, where there is almost no summer rainfall, irrigation is essential for elderberry production. Commercial growers with managed plantings will use irrigation to maximize plant health and subsequent yield.

*pH.* While no systematic studies have been conducted to assess optimal soil pH for elderberry production, European elders have been shown to grow in soils with a pH ranging from 4.2 and 8.0 (Atkinson and Atkinson 2002).

**2. Site Preparation.** Seedlings and newly planted elder cuttings do not compete well if surrounded by other vegetation. In preparation for planting, perennial weeds should be killed, pH adjusted between 5.5 and 7.5 (Coastal Zone Resources Division 1978; Hightshoe 1988) if it has been noted to be a problem, and tile drainage or berms installed if excessive field moisture has been identified as being a problem. While elder's adaptability to a diversity of sites makes them an attractive option for growers with sites that are not well suited for other crops, good agricultural practices will enhance production.

Sites where strawberries, mint, alfalfa, potatoes or tomatoes have previously been grown are not desirable, as those crops are frequently associated with the presence of *Verticillium*. Any practices designed to enhance soil fertility and organic matter content will be beneficial to the establishment and development of an elderberry plantation. Excellent results have been obtained on sites freed of weeds and sown with a mixture of slow growing grasses and clover the year before planting (S. Mercier, person. commun.). When compared to bare soil, such ground cover prevents soil erosion, controls weed proliferation, offers better control over soil moisture and temperature, improves water penetration, and requires less maintenance.

*Mulching.* Elders are not competitive with weeds when first planted. The use of plastic or organic mulches such as wood chips, sawdust and bark, is an attractive option. The plants are shallow-rooted and the use of plastic mulch conserves soil moisture and promotes root growth near the surface of the soil. While such roots might be perceived to be at a greater risk of cold temperature damage, data gathered over a three-year period at Agriculture and Agri-Food Canada's experimental farm in L'Acadie, Québec, have not shown any negative impact on the growth or survival of elderberry bushes with black plastic mulch (D. Charlebois, unpubl.).

*Irrigation.* Elderberries possess an extensive, shallow root system that can take advantage of any nearby moisture. Excess or inadequate moisture is a negative stress to elderberries, with a possible serious impact on development and production. The availability of water will depend upon the water holding capacity of the soil, the nature of the site, the slope of the terrain, the depth of the ground water table, average rainfall, planting density and the age of the plants. When the cuttings are first planted, it is essential that they receive enough water to get them off to a good start. Hand watering may be useful in the absence of an irrigation system. The young cuttings should receive between 1.5 cm and 2.5 cm of water weekly. Warmer and drier sites will probably need additional moisture. The plant will remain relatively unaffected, except for a slower growth, if insufficient moisture is available for a short period. In general, the leaves can turn yellow and fall prematurely if the plant experiences a prolonged period of water shortage.

European elder tolerates moderate drought by keeping a low maximum leaf water conductance (Vogt 2001). While it is rated as a highly vulnerable to cavitation and drought-induced embolism, it has developed survival strategies to compensate (Vogt 2001). Proper selection of a suitable site, as well as adequate preparation (berming, drainage tiling, and irrigation), are critical for success. Elderberries have done well when irrigated following the general guidelines for most perennial crop species; i.e. 2.5 cm water per week during the growing season with higher levels during fruit ripening and times of drought. However, no research has been done to accurately determine moisture needs. The effectiveness of various irrigation systems has not been experimentally investigated for elderberry. While trickle systems are effective in Missouri (P.L. Byers and A.L. Thomas, unpubl.) and other production areas, systems may need to be adjusted in response to root system development as plants age.

### **C. Stock Selection and Planting**

**1. Stock Selection.** A new plantation can be established from seeds, seedlings, or cuttings. One-year-old rooted cuttings are the type of stock that is most commonly selected, but older stock will also yield good results. The type of stock selected, its age, and consequently its size, are all factors that will directly affect the cost. One-year-old stock raised in plug trays facilitates mechanical transplanting but does not establish as quickly as older and larger transplants.

*Seeds.* The genetic variability inherent to seed propagation is not desirable from a commercial production perspective but may be preferred in situations such as wildlife plantings where genetic diversity is a consideration. In a breeding program, seedling populations are generated from which selections may be made for potential future cultivars. Seeds require stratification before they will germinate (see Stratification).

*Seedlings and Cuttings.* If bare-root seedlings/cuttings are used, soak the roots in water a couple of hours prior to planting (Martin and Mott 1997). When the rooted cuttings/seedlings are to be planted in bare soil, one only needs to open a furrow approximately 15 to 20 cm deep with a harrow or disc and place the plant material in it. If larger plant material is used, the furrow will have to be made wider and deeper, as appropriate. Regardless of the type of stock, it is essential to ensure that each plant is planted upright with the root system completely buried to avoid uprooting. This precaution is particularly important in the case of plug cuttings that are at risk of being uprooted by freeze-thaw heaving. The furrow may be left open to promote rainfall catchment.

If the plantation is small with no more than a few hundred elders, a metal rod may prove to be a practical method of making holes to receive the cuttings or seedlings. A mechanical strawberry planter or the like may also be used if a large number of cuttings are to be planted. However, it is important to

ensure that the cuttings are set at a depth slightly above their collar and that the earth is properly tamped down around them.

While one-year old cuttings are expected to produce a sizable crop as early as the second year in the field, seedlings will not do so until the third or fourth year (Bolli 1994).

## **2. Planting**

*Period.* No research on different planting dates for a single site has yet been conducted, but it seems that elders can be planted at any time of year, provided that they can be irrigated after planting. In general, planting during the dormant period yields the best results. Planting in the spring, even late spring, has produced excellent results in southern Québec and Missouri. Planting late in the fall (in November) has reportedly yielded excellent results in southern Ontario (R. Geier, person. commun.). Since American elder is hardy up to zone 2, fall planting may be advantageous in areas with well defined seasons by enabling growth to resume as soon as the ground thaws in the spring.

*Density.* The planting density decision should also allow for the spreading of the bushes that will occur as the fruit ripens: the branches tend to bend under the weight of the fruit clusters, causing spreading. A common practice in commercial blueberry and primocane fruiting raspberry production that should work with elderberry is to erect a simple t-trellis made from rebar and strung with baling twine or wire that catches the fruit laden canes and keeps them from falling into the row middles. Appropriate pruning should enable the grower to keep the aisles between rows reasonably clear without adversely affecting fruit production.

Under most of its natural distribution range, cuttings set 1.5 m apart or less will form a nearly solid hedgerow before they reach full production capacity, while if they are set 2.0 m apart or more, each

bush should be accessible from all around even when fully grown. Wider spacing ensures better air movement that can reduce the incidence of fungal diseases but allows more weed growth between plants. Spacing between rows will depend on the equipment at the grower's disposal. To determine row spacing, allow between 2.0 m and 2.5 m for bush development and add the width of the equipment that will be used to maintain the aisles. To illustrate: spacing cuttings 2.0 m apart in each row and leaving 4.0 m between rows will result in a maximum density of approximately 1,200 bushes per hectare, while reducing these distances to 1.8 m and 3.0 m respectively will increase planting density by 40 per cent.

#### **D. Fertilization and Mycorrhiza**

In an English study, Atkinson and Atkinson (2002) found that European elder can grow in soils with a broad spectrum of nitrogen, phosphorous and potassium content ranging from 18 to 354  $\mu\text{g/g}$ , 71 to 192  $\mu\text{g/g}$ , and 24 to 610  $\mu\text{g/g}$ , respectively. Under favorable conditions, elders grow at an impressive rate. New stems may add nearly 2 m to their length in the course of a single year. Growth of this order requires large amounts of nitrogen and potassium. To meet the needs of an elderberry plantation, Craig (1978) proposed a simplified fertilization method: apply 100 g of 10-10-10 fertilizer for every year of the plant's age, up to a maximum of 450 g. Alternatively, potassium chloride (potassium muriate) may be used and applied every year or every second year. Good results have been reported from an application of approximately 220 kg of potassium chloride per hectare every second year (R. Geier, person. commun.). Potassium in other forms would also be satisfactory. Apply the fertilizer early in the spring, immediately after the bushes have been pruned. As with all perennial fruit crops, since phosphorus moves so slowly into the soil, if a planting site is low in phosphorus it should be adjusted prior to planting.

Nitrogen can be applied in any form. When the cuttings are set out, all that is required is to apply the equivalent of 30 g of nitrogen by hand near, but not touching, the base of each cutting. Where the

cuttings are being planted through plastic mulch, an equivalent quantity may be applied immediately before the mulch is laid down. In the second year, an addition of the equivalent of 60 g nitrogen around each plant should be adequate. The fertilizer should be applied in strips in the case of elders planted on plastic mulch, as their roots will already have spread beyond the mulch. In subsequent years, approximately 60 kg of nitrogen per hectare should be applied early in spring, at budbreak. Depending on how vigorous the bushes are, this may be followed by a second application of between 20 and 24 kg of nitrogen per hectare in late May or early June. In accordance with Craig's (1978) recommendations, the maximum application rate should not exceed 0.45 kg ammonium nitrate per plant per year.

Elderberry roots associate readily with mycorrhizal fungi when treated with a commercial inoculant for trees (D. Charlebois, unpubl.); however, the effect of such association has not been evaluated to date.

Hyphae from unidentified fungi have also been observed in roots of wild and cultivated American elderberries. No effort was made to identify the species present or to assess their relationship (mycorrhiza, pathogen or other). A few authors have reported the presence of vesicular-arbuscular mycorrhizas in European elder (Harley and Harley 1987; Grime et al. 1988; Atkinson and Atkinson 2002).

## **E. Pruning**

Under normal conditions, individual canes usually die between the third and fifth year (Deam 1924).

Pruning is essential to control plant growth, to remove dead or diseased branches, to stimulate growth of new branches and canes, and to promote fruiting (Stang 1990).

**1. Maintenance pruning.** Maintenance pruning should be done every year to remove dead or broken branches and manage growth. Removing dead branches not only facilitates harvesting but also helps reduce the incidence of diseases caused by insects, fungi or bacteria. Branches that are less than 30 cm

from the ground are often removed, which facilitates passage of equipment and eliminates branches that produce fruit that is inefficient to harvest and often of lower commercial value. In some cultivars, such as ‘York’, the fruit load may be such that some branches will bend until they touch the ground. Identify and remove problematic canes; ideally a better alternative would be to harvest the flowers from such canes and avoid any fruit overload.

**2. Rejuvenation pruning.** Fruit yields will increase steadily during the first three years following establishment. However, while the total quantity of fruit will increase, the fruit clusters will become smaller over that period (D. Charlebois, unpubl., P.L. Byers and A.L. Thomas, unpubl.). Usually in the fourth year, productivity will decline due to a number of factors, with aging of the canes probably being the main one. Accordingly, the bushes should go through some rejuvenation pruning in about the fourth year, or later if their growth has been slow.

In elders, inflorescences form mainly at the ends of branches. The vigor of the branch will have a decisive effect on the size of the fruit cluster. Less vigorous branches will produce small fruit clusters that will be among the first to ripen. As a rule, new shoots and one-year-old canes bear large inflorescences that produce slightly larger berries, and those berries ripen a little later.

A healthy elderberry bush will withstand extensive pruning without difficulty. Pruning it back to ground level will cause it to send up numerous vigorous shoots. However, while this is the simplest of all methods, it does result in substantially lower fruit production in the year that the pruning is done. The impact on production in subsequent years has not yet been evaluated.

The method that probably has the smallest adverse impact on fruit production is the selective removal of wood that is more than three years old. Another advantage of this method is that pruning can be

adapted to individual cultivars. ‘Kent’ and ‘Victoria’, for example, tend to form a well-defined trunk, and for those cultivars it will be preferable to prune old branches right back to the trunk, while leaving 2-9 branches that are 1-3 years old (Stang 1990). However, erratic branching can make it difficult to clearly establish the age of individual canes. ‘York’ does not usually form a well-defined trunk and sends up large numbers of new shoots; it should not be treated in the same way as ‘Kent’ and ‘Victoria’. ‘Scotia’ might be described as intermediate in terms of its ability to form a well-defined trunk. The next step, for all cultivars, is to prune back the lateral and terminal branches to enhance the rigidity of the plant. This is labor-intensive and requires a high degree of familiarity with the plants on the part of the grower. If the plants are widely spaced and vigorous, and if they are being grown under favorable conditions, with good pest control, fertilization and irrigation, more canes can be left unpruned.

An intermediate approach is to prune all the branches to a height of somewhere between 60 cm and 1 m above ground level. This method is quick and does not entail any decision-making about the age or number of branches. Provided enough old wood is left, this type of pruning will promote the development of shoots that will grow into vigorous flower-bearing canes. With some cultivars, new shoot production will be stimulated as well.

**3. Corrective pruning.** In a dense elderberry plantation, water stress during or after flowering may cause fruit abortion. Pruning out non-fruiting canes is a way of minimizing the impact of such stress. Canes that are infested with cane borers or other insect pests may also have to be pruned out in order to limit any further infestations.

**4. Disposal of residues.** All removed branches should preferably be disposed of in such a way as to avoid spreading disease and insect pests and keeping the plantation clean. If there is reason to suspect

that they may be diseased or insect-infested, it is preferable to burn the branches. Simply shredding the pruned canes that have been left in the aisles is not sufficient to eliminate many insect pests that may be infesting them (Stokes 1981). However, from a practical standpoint, commercial elderberry growers often flail canes in the aisleway.

#### **F. Weed control**

Elderberry plantations, especially new ones, should be kept weed-free. During the establishment period, competition from other vegetation will adversely affect the growth and survival of cuttings and seedlings. Once the bushes have become well established, however, they become competitive. Competition from weeds, however, may result in fruit abortion and stunted growth.

Plastic mulch may be a useful option for weed control within rows of elderberry bushes. A cover crop is useful in the aisles; select a species that is an undemanding, slow-growing perennial that requires minimal mowing, water, and fertilizer, and that provides a favorable environment for organic matter accumulation and reduces soil erosion by minimizing water and wind action. Proper site preparation before the elder cuttings are planted, including application of a non-selective postemergent herbicide, should serve to minimize weed growth until the selected ground cover has had time to become established. Once established, the ground cover will have to be mown frequently enough to keep the seedlings/cuttings clearly visible and plant debris should be raked away from the elderberry plants in order to discourage rodents from overwintering and feeding on the plants (Martin and Mott 1997). Since elders are shallow-rooted, mechanical activity in the planting, including mowing, tillage, and harrowing, should be reduced to a minimum to avoid soil compaction and root damage. On small plantations, weeds may be eliminated by cultivation.

Elderberries are considered a minor crop with the result that few herbicides are labeled for either preemergent or postemergent weed management. Use non selective postemergent herbicides very cautiously because the herbicide may be taken up by the young shoots and passed on to the parent plant, which will then show symptoms and be injured. Always check your local applicable laws before using any organic or non-organic chemical.

## **G. Pests and Diseases**

**1. Insects.** Few insect pests were identified in small elderberry plantings consisting of 240 four-year-old bushes in southern Quebec (D. Charlebois, unpubl.). However, there are some species that might produce a measurable economic impact in a larger-scale plantation. The currant borer, *Ramosia tipuliformis* (Clerck), attacks currants and elders (Pirone et al. 1960). Insects and mites that may be pests on elderberries include the elder shoot borer, *Achatodes zae* (Harris) (Silver 1933), of which the larvae feeds on the canes in which they hatch, and the elder borer, *Desmocerus palliatus* (Forster), which in its adult stage eats elder pollen and leaves, and lays its eggs in canes near ground level. Larval feeding causes the die-back of branches and sometimes the entire shrub (Pirone et al. 1960). Infested twigs should be pruned promptly and burnt. Eriophyid mites (*Eriophyes* spp.) feeding on leaves (Schooley 1995) and flowers and causing flower abortion can significantly impact yield in the Midwestern US (Finn et al. 2008). Vaněčková-Skuhravá (1996) reported that the eriophyid mite *Epitrimerus trilobus* (Nalepa) overwinters within and beneath leaf buds of *S. nigra* in the Czech Republic. However very little is known about eriophyid mite species that may infest elderberry in North America, nor their life cycles.

The larvae of the cecropia moth, *Hyalophora cecropia* L., the eastern tent caterpillar, *Malacosoma americanum* (Fabricius), the forest tent caterpillar, *Malacosoma disstria* Hübner, sawflies such as *Langium atroviolaceum* (Norton) (Eaton and Kaufman 2007) and *Macrophya trisyllaba* (Norton)

(Amett 2000) in North America, and *Macrophya ribis* (Schrank) in England (Atkinson and Atkinson 2002), the fall webworm, *Hyphantria cunea* (Drury), and the rusty tussock moth, *Orgyia antiqua* L., all eat elder leaves. Gall mites and the two-spotted spider mite, *Tetranychus urticae* (Koch), suck sap from the leaves. Sap beetles feed on the sap of the bush and juice from the fruits. Adult European snout beetles, *Phyllobius oblongus* L., eat the margins of leaves and buds of elderberry bushes, while their larvae eat the roots. Potato flea-beetle (*Epitrix* sp.), green stink bug (*Acrosternum hilare* (Say)), omnivorous-looper (*Sabulodes aegrotata* (Guen)), grape mealybug (*Pseudococcus maritimus* (Ehrhorn)), San Jose scale (*Quadraspidiotus perniciosus* (Comstock)), and madrone thrips (*Thrips madronii* (Moulton)) are all considered of minor importance (Pirone et al. 1960). Management strategies include hand removal, sanitation, and application of labeled insecticides at timely intervals. Care must be taken when using insecticides in order to avoid any residue from contaminating the flowers (Guédon et al. 2008) or fruit.

Tingle and Mitchell (1986) have shown that leaf extract from *S. simpsonii* was effective in reducing egg deposition from the tobacco budworm (*Heliothis virescens* (Fabricius)). The insect repellent potential of American elderberry leaves has also been reported by Durant et al. (1981).

**2. Mammals and Birds.** Both elder sub-species present many features, such as fall ripening, small seeds, and short retention time on the plant when ripe, that are considered adaptations to maximize seed dispersal (Stiles 1980). Elderberries are considered to be fairly digestible (Short and Epps 1976). In some regions, mammals such as chipmunks, deer, rabbits, raccoons, squirrels, opossums, and woodchucks may eat elder leaves and fruit (Hankla 1977). Some of these pests will even eat unripe fruits (Hankla 1977; Schaefer and Schmidt 2002). Browsing by mammals can sometimes be severe but is often insufficient to seriously affect growth. An electric fence will keep deer out, but will be ineffective against smaller animals. European elder leaves are thought to be toxic to mammals (Grime

et al. 1988). Various farm animals will also feed on elderberries. Despite a claim made by Hankla (1977), there is no documented proof that elderberry vegetation can be fatal to wild or farm animals.

American and European elders are also attractive to birds (Martin et al. 1951; Wyman 1969; Rajchard et al. 2007; Brookes 2008; Stiebel and Bairlein 2008) and a number of species eat the berries (Martin and Mott 1997) The presence of amygdaline, a cyanogenic glycoside in the fruit, has no deterrent effect (Struempf et al. 1999). If not harvested, European elders are usually stripped of their fruits by early November (Atkinson and Atkinson 2002). Netting, while effective is expensive to put in place and to maintain. There are various bird-scaring systems available such as noise cannons and distress calls, but unless a grower is vigilant about managing the frequency and placement of the various bird alarms, they rapidly become ineffective and only go to infuriating your neighbors. Birds of prey are the elderberry grower's natural allies. Territorial birds like the eastern kingbird (*Tyrannus tyrannus* L.) can sometimes help discourage unwanted bird species in eastern North America. Trap crops may also be useful. Millet, rye and wheat have been reported to produce good results in attracting birds away from elderberries. If these crops are harvested early, grain residue should be left on the ground and disposed of only after the elderberries have been harvested. The efficacy of this approach is limited with bird species that mainly or exclusively feed on fruits. Depending on the size of the plantation and the seriousness of the bird problem, it may prove simpler for the grower to resign himself to the loss of a percentage of the crop than to install a bird-scaring system. As a last resort, prompt harvesting of ripe fruits should be considered (Stang 1990).

**3. Fungal and Viral Diseases.** The following pathogenic fungi have all been reported on *Sambucus* species in landscape or fruit production uses (Pirone et al. 1960).

*Cankers.* *Cytospora leucosperma* (Pers.: Fr.) Fr. [syn. *Cytospora sambucicola* Tehon & Stout], *C. chrysosperma* Pers.: Fr., *Diplodia* sp., *Nectria cinnabarina* (Tode) Fr., *Neonectria coccinea* (Pers.: Fr.) Rossman & Samuels [syn. *N. coccinea* Desm.], *Sphaeropsis sambucina* (Cooke) Sacc. Girdling of the infected twigs is usually followed by the death of its terminal portion. The infected material should be pruned and destroyed.

*Leaf-spots.* *Ascochyta wisconsina* Davis, *Phaeoramularia catenospora* (Atk.) [syn. *Cercospora catenospora* Atk.], *Cercospora depazeoides* (Desm.) Sacc., *Cercospora prolifans* (Ellis & Holw.) Sacc., *Phyllosticta sambuci* Desm., *Mycosphaerella* sp., *Ramularia sambucina* Sacc., *Septoria sambucina* Peck. Infection is usually moderate requiring no particular intervention.

*Powdery mildews.* *Erysiphe penicillata* (Wallr.:Fr.) Link [syn. *Microsphaera alni* (D.C. ex Wallr.)], *Erysiphe grossulariae* (Wallr.) de Bary [syn. *M. grossulariae* (Wallr.) Lév.], *Phyllactinia guttata* (Wallr.:Fr) Lev. [syn. *P. corylea* (Pers.) Karst.], *Podosphaera macularis* (Wallr.) U. Braun & S. Takam [syn. *Sphaerotheca humuli* (DC.) Burrill.].

*Thread blight.* Thread blight caused by *Corticium koleroga* (Cooke) Höhn. [syn. *Pellicularia koleroga* Cooke] (Pirone et al. 1960; Hightshoe 1988), root-rots cause by *Helicobasidium purpureum* Pat., *Phymatotrichum omnivorum* (Duggar) Hennebert, and *Xylaria multiplex* (Kunze) Fr.; and wilt caused by *Verticillium albo-atrum* Reinke & Berthier have also been reported (Pirone et al. 1960). A verticillium wilt attacks weakened bushes and sometimes kills isolated canes, but as a rule the affected bush survives the infection. However, it is advisable to avoid establishing an elderberry planting on a site where a sensitive species, such as a member of the Solanaceae, has recently been grown. *Puccinia bolleyana* Schw. [syn. *Puccinia sambuci* Arthur] has been reported on American elder (Kellerman 1904; Byers and Thomas 2005) and *Hyphodontia sambuci* (Pers.) J. Erikss [syn. *Corticium sambuci*

Pers.] on European elder in Northern Europe. No description of the symptoms was however provided by the authors. Proper spacing and alignment of the plants usually help reduce the appearance and spread of such diseases.

*Viruses.* Elderberries seem to be particularly good hosts for viruses (T. Jones, pers. comm.). Viruses infect various elderberry species in many countries in Europe and North America (Jones and Murant 1971; Mamula and Miličić 1975; Van Lent et al. 1980 and references within). Tomato ringspot and cherry leaf roll viruses infect American elder (Jones 1972; OEPP/EPPO 1996). It is impractical to control the vectors for elderberry viruses (nematodes, leafhoppers, aphids etc.) and therefore the best approach to control is to plant virus-free, clean stock (see Micropropagation).

## **H. Response to Anthropogenic Stress**

Elderberry is not salt tolerant, an important point to consider if elderberries are to be planted along road sides or are to be irrigated with poor quality water. American elder tolerates air pollution and can be used as an ornamental in urban areas (DeGraaf and Witman 1979; Beaudry et al. 1982). European elder withstands various anthropogenic pollutants such as fluoride and sodium (Heinrich and Schaller 1987), ozone (Davis et al. 1981; Kline et al. 2008), sulfur dioxide and lead (Rachwal 1983), and various heavy metals (Novikova and Kosheleva 2007). However, ozone injuries have been frequently found in field-grown European elders in Poland (Godzik 1998) and in a closely related species, *S. racemosa*, in Ukraine (Blum et al. 1988). *Sambucus racemosa* and *S. mexicana* have also been used as bioindicators for monitoring ozone (Campbell et al. 2007). Reduced growth will occur under deficient water supply, poor drainage, and soil compaction. Care must be taken to avoid exposure to herbicides and some plant growth regulators since reduced growth or death may occur from exposure to these chemicals (Marshall 1989). Symptoms ranging from leaf scorching to plant death have been observed following exposure to herbicide drift.

## **IV. FRUIT DEVELOPMENT AND HARVEST**

### **A. Pollination**

According to Marie-Victorin (1935), the stamens of elders are so divergent that self-fertilization is virtually impossible. While some claim that two or more cultivars are needed for optimal fruit production (Bailey and Bailey 1976; Poincelot 1980; Grauer 1990), a planting of a single cultivar will produce good results. Extensive observations of isolated wild plants that consistently produce fruit further the claim that American elder is self fertile (P.L. Byers and A.L. Thomas, unpubl).

Elder flowers and fruit are borne in cymes. Elder flowers do not have nectaries, and few pollinating insects visit them while they are in bloom. Field observations made over 3 years in several elderberry orchards in Québec indicate the insects probably play a negligible role in the pollination process (D. Charlebois, unpubl.). American elder is among the plant species found in Florida that are not visited by apoid insects (Pascarella et al. 2001). A similar lack of interest from this group of insect has also been observed in Québec (D. Charlebois, unpubl.). In contrast with the American elder, European elder is believed to be routinely insect-pollinated (Grime et al. 1988). However, the exact determination of insect involvement in the pollination process is difficult considering the confounding action of the wind and passive self-pollination (Vaissière 2005).

Observations made on wild bushes and orchards of various ages seem to indicate that the wind and plant density are probably the most important factors responsible for successful pollination (Guilmette 2006; Guilmette et al. 2007). Elderberry pollen grains are often found in traps from various observatories (Jäger 1989) indicating that they are easily carried by the wind, in contrast with the observations made by Bolli (1994) suggesting that such pollen grains would not normally travel much further than the inflorescence from which they originate.

In view of the importance of wind as a vector in elderberry pollination, it seems reasonable to assume that planting density will have a measurable impact on yield, especially when the planting is young and the bushes are small, with few flowers.

## **B. Fruit Ripening**

Flower cymes and the subsequent fruit clusters arise mainly on the terminal portion of one- and two-year-old canes (Stang 1990). New canes bear a single fruit cluster that ripens later than those on older canes since most of the energy is first used for vegetative growth. When the berries appear, they are green and held relatively tightly in the cyme. As they ripen over a period of six to eight weeks, they first turn red and finally black with a hint of purple and a glossy appearance. Individual berries usually remain attached to their pedicels for up to several days after becoming fully ripe, allowing for timely harvest and processing. The stalks tend to bend under the weight of the ripe berries, and fruit clusters occasionally become detached from the plant by the wind or the weight of birds feeding on them (Bir 1992). In such a case, individuals should be identified and the larger clusters used for flower production. All cultivars do not ripen at the same time (Mathieu et al. 2008a) and this characteristic can be exploited to spread harvest over a longer period than if only one cultivar was used. Most of the fruit on a given plant ripens over a period of 3 weeks.

Elderberries go through important biochemical changes during ripening. Cultivars of American and European elderberries follow similar trends from fruit set to harvest. For instance, titratable acidity and total amino acid content decrease while total soluble solids, anthocyanin and phenol contents, and antioxidant capacity all increase (Künsch and Temperli 1978; Kaack 1990a; Mathieu et al. 2007; Mathieu et al. 2008b, a). Such knowledge allows a more efficient harvest schedule and a better use of the fruits by the processing industry.

The fruits of the native wild American elder not only ripen later than those of the various cultivars (Hayes 1984; Mathieu et al. 2008a) but also ripen less uniformly. This heterogeneity in the ripening process is attributable to a number of factors, including the age of the fruit-bearing canes and the amount of sunlight the fruit clusters receive. Berries on older canes that are exposed to the sun will ripen first.

### **C. Harvest**

Elderberries are not well suited for mechanical harvesting as the fruit do not separate readily from the pedicels and, in the case of American elderberry, the crown spreads the catcher plates on currently available mechanical harvesters, allowing fruit to fall to the ground. While it is likely that elderberries could be mechanically harvested, modifications in training systems and in existing mechanical harvesters will be necessary. At present, most of the crop is harvested by hand.

Extensive, structured pruning to enhance light exposure throughout the canopy will allow fruit ripening to be more uniform and will also shorten the work of harvesting by fostering the formation of fewer but larger fruit clusters. The berries should be harvested when a majority of them are dark blue, almost black, in color. An individual plant can usually be harvested in two to three passes at five to seven day intervals over a period of two to three weeks.

At harvest typically the entire cyme is collected. This operation is more easily accomplished in the morning, when the peduncles are engorged with water and consequently tend to break more readily. The fruit clusters are collected into containers of capacity suitable to allow rapid cooling. Elderberries that are not immediately frozen should be refrigerated and processed shortly after harvest, as fruit quality rapidly declines at room temperature.

Considering their rather small size and lack of appeal as a fresh product, elder fruit are unlikely to be sold fresh. Elders do not form a consistent abscission zone between the pedicel and the fruit, and many fruit tear and leak when removed from the cluster, making marketing of the fresh cluster impractical for anything more than immediate local sales. Much of the crop is frozen immediately after harvest, which facilitates long term storage until processing. Alternately, the fresh fruits can be pressed and the resulting juice frozen.

If the stems are to be removed before the berries are frozen, the fruit clusters are simply shaken rapidly over a screen that will allow the berries to fall through while intercepting the stems. Cleaning is done by dumping the berries into a container of appropriate size until it is half filled. Enough water is then poured in to cover them. The container is gently shaken, causing stems, leaves, green berries and any insects that may have been gathered along with the berries to float to the surface of the water, while the ripe berries remain at the bottom. More water is then added, and all this unwanted material is poured out of the container. After this rinsing operation, the berries are poured out on to a screen, to form a thin layer. A fine water spray can be used to remove any sand and soil particles that may still cling to them. In addition, the berries are inspected at this stage, and any foreign bodies or unsatisfactory specimens are eliminated. After being left to drain for a few minutes, they may be packaged and immediately chilled and stored, either fresh or frozen.

Removing the fruit from the clusters is difficult when the fruit is fresh but simple once they are frozen. After the elderberries are frozen, the stems can readily be removed simply by mechanical agitation of the fruit clusters over shaking wire-mesh or a similar device such as a blueberry destemmer. Fruit quality can then be evaluated and plant debris and below grade fruits eliminated. The peduncles represent approximately 10 per cent of fresh cyme mass.

## D. Yield

1. *S. nigra* ssp. *canadensis*. Yield data from wild populations are lacking. In one study, Caisse (1998) measured the productivity of wild American elders located in the Acadian peninsula (New Brunswick). She reported very low yields ranging from 0 to less than 250 g/plant. Considering the natural density of the plant over the studied area, this author evaluated the potential yield to be less than 12 kg/ha (Caisse 1998). Under natural conditions, the yield is likely to show large annual variations owing to the lack of control over the production parameters. The natural low density of the plant and the lack of control over predators all seriously limit the plant from reaching its full production potential in the wild. Even with these limitations, large quantities of American elder are harvested from wild plants in the Midwestern US (P.L. Byers and A.L. Thomas, unpubl.).

In managed plantings, there will be no significant fruit production in the year that the cuttings are planted (Stang 1990). This juvenile (non-reproductive) period can extend to three years if seedlings are used. During planting establishment, removing flower clusters as they appear will encourage vegetative growth. In USDA-ARS hardiness zones 5 and 7, production of between 1 and 3 kg per bush was obtained from cuttings in the second year in the field (Finn et al. 2008). However, in hardiness zone 8 in Oregon, yields as high as 6 kg/plant were achieved the year after planting and nearly 13 kg/plant two years after planting (Finn et al. 2008). Average yield may amount to as much as 9 kg per bush in the second production year (third year in the field), and peak at 11 kg the fourth year, and slightly decrease the fifth year if no pruning is performed (D. Charlebois, unpubl.). These yields are very close to those reported by Adams almost 100 years ago (Adams 1915). Unfortunately, increased fruit production is accompanied by smaller fruit clusters, which results in higher harvesting costs. As the bushes age in subsequent years, productivity may be expected to decline gradually. Pruning to encourage vigorous growth is essential to keeping the elderberry plantation productive. Little is reported in the literature on

the long term productivity of American elder; plants in trials in Missouri remained productive for 7 years (P.L. Byers and A.L. Thomas, unpubl.).

**2. *S. nigra* ssp. *nigra*.** In a study conducted between 1997 and 2003 in Poland, Ważbińska et al. (2004) reported yields varying between 2.9 and 7.0 kg/bush for wild growing and ‘Sampo’ and ‘Samil’ cultivars, respectively. Yield was shown to be dependant on site and cultivar with a 40% difference directly attributed to site. The average yield for the wild growing European elder was much higher than the one reported by Caisse (1998) for American elder likely because the former was maintained under controlled conditions while the latter was evaluated in the wild.

## **V. PROPAGATION**

### **A. Breeding and Selection**

There is little published information on *Sambucus* concerning the available and potential parents for specific traits and information on inheritance patterns. Breeding objectives for elderberry include large berry size, firmer berry texture, large berry cluster size, small seeds, self fruitfulness, increased productivity (number and size of cymes and berry size), vigorous and strong canes, uniformity of ripening within and among clusters, attractive color (glossy, dark), better fruit and juice quality, increased nutraceutical content, resistance to shattering, resistance to diseases, immunity or tolerance to virus diseases, wider adaptation, and pendulous fruit clusters less prone to bird damage (Darrow 1975; Lee and Finn 2007; Kaack et al. 2008). The Danish breeding program is seeking plants that are low growing with strong upright shoots from the root or lower part of the bush, characteristics that improve harvest efficiency (Kaack 1989). The Missouri State University/University of Missouri development program, in addition to the characteristics mentioned above, is seeking plants with tolerance to a species of eriophyd mite that causes a significant economic impact. The usual practices of pollen collection, emasculation of the female parent, and controlled pollination are followed. Emasculated

blossoms are best isolated from chance pollen before and after pollination; this can be accomplished by protecting the cluster with a paper bag. Fruit clusters resulting from controlled crosses must be protected from bird depredation. Fruit is harvested when all berries in a cluster are fully ripe. Germinated seedlings can be carefully transplanted to individual containers, and later planted into selection rows in the field. Seedlings frequently flower and fruit in the second season, allowing for rapid selection for a number of traits of interest. Advanced selections in the Missouri State University/University of Missouri program are further evaluated for three harvest seasons in replicated second test plots (P.L. Byers and A.L. Thomas, unpubl.).

Elders can generally be multiplied by seeds or one of the following vegetative methods: layering; suckers; micropropagation; and softwood, hardwood, and root cuttings (Laurie and Chadwick 1931; Mahlstedt and Haber 1957). Seedling production is usually not used to establish orchards for fruit production, but is useful for producing large numbers of plants for wildlife habitat or in breeding work. Thanks to their vigorous vegetative growth of up to 2 m in a single year, the use of cuttings is the most efficient propagation method. In some situations, where it is desirable to produce large numbers of a specimen in a short period of time, propagation by cuttings may not be adequate. In vitro or micropropagation may be necessary in these instances. In vitro propagation also allows for meristemming or a combination of meristemming after heat therapy to eliminate viruses from the planting stock. Regardless of the source of material used, it will take between 3 to 5 years to attain full fruit production (Stang 1990). Sources of certified pathogen-free tested material are limited at present; as the elderberry industry develops this may become a serious problem. Whether from seeds or from cuttings, appropriate procedures must be followed in order to produce certified pathogen-free material (European and Mediterranean Plant Protection Organization 2008). While elder seeds, seedlings, and cuttings are commercially available, there are few distributors, and care must be taken to ensure that cultivars remain true to type. Finn et al. (2008) have determined that there was definitely a genotype x

environment interaction for phenological, reproductive, and vegetative traits for a group of American elderberry genotypes grown in Oregon and Missouri. Their results suggest that, at least in these diverse environments, that the performance of a genotype in one environment is not predictive of how it will perform in the other. This means that it is important to trial cultivars in the region where they will be grown to determine if they will be commercially viable.

## **B. Seedlings**

American elder produces between 79,000 and 511,500 seeds per kilogram (Vines 1960; Stiles 1980) with an average of about 105,000 seeds per kilogram (Hankla 1977).

**1. Sources of Seeds.** A mature American elder plant may produce several hundred panicles, each with up to 2,000 fruits containing from three to five seeds. A single plant may thus supply several tens of thousands of seeds each year. Extracting seeds from elderberries is a relatively simple matter, and it may prove advantageous for the prospective grower to obtain seed from ripe berries harvested from healthy, productive bushes.

### **2. Extraction of seeds**

*Enzymatic extraction.* The easiest way to extract elderberry seed is to lightly mash the fruits in water with pectinase added to the slurry. In 24-72 hours the skin and flesh will be completely degraded. Add water and pour off the remains of the flesh and skin and any floating, non-viable seed. Allow the seeds to dry. This avoids the risk of damage that a blender or food processor may inflict if not carefully managed.

*Mechanical extraction.* If pectinase is unavailable, carefully purée the ripe berries by hand or in a food processor or blender, adding enough water to ensure that the berries are reduced to a pulp and the seeds

extracted. The processor or blender should be run long enough to separate the seeds from the pulp; depending on the number of berries and the quantity of water used, a few seconds should be adequate. Some seeds will be observed floating on the surface of the liquid. These are probably empty or unlikely to germinate and should be discarded. Strain the purée through a sieve fine enough to ensure that the seeds, which are approximately 1 mm in diameter, will not pass through it. Rinse the residue with water several times and, if necessary, run it through the food processor or blender again to eliminate the remaining fruit pulp. Filter after each rinse then allow the seeds to dry. Finally, shake the seeds through a sieve to eliminate any remaining residue

Seeds will remain viable for several years if kept in a closed container at a low temperature (4°C)(Young and Young 1992). As a rule, however, it is to be expected that the fresher the seed, the higher the germination rate. Fresh European elderberry seed is reported to have a germination percentage of 62.5% following a stratification treatment (Clergeau 1992). The germination rate of various American elder cultivars varies between 40 and 60% (D. Charlebois, unpubl.).

**3. Stratification.** Elderberry seeds will not germinate readily contrary to what Bailey (1930) reported. They contain a dormant embryo and thick but water permeable teguments (Young and Young 1986; Martin and Mott 1997; Hidayati et al. 2000), and consequently require a period of stratification at low temperature. The extent of the pre-treatment has been reported to vary considerably across the distribution range of the species (Bir 1992). Untreated seeds can take up to two years before germinating. While inexpensive and simple, this material yields poor results. Scarification with sulfuric acid can be used prior to the stratification treatment (Heit 1967; Hankla 1977; Young and Young 1986). This treatment weakens the teguments and enables the grower to omit the initial period of storage at room temperature. Barring the use of sulfuric acid, the following technique is successful. Place the seeds in a sealed plastic bag containing a sterile and moist but not wet medium. Adding

gibberellic acid to the watering solution increases germination rate (Hidayati et al. 2000). Peat moss is usually satisfactory but sand can also be used. Sixty to 90 days at room temperature followed by cold (4°C) storage for approximately 90 days will yield good results (D. Charlebois, unpubl.). After that period, the bags may be placed in light at room temperature until the seeds germinate. This method offers the advantage of selecting only viable seedlings but requires their manipulation during transplantation. Alternatively, seeds can be sown in late fall or spring directly on a raised bed at a density of about 100 seeds per meter and thinned as necessary.

**4. Potting and Transfer to the Field.** Seedlings may be transplanted into plug trays containing a commercial potting mix. Direct exposure to sunlight should be avoided, and care must be taken to ensure that the potting medium is kept moist. A starter fertilizer for woody plants may be used, according to the manufacturer's recommendations. Elderberries do not grow as well in pots as they do in the field and should be transplanted to their final location as soon as possible. When the seedlings have attained sufficient size, they may be transferred to the field. A good way to assess seedling development is to examine the root system. Depending on how well advanced they are, it may be advisable to keep them in containers for another year.

### **C. Cuttings**

Elders are exceptionally well suited for propagation by means of cuttings. Mother plants for cuttings should be true to type and healthy. In particular, care must be taken to ensure the identity of mother plants since many cultivars can hardly be distinguished solely on morphological features of the vegetative parts, and their tendency to produce suckers can sometimes be a source of confusion in nurseries when cultivars are planted too close to one another. Cuttings can also be removed from wild plants when elite specimens are found or for breeding purposes (DeGraaf and Witman 1979). Once the planting is well developed, cuttings may be taken from producing bushes during maintenance pruning

operations. Elderberries are easily propagated from hardwood (lignified cuttings, taken in winter), softwood cuttings (immature, succulent cuttings, taken in summer), root cuttings, or suckers (Stang 1990; Schooley 1995).

**1. Hardwood Cuttings.** Collect hardwood cuttings in November, after the leaves have fallen, to avoid the risk of harvesting material that has been winter-damaged. Cuttings commonly include 3-5 buds. Place the cuttings together in bundles, set upright in coarse sand or peat moss, in which they are buried to half their height, and store in a cold room or cellar (around 0°C). If harvested in April or May, treat the hardwood cuttings as softwood cuttings (see following section) or set out directly in the field. Cuttings can also be harvested in late winter or early spring, but while the elders are still dormant. In both cases, the taking of cuttings can be judiciously timed to coincide with the pruning of the bushes. If cuttings are taken in the fall, storage space is required, and there is no assurance that the cuttings will be in good condition the following spring. On the other hand, if cuttings are taken in the spring, the physiological condition of the canes cannot readily be determined, resulting in a variable percentage of successful cuttings. In very cold climates, the tips of canes may suffer winter damage. To address this problem, woody sections of cane, located several centimeters down from the apex should be selected from vigorous canes.

Soaking the bases of the cuttings in a solution of indolebutyric acid may be beneficial in stimulating rooting, although it is not essential. The cuttings are set upright in a trench, spaced between 7 and 10 cm apart, and covered with a medium, with the upper buds left protruding above the soil surface. The medium used should possess good water-holding capacity, but without allowing excessive water to accumulate; for that reason, sand is often selected as the planting medium. A media with 50-75% perlite and 25-50% peat works well. New roots will appear within the first two weeks and cease to emerge after about a month (Wilson and Wilson 1977). According to these authors, the presence of

leaves is necessary for the production of roots. Another method is to lay down a strip of plastic mulch and push the cuttings into the soil through the plastic, approximately 15 cm apart, with 2 to 4 cm of cane protruding. Alternatively, they can be set in their permanent location as just described. The great advantage of this last approach is that the cuttings need not be transplanted; the disadvantage is that not all the cuttings will root leading to gaps in the row. One way to minimize this problem when cuttings are in sufficient number is to place up to three cuttings at the same location and thin out successful cuttings that might be in excess.

During the two months after the cuttings have been set out in the field, they will produce foliage, followed by the appearance of new roots. The planting medium should be kept moist during this period. Growth of the new canes may be anywhere from 15 cm to 100 cm in the first year. If larger plants are required, the cuttings may be kept under these conditions for an additional year. Given favorable weather conditions and a suitable location, the success rate may be in excess of 95%; under more adverse conditions, such as a dry year, the rate may be as low as 20%. In a production context, then, it would be prudent to estimate the production performance of hardwood cuttings at approximately 50%.

**2. Softwood Cuttings.** Softwood cuttings are taken during the growing season. The optimal period for this purpose is between the time the bushes are at the flower bud stage and the end of their flowering or the beginning of fruit set. In southern Québec (hardiness zone 4-5), that period extends from late June to late July; in Missouri (hardiness zone 5-6), that period is late May to early July. As cuttings are collected care must be taken to protect against overheating and desiccation.

A cutting containing between two and three nodes will normally be satisfactory. They should always be taken from bushes that are healthy and vigorous. There is no danger of taking too many cuttings from any particular bush as elders are well able to withstand drastic pruning and only the ends of canes are

used. Early removal of flower stalks on the parent plants may be one way to promote more vigorous vegetative growth.

Each node bears two opposite buds in the axils of the compound leaves. The first cutting taken from a cane ends in a non-woody portion that is frequently green, consists of a number of telescoped internodal spaces, and may include flower buds. Ideally, the basal end of the cutting should not be more than 10 mm in diameter, in order to maximize rooting. Cuttings larger than this tend to root less satisfactorily, and their abundant foliage makes them more sensitive to rot. Techniques to improve rooting success of softwood cuttings include the following: avoid desiccation or overheating of cuttings during collection; remove all but the base two leaflets of each retained compound leaf, which reduces transpirational loss of water during the rooting period, before sticking into the rooting media; and provide intermittent mist during the rooting period.

**3. Root Cuttings.** Collect root cuttings in early spring before growth begins. Root segments that are 15-20 cm in length and 3-5 mm in diameter are ideal. Place root segments in shallow pots of sterile media, cover with 2.5-3 cm of media, and keep warm and moist. Each segment will produce at least one plant.

#### **D. Micropropagation**

Elders can readily be propagated by means of *in vitro* culture, and the propagation medium may also be used for rooting (Brassard et al. 2004). Low mortality rates are observed during the acclimatization phase, and acclimatized plants adapt well to field growing conditions (D. Charlebois, unpubl.).

Moreover, micropropagation is sometimes the only way to obtain virus free material. In view of the cost of this propagation method and the technology involved, it is not within most growers' reach.

However, there are a number of commercial laboratories that could propagate exceptional individual plants on a large scale in a short time on a contract basis.

## VI. USES

The attractive appearance, flowers and fruit of the European and American elders and their numerous cultivars have earned them a good reputation as an ornamental. Consumers appreciate the color and shape of the foliage, and various cultivars are commercially available. The shallow, aggressive root system and hardiness of the wild species make it ideal for river bank stabilization or shelterbelt establishment. They are also praised for their qualities as suitable plant materials for wildlife and habitat management programs (Martin and Mott 1997) providing both shelter and food to countless species of animals, birds, and insects. Of the various species and subspecies of elderberries found in North America, *S. nigra* ssp. *canadensis* and *S. nigra* ssp. *cerulea* (Raf.) R. Bolli probably possess the greatest value for wildlife (Coastal Zone Resources Division 1978). Leaves, flowers, but particularly berries have been used by North American and European people as foods, medicines and to produce dyes for a wide variety of objects such as artifacts and leather (Stang 1990; Moerman 1998). The flowers are still used by craftsmen to produce a yellow dye (Allen et al. 2002), in the perfume industry (Durand et al. 1981), and to make a refreshing drink (Hibler 2004). Leather was also tanned using tannin from the bark and the roots. Similarly, berries and leaves of *S. simpsonii* Rehder (syn. *S. canadensis* var. *laciniata* A. Gray) have been used to produce dyes for the wool industry (Smith 1993). Stems of American elder were used to make flutes, whistles, and spouts for collecting sap from sugar maple (Durand et al. 1981; Stang 1990). Twigs were also used to build pieces for looms (Durand et al. 1981). The leaves are said to have insect repelling properties (Durand et al. 1981). More recently, *S. nigra* ssp. *nigra* agglutinin extracted from the bark (Broekaert et al. 1984; Greenwood et al. 1986) has been used in numerous biochemical and histological studies dealing with various forms of cancer (Dall'olio et al. 1996; Lekka et al. 2006).

However, the elder is primarily valued as a food and medicinal plant and description of such uses are part of the long history of the Native American people and European culture. These characteristics have been documented by Gunther (1945), Vines (1960), and Moerman (1998). The subspecies *nigra*, in particular, has been the subject of many traditions, some of which are current to this day. While the Native Americans had a long history of using the native *Sambucus* species, the European immigrants quickly recognized the similarity between *S. nigra* ssp. *canadensis* and *S. nigra* ssp. *nigra* and then used it similarly for folk medicine. Because of the similarities between these two subspecies, the information presented next is to be taken as applicable to either one. Where possible, the name of the subspecies referred to has been indicated.

#### **A. Folklore**

Elders appear frequently in European folklore (Chrubasik and Chrubasik 2008), and, to a lesser but still significant extent, in North American folklore. This is apparent from the numerous uses to which elders have been put through the ages. Duke (1985) and Moerman (1998) provide excellent surveys of this field. The main lines of their work are summarized in the following paragraphs.

Folk wisdom has discovered many uses for elders. Whistles and popguns can be made of the young shoots after the pith has been removed. Large hollowed out stems were crafted into blowguns by the Houma for hunting and fishing and by many people to make medicine blowing tubes. The Seminole people used root bark as a ritual purification emetic after funerals and by doctors after the death of a patient. The pith can be removed from the canes to turn them into reproduction sites for solitary bees, especially in the vicinity of alfalfa fields.

Over and above these practical uses, American elder is prominent in traditional medicine. A poultice made from the leaves reportedly relieves pain and promotes the healing of contusions and sprains or as a disinfectant to wash sores to prevent infection. The dried leaves are combined with mint leaves and used to treat dyspepsia. An infusion from dried branches was used to cure severe headaches. An infusion made from the flowers is said to have soothing and laxative properties or was used to “sweat out fever”. The juice of the fruit with some added honey is reportedly a highly effective cough syrup. The same mixture with the addition of some extract of sumac (the fruit of *Rhus glabra*) can be gargled to treat a sore throat. Infusions of the berry were consumed as an antirheumatic. The inner bark is used to prepare ointments. Bark scrapings were used as an emetic and laxative. The pith was infused by the Iroquois to treat heart disease and venereal disease. Meskwaki women used elder to assist childbirth. The Choctaw decocted seeds and roots for liver troubles. Dried flowers were used to treat colic in infants by the Mohegan. Elder has been considered to possess carminative, cathartic, cooling, cyanogenic, depurative, diuretic, emetic, laxative, exciting, calming, stimulant, sudorific and toxic properties, and it has been used in folk medicine to treat abrasions, asthma, bronchitis (Kültür 2007), bruises, burns, cancer, chapping, chills, dropsy, epilepsy, fever (Kaileh et al. 2007), gout, headache (Passalacqua et al. 2007), neuralgia, psoriasis, rheumatism, rashes, sores, sore throat, swelling, syphilis and toothache.

Other elderberry species have been popular in folk medicine wherever they grow, as in Brazil where *S. australis* (de Barros et al. 2007), in Mexico where *S. mexicana* (Adame and Adame 2000), and in Iran and Turkey where *S. ebulus* are still in use (Ebrahimzadeh et al. 2007; Kültür 2007). The antioxidant activity of this last species has been shown to be high (Hosseinimehr et al. 2007). A number of studies have been conducted with a view to identifying molecules that might account for the berry’s medicinal properties. To date, however, most research on elderberries has focused on the European subspecies *nigra*.

Unfortunately, few of the claims made about the medicinal properties of elderberries are supported by scientific research or clinical studies (Schapowal 2007) and they must be regarded as the stuff of popular tradition, not solid fact based on rigorous experimentation. The elder, in fact, is so firmly rooted in folk medicine and popular traditions that some scientists have attempted to determine whether there is any basis for the claims that have been made for it. Yesilada (1997; Yesilada et al. 1997), for example, investigated the anti-inflammatory and anti-arthritic properties of elder (*S. ebulus*). He conducted in vitro studies on the inhibitory effects of extracts from a number of plants frequently used in Turkish folk medicine, including European elder. Their findings reportedly validated some of the latter's traditional uses.

## **B. Food**

It might seem at first glance that eating elderberries would be inadvisable, as all parts of the bush contain toxic alkaloids (Allen et al. 2002). In fact, the canes, roots and leaves are not hazardous if properly prepared. The leaves contain hydrogen cyanide (HCN), and should not be used to make alcoholic beverages if their HCN content exceeds 25 ppm. Children who play with elderberry canes are potentially at risk of alkaloid or cyanide poisoning. Sixty mg of cyanide is enough to kill a man (Duke 1985). The berries, for their part, may be eaten raw in reasonable quantities without inconvenience; if consumed to excess, they may cause discomfort and vomiting (Li 2000). Cooking the berries will eliminate these drawbacks. It was used by Native American tribes and settlers as food source and as a fermentable fruit (Allen et al. 2002).

Nearly every part of the American elder has some culinary use. The berries are used in the preparation of pies, jelly, punch, wine or liqueurs. The flowers can be added to the batter used to make various items such as pancakes, muffins or waffles. The flower clusters are made into fritters. Elderflowers

soaked in water with citrus make a delightful non-alcoholic cordial. Elderflower wine is a lovely pale yellow color and is reported to be delicious, and tea can be made from the flowers as well. The marinated flower buds are sometimes used as a substitute for capers. The young shoots, when cooked, are similar to asparagus, although the green older parts are toxic. The pith from the canes can be used in soups as a thickener.

In Europe and in North America, there are a number of commercially available products that contain elderberry juice, puréed or dried elderberries. They are used as a food coloring and to enhance the nutritive value of some common foods. In particular, they are an ingredient in various juices, snack-bars, condiments and drinks. Europeans and Native Americans have long made wines, spirits, syrups, jellies, jams or pies out of elderberries, and harvesting from wild bushes is still practiced today in many countries (Ghirardini et al. 2007; Łuczaj and Szymański 2007).

**1. Chemical Composition and Nutritive Value.** The oldest published chemical composition analysis of American elderberry probably dates back to 1941 (Wainio and Forbes 1941). More recent comparative data are presented in Table 1. Commercial elderberry juice concentrate is among the richest in total phenolics and highest in antioxidant capacity compared to other red fruit juice concentrates (Bermúdez-Soto and Tomás-Barberán 2004). European and American elder berries are rich in anthocyanins and phenols (Rimpapa et al. 2007; Mathieu et al. 2008b). As will be seen, elderberries are noteworthy for their fiber, calcium, iron, phosphorus, vitamin B6 and vitamin A content. They also score high in terms of vitamin C content. One hundred grams of elderberries contain 60% of the recommended daily intake of vitamin A and vitamin C, and 12% of the recommended daily intake of vitamin B6 (USDA ARS 2008). These figures are likely to change for the various available cultivars, the management practices used and the environment they were grown in; however they illustrate the nutritious quality of elderberries.

Table 1. Nutritive values for various small fruits (content per 100 g fresh fruit)

	Elderberry	Grape	Raspberry	Blackberry	Strawberry	Cranberry	Blueberry
Water	79.8	80.5	85.8	88.5	91.0	87.1	84.2
Energy (kcal)	73	69	52	43	32	46	57
Amino acids (mg)	0.645	0.574	ND	ND	0.563	0.862	0.497
Calcium (mg)	38	10	25	29	16	8	6
Carbohydrates (g)	18.4	18.1	11.9	9.6	7.7	12.2	14.5
Fat (g)	0.50	0.16	0.65	0.49	0.30	0.13	0,33
Fiber (g)	7.0	0.9	6.5	5.3	2.0	4.6	2.4

Adapted from the Internet site of the United States Department of Agriculture (USDA)

<http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/measure.pl>.

The two major pigments found in elderberries are cyanidin 3-sambubioside and cyanidin 3-glucoside (Bermúdez-Soto and Tomás-Barberán 2004). They also contain quercetin and flavonols but no ellagic acid derivatives (Bermúdez-Soto and Tomás-Barberán 2004; Lau et al. 2004). Elder flowers are also rich in quercetin, kaempferol (Brand-Garnys et al. 2007) and other glycosylated flavonoids (Lin and Harnly 2007). Elder berries are a good source of high biological value protein (Künsch and Temperli 1978). Kaack (2008a, b) presented an extensive study of European elder aroma composition and sensory quality of flower and fruit juices processed from various cultivars. Marked differences were observed between cultivars that could be used to guide the processing industry.

The characterization of seeds oils of *S. nigra* ssp. *canadensis*, *S. nigra* ssp. *nigra*, and *S. racemosa* has been reported by Schuette and Brooks (1936), Gigienova et al. (1969), and Johansson et al. (1997), respectively. The amount of extractable oils is significant (c.a. 30% dry weight) for this last species, and wastes from various manufacturers could probably be used as food supplements or cosmetic agents

(Johansson et al. 1997). Wastes from American and European elderberries processing would likely be used in a similar fashion. In fact, the oil content of European elder press residues can reach up to 12% and these residues are particularly rich in tocopherol (Helbig et al. 2008). Important amounts of anthocyanins can be extracted from elderberry pomace, an agroindustrial waste traditionally transformed into animal feed or organic fertilizer, which can advantageously be used by the food, cosmetic, and pharmaceutical industries (Seabra et al. 2008). Various N-phenylpropenoyl-L-amino acid amides have been identified in European elder leaves (Hensel et al. 2007). Their possible role in human health is currently under study. Different phenolic acids have also been isolated from European elder bark (Turek and Cisowski 2007) and flowers (Waksmundzka-Hajnos et al. 2007).

**2. Toxicity.** Unripe berries, leaves and bark are said to be toxic (Tull and Miller 1991). Most plant parts but particularly leaves (Bourquelot and Danjou 1905) are thought to contain various cyanogenic glycosides (Atkinson and Atkinson 2002) that can induce stomach aches and vomiting if consumed in large enough quantity. However, the presence of such compounds is quite variable between populations of European and American elder (Jensen and Nielsen 1973; DellaGreca et al. 2000a, b; Bradberry and Vale 2007). They are even absent in many cases (Buhmester et al. 2000). Moreover, some of the degradation compounds resulting from the oxidative degradation cleavage of cyanogenins found in European elder are thought to be harmless (Seigler 1976; DellaGreca et al. 2000b). Release of hydrogen cyanide has been reported during berries transformation from this plant (Pogorzelski 1982). The transformation of cyanogenic glycosides is performed by hydroxynitrile lyases to produce HCN, which has a role as a defense mechanism against herbivores and microbial attacks (Hickel et al. 1996). Hanlka (1977) mentioned that new growth can be fatal to cattle and sheep. Lectins found in the bark of various *Sambucus* species are thought to be responsible for its toxicity (Van Damme et al. 1997; Lehmann et al. 2006). The gene encoding for the type-2 inactivating protein of European elder has been expressed in transgenic tobacco where it produced an enhanced resistance to some insect species,

emphasizing the protective role of such protein (Rapisarda et al. 2000). Similar toxicity of the aphid *Aulacorthum magnoliae* feeding on *S. sieboldiana* to the predator *Harmonia axyridis* has been reported (Fukunaga and Akimoto 2007). Lectins and ribosome inactivating protein composition of the bark and fruits of elders is complex and their role is not well understood (Atkinson and Atkinson 2002).

The allergological potential of elderberry pollen has not been determined, although its presence in the air was not considered a health problem in Vienna three decades ago (Horak et al. 1976). Since *Sambucus* pollen concentration has been constantly on the rise between 1976 and 1989 (Jäger 1989) and may have increased even further since, its impact on allergies must probably be reevaluated.

The toxicity of some chemicals found in European elder has been put to good use in the field of micropropagation. Kuhn et al. (2007) successfully demonstrated the antifungal property of elderberry fruit and leaf extracts on the fungus *Microdochium nivale*.

### **C. Medicinal Plant**

Despite a few reported cases of poisoning in animals and humans, the European and American elders have acquired an impressive reputation as a medicinal plant and their medicinal value has been recently reviewed by Charlebois (2007). Amerindian and European peoples made use of the American and European elder, respectively. In both cases the leaves, flowers, and fruit have long been used to alleviate or cure various ills.

**1. Leaf.** The leaves are ground up and applied to wounds or contusions to relieve pain. Even today, *S. nigra* ssp. *canadensis* or *S. mexicana* leaves are utilized in Central America to treat measles (Folliard 2008).

**2. Flower.** The flowers of European and American elders are used mainly in infusions to relieve the symptoms of rashes of allergic origin and intestinal problems. They are reported to be effective as a diuretic and laxative as well (Beaux et al. 1998; Uncini Manganelli et al. 2005) and are even recommended by the German Commission and the European Medicines Agency for upper respiratory tract infections (Blumenthal et al. 1998; European Medicines Agency 2008).

**3. Fruit.** However, it is the fruit of the elders that has always been its most widely used part. Not only are these berries an effective diuretic and laxative but, like the flowers, they are also used to treat various disorders, including colic, sinus congestion, constipation, diarrhea, sore throat, colds (Schapowal 2007) and rheumatism ((Novelli 2003; Uncini Manganelli et al. 2005). They are known to show anti-inflammatory (Barak et al. 2002; Gorchakova et al. 2007), antiviral (Zakay-Rones et al. 1995; Zakay-Rones et al. 2004), antioxidative (Pool-Zobel et al. 1999), and antibacterial (Chatterjee et al. 2004) actions. However, juice concentrate had no effect on kidney stone-inducing ions solubility (Walz and Chrubasik 2008). Antibacterial activity on two strains of *Streptococcus pneumoniae* was also reported for *S. mexicana* by Molina-Salina et al. (2007).

Research has shown that elderberries contain a number of active substances (Bermúdez-Soto and Tomás-Barberán 2004). We now know that they contain tannins, which relieve diarrhea and nasal congestion. They also contain valeric acid, which eases breathing, and hence their usefulness in the treatment of asthma (Novelli 2003)). In addition, elderberries contain soluble compounds that can stimulate insulin secretion and enhance glucose absorption, suggesting that they may be a potentially valuable weapon in treating the symptoms of diabetes (Gray et al. 2000; Goetz 2007).

**4. Antiviral and Antimicrobial Properties.** European elder flower extract can inhibit prokaryotic neuraminidase *in vitro* (Schwerdtfeger and Melzig 2008). Other interesting curative properties are

attributed to Sambucol<sup>®</sup>, a commercial product containing a standardized extract from the European elder (Zakay-Rones et al. 1995). These authors found that the compound possessed the property of deactivating hemagglutinin, a protein found on the surface of some viruses that enables the virus to attach itself to a host cell. Viruses with hemagglutinin include those in the group known as the myxoviruses, which cause influenza, among other disorders (Anonymous, 2005).

In light of this observation, Sambucol<sup>®</sup> was tested as a treatment for influenza. The results are suggestive: 93% of the patients who were given Sambucol<sup>®</sup> experienced relief of their symptoms after two days, whereas 92% of those who received a placebo took up to six days to recover. The authors realized that Sambucol<sup>®</sup> possessed the property of inhibiting the replication of 11 strains of the influenza virus, and hence expedited recovery (Barak et al. 2001; 2002). In addition, Sambucol<sup>®</sup> appears to possess the capacity to activate the immune system by stepping up cytokine production. The investigators even suspect that it may act as an immunoprotector or immunostimulant, and that it may be advantageous to give it in conjunction with chemotherapy in treating immunodepressive cancers or even AIDS (Barak et al. 2001).

This latter hypothesis was formulated after two cases had been observed in which patients with HIV used an elder-based decoction in conjunction with chondroitin and glucosamine sulfate (Konlee 1998). In both cases, the number of cancer cells declined substantially. One of the patients also reported that his general state of health had improved in various ways: less swollen ganglia, less inflammation of the colon, and the return of restorative sleep. However, the rather small number of cases studied does not fully warrant these results.

Uncini Manganelli et al. (2005) conducted an *in vitro* study on the antiviral activity of three plants, including the European elder, on the feline immunodeficiency virus (FIV). FIV and HIV share many

characteristics, making FIV a useful animal model for AIDS research. Their findings suggest the elder may potentially be highly useful in treating HIV. However, further research will be required in order to identify the specific substance that possesses the antiviral activity (Uncini Manganeli et al. 2005).

Another study has confirmed that there is in elder bark a non-toxic ribosome protein deactivator. The use of these proteins in conjunction with monoclonal antibodies appears to be a promising tool in the field of cancer therapy (Girbes et al. 2003). Rutin and chlorogenic acid are found in elderberry fruit (Lee and Finn 2007) and plant parts (Thomas et al. 2008). Rutin and chlorogenic acid have anti-oxidant and antimicrobial activities (Basile et al. 2000; Grace and Logan 2000; van der Watt and Pretorius 2001; Zhu et al. 2004). Additionally, chlorogenic acid has antiviral activity (Chiang et al. 2002) and may have some cancer preventative activities in rodents (Conney et al. 1991; Mori et al. 2000). Thomas et al. (2008) quantified rutin and chlorogenic acid levels in flowers, green stems, woody stems and green leaves of *S. nigra* ssp. *canadensis*. The levels of both compounds varied among the various parts, among cultivars, among harvest times, and depending on where the plants were grown. They felt that these plant parts could be viably harvested to provide these compounds as phytochemicals.

**5. Anthocyanins and Antioxidant Capacity.** Elderberries contain abundant quantities of anthocyanins, the pigments that give them their purple color (Fossen et al. 1998). This abundance of anthocyanins and other polyphenolics is especially valued in today's markets for their potential health benefits (Strack and Wray 1994; Wang et al. 1996; Hollman 2001; Lee 2004). The antioxidant capacity of the anthocyanins in elderberries has been reported to exceed that of vitamins C and E (Anonymous, 2005). Most of the anthocyanins contained in the berries are metabolized before entering the blood stream (Frank et al. 2005). In this era, every crop is trying to position itself through studies as the one with greatest levels of anthocyanins, other polyphenolics or antioxidants (Croisetière 2006).

Lee and Finn (2007) examined the anthocyanins and phenolic composition of elderberry genotypes that represented *S. nigra* ssp. *nigra* and *S. nigra* ssp. *canadensis* backgrounds. While they found that the levels of the various compounds varied among genotypes and years, the most striking differences were between the two species. It was well known that *S. nigra* ssp. *nigra* has no acylated anthocyanins whereas *S. nigra* ssp. *canadensis* contained the more stable acylated anthocyanins (Brønnum-Hansen and Hansen 1983; Inami et al. 1996; Malien-Aubert et al. 2001; Turker et al. 2004). Lee and Finn (2007) found that the same 11 anthocyanins were present in all *S. nigra* ssp. *canadensis* genotypes they tested: cyanidin 3-sambubioside-5-glucoside (second major pigment present), cyanidin 3,5-diglucoside, cyanidin 3-sambubioside, cyanidin 3-glucoside, cyanidin 3-rutinoside, delphinidin 3-rutinoside (trace levels present), cyanidin 3-(*Z*)-*p*-coumaroyl-sambubioside-5-glucoside, cyanidin 3-*p*-coumaroyl-glucoside, petunidin 3-rutinoside (trace levels present), cyanidin 3-(*E*)-*p*-coumaroylsambubioside-5-glucoside (major pigment present), and cyanidin 3-*p*-coumaroyl-sambubioside. This was the first time delphinidin 3-rutinoside and petunidin 3-rutinoside had been reported to be present in *S. nigra* ssp. *canadensis*. Cyanidin-based anthocyanins were the major anthocyanins present in *S. nigra* ssp. *canadensis* and all of these samples had more acylated anthocyanins (>60% of the total pigment present) than non-acylated anthocyanins. The *S. nigra* ssp. *nigra* genotypes, ‘Korsør’ and ‘Haschberg’ had five and seven individual anthocyanins, respectively. These genotypes contained cyanidin 3-sambubioside-5-glucoside, cyanidin 3,5-diglucoside, cyanidin 3-sambubioside, cyanidin 3-glucoside, and pelargonidin 3-glucoside (present in trace levels). ‘Haschberg’ had two additional peaks (trace levels of cyanidin 3-rutinoside and delphinidin 3-rutinoside). This was the first report to identify delphinidin 3-rutinoside present in *S. nigra* ssp. *nigra* (only detected in ‘Haschberg’). ‘Korsør’ examined by Kaack and Austed (1998) also had cyanidin 3-glucoside as the major pigment. The *S. nigra* ssp. *nigra* samples examined by Watanabe et al. (1998) and Inami et al. (1996) were found to have slightly more cyanidin 3-sambubioside than cyanidin 3-glucoside. Bridle and García-Viguera (1997) reported cyanidin 3-sambubioside-5-glucoside as the

major anthocyanin in the *S. nigra* ssp. *nigra* sample they tested, but Brønnum-Hansen and Hansen (1983) reported cyanidin 3-glucoside as the major pigment of *S. nigra* ssp. *nigra*. As in previous research with *S. nigra* ssp. *nigra*, Lee and Finn (2007) found there were no acylated pigments in ‘Korsør’ and ‘Haschberg’. Both subspecies contained 3-sambubioside-5-glucoside, 3,5- diglucoside, 3-sambubioside (second major pigment present), and 3-glucoside (major pigment present) of cyanidin. *Sambucus nigra* ssp. *nigra* also had cyanidin-based anthocyanins as the major anthocyanins. Wu et al. (2004) identified three additional minor anthocyanins in *S. nigra* ssp. *nigra* (cyanidin 3- rutinoside, pelargonidin 3-glucoside, and pelargonidin 3-sambubioside) – the first time a non-cyanidin-based anthocyanin was reported in elderberries. ‘Korsør’ and ‘Haschberg’ contained trace levels of pelargonidin 3-glucoside, but pelargonidin 3-sambubioside was not detected. In conclusion, *S. nigra* ssp. *canadensis* would be a better choice to use when processing fruit as the acylated anthocyanins will have greater color stability and maintain a better antioxidant capacity compared to *S. nigra* ssp. *nigra*.

Further in Lee and Finn (2007), they found that both subspecies had three cinnamic acids and five flavonol glycosides but that the proportion of the individual polyphenolics differed between them. Neochlorogenic acid (3-caffeoylquinic acid), chlorogenic acid (5-caffeoylquinic acid), quercetin 3-rutinoside, and isorhamnetin 3-rutinoside were the major polyphenolics present in *S. nigra* ssp. *canadensis*. Chlorogenic acid and quercetin 3-rutinoside were the major polyphenolics in *S. nigra* ssp. *nigra*. Isorhamnetin 3-glucoside was present at low levels in *S. nigra* ssp. *nigra*. Neochlorogenic acid, cryptochlorogenic acid, kaempferol 3-rutinoside, isorhamnetin 3-rutinoside, and isorhamnetin 3-glucoside were identified for the first time in *S. nigra* ssp. *canadensis* and *S. nigra* ssp. *nigra* berries.

In an evaluation of the antioxidant potential of European elderberries to inactivate free iron radicals in human plasma, Halvorsen et al. (2002) surveyed a wide variety of fruits, berries, vegetables and grains in a typical Norwegian diet for their total antioxidant levels. While the study did not allow for statistical

differences to be assessed between the berry crops, they found that antioxidant capacity of ‘Samdal’ elderberry (3.37 mmol/100 g) was comparable to wild *Rubus idaeus* (3.97 mmol/100 g), cultivated ‘Veten’ raspberry (3.06 mmol/100 g), ‘Hardyblue’ (syn. 1613A) blueberry (*Vaccinium corymbosum* L.) (3.96 mmol/100 g), and ‘Corona’ strawberry (*Fragaria* × *ananassa* Duch ex Rozier.) (2.34 mmol/100 g). However ‘Samdal’ tended to have lower levels than those for wild strawberries (*F. vesca* L.) (6.88 mmol/100 g), wild blackberry (*Rubus nemoralis* Müll) (6.13 mmol/100 g), genotypes of black currant (*Ribes nigrum* L.) (7.3: Botany5 mmol/100 g), and bilberry (*V. myrtillus* L.) (8.23 mmol/100 g). Frank et al. (2005) concluded that the anthocyanins contained in European elderberries have a low bioavailability. More studies are needed to fully understand the relationship between elderberry chemical composition and the various effects reported.

#### **D. Ecological Value and Ornamental Potential**

The American and the European elderberries continue to have value in ecosystem management and restoration. They play an important ecological role in providing food, cover and shelter to a variety of birds and mammals (Hankla 1961; Worley and Nixon 1974; Coastal Zone Resources Division 1978; DeGraaf and Witman 1979; Elias 1980; Martin and Mott 1997; Rajchard et al. 2007). Some mammals will also feed on twigs and leaves. Their shallow root system can advantageously be used for stabilizing river banks. Their tendency to form dense thickets makes them good candidates as windbreaks along roadsides and farm fields (Paquet and Jutras 1996). Their hardiness makes them suitable as ornamentals well outside their natural distribution range.

#### **E. Markets and Production Costs**

Very little information has been published on the market potential and the production costs of elderberries and only general information is available (Charlebois and Richer 2005). Numerous products derived from the elderberries and the elder flowers are currently available in various parts of

the world. However, these few examples are not adequate to enable us to estimate the actual quantities of flowers and fruits that the market might be able to absorb. Accordingly, an economic study will be required in order to obtain a clearer picture of the quantities of elderberries processed worldwide. The nutrient value and the medicinal potential of elderberries can advantageously be compared to those of better known fruits such as strawberries, blueberries and cranberries. Moreover, elderberry production is not as demanding as any of the above. With the introduction of new cultivars and the publication of production guides it is to be expected that new products will be introduced in the years to come.

## **F. Processing**

Few studies addressed the potential effects of processing on elderberry derived product quality and much of them deal with the European subspecies. Nakatami et al. (1995) and Inami et al. (1996) have demonstrated that acylation confers a better light and heat stability to anthocyanins extracted from American elderberry compared to those extracted from European elderberry. Pigments extraction from elderberry pomace can be optimized by adding citric acid to the extraction solvent, which increases the efficiency of the extraction process and helps stabilize the pigments.(Kaack 1990b). Selection of cultivars with high vitamin C content along with reduced air exposure of the juice extracted should be considered as a mean to maintain pigment integrity during processing (Kaack and Austed 1998). As a rule, processing can impact negatively on phytonutrients such as anthocyanins and polyphenolics (Lee et al. 2002) thus further emphasizing the need to select cultivars with high phytochemical content.

In a detailed study on aroma composition and sensory quality of fruit juices processed from European elderberry cultivar, Kaack (2008a) and Kaack et al. (2005) showed the complex chemical composition and transformation of such juices. Kaack (2008b) also investigated the effect of temperature, liquid phase composition, and extraction time on the extraction of various chemicals from European elder

flowers. From the results obtained with his analytical technique, Kaack (2008a, b) proposed a consumer oriented selection of cultivars.

The effect of packing materials and storage time on volatile compounds in tea processed from flowers of European elder was also investigated. Kaack and Christensen (2008) demonstrated that the aroma of elder flowers is complex and that its chemical composition is affected by the packing material used and storage time.

## **VII. CONCLUDING REMARKS**

The production and transformation of elderberry fruit and flowers are established in Europe. With the demonstrated quality of its anthocyanins, and the ever growing body of evidence pointing to their health benefits, it is expected that elder production will increase in North America. The publication of an increasing number of studies on the chemical characterization of various plant parts from different elderberry species is likely to help breeders select elite cultivars. The continuing research on phytonutrients and their benefits to human health will probably play a key role in convincing both processors and consumers of the many advantages of elderberry consumption. Elderberries are easy to grow and offer a wide range of applications. With the release of new cultivars, as well as additional basic horticultural research, they offer a huge potential to seasoned growers and weekend gardeners alike.

## **LITERATURE CITED**

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