Chapter 17
Woody Ornamentals

Paul E. Read and Christina M. Bavougian

Abstract Woody ornamental plants are the backbone of massive horticultural industries. They provide the basis for the retail selling of plants through nurseries, garden centres and increasingly supermarkets and multiple retailers. Equally they provide the foundation for all urban, peri-urban and rural landscape designs. These are the horticultural products which bring pleasure, leisure and relaxation to populations worldwide. Here is a sector where impulse buying results in considerable price elasticity. Purchasing plants in the retail sector is a pleasurable event and not governed by cost. This chapter provides a major review of the science and technology which supports this sector of horticulture. It has developed very substantially over the last 50 years. Applied science and technology has provided whole new avenues for propagation, husbandry, nutrition, pest and pathogen control and vastly expanded the range of plants available. Realisation is now developing that some plants despite their attractiveness can become invasive, even noxious weeds. As a result, researchers have devised ways to create seedless woody ornamentals from plants that are weedy, invasive or produce toxic fruits, as was the case with the recently publicized fruitless 'Anna Bela' tung tree (*Aleurites fordii*) (Rinehart et al., Hort Sci 48:123–125, 2013). The future for woody ornamentals looks bright. Although there are challenges to providing plant materials that will meet the needs of customers, the woody ornamental industry will continue to grow and flourish into the foreseeable future, enriching the lives of future generations.

Keywords Woody ornamental · Leisure · Pleasure · Propagation · Multiplication · Pest and pathogen control · New crops

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Fig. 17.1 American redbud (*Cercis canadensis*) provides an attractive contrast to the ornamental textures and stature of Norway spruce (*Picea abies*). (Photo courtesy of Nebraska Statewide Arboretum, Lincoln, NE, USA)

Introduction

Nearly all plants that have cellulosic and lignified cells could be used as ornamentals. However, this chapter will focus on trees and shrubs that are not covered elsewhere in this Trilogy. Such plants termed as “woody ornamentals” may be considered for landscape uses to take advantage of their unique characteristics, including presence or absence of flowers and flower color; foliage color and morphology; plant form, including stature, shape and size; and textural features. Figs. 17.1 and 17.2 illustrate how flowering trees can interact with evergreens and can be used to frame attractive vistas.

Scope of the Industry

The United States is the world’s largest producer of (and market for) nursery crops with total gross sales of US$ 4.65 billion in 2006 (Anon 2007). The nursery and greenhouse industry makes up the fastest-growing sector of U.S. agriculture; gross grower sales are increasing at approximately US$ 500 million annually (Mizell et al. 2012). In 2002, nursery production contributed US$ 18.1 billion to the U.S.

Fig. 17.2 The pendulous branches and flowers of *Cladrastis* beckon the observer to travel along the path in this interesting landscape. (Photo courtesy of Nebraska Statewide Arboretum, Lincoln, NE, USA)

economy and provided almost 2 million jobs (Behe et al. 2008). Of total gross sales, 76 % was production of woody ornamentals including broadleaf evergreens, deciduous shade trees, deciduous shrubs, deciduous flowering trees, coniferous evergreens, palms, and other woody ornamentals, vines and ground covers (Anon 2007). An additional 7 % of total sales was attributed to propagative nursery materials, a portion of which should also be included here because much of the root-stock, lining-out stock, seedlings, tissue culture, and other products were undoubtedly woody ornamentals.

According to Mizell et al. (2012), "ten states account for more than two-thirds of all nursery-crop output in the U.S.: CA (20 %), FL (11 %), NC (8 %), TX (8 %), OH (5 %), MI (2–4 %), PA (2–4 %), and NY (2–4 %)." In 2006, the states with the largest area in nursery production were OR: 94,250 acres; NC: 48,454 acres, PA: 46,839 acres, MI: 45,886 acres, and FL: 40,706 acres (USDA 2007). California was not among the top five states for production area (even though it has the highest gross nursery crop sales for any state) because of what is grown there, i.e., high-value container-produced broadleaf evergreen plants such as azalea, boxwood (*Buxus* spp), *Euonymus*, and holly (*Ilex*)(Anon 2007).

Container production of nursery crops has increased in popularity in recent decades; currently well over 50 % of woody ornamentals produced in the U.S. are grown in containers (Hall et al. 2005). In 2006, 88 % of broadleaf evergreens, 77 % of deciduous shrubs, 59 % of coniferous evergreens, 50 % of deciduous flowering trees, and 47 % of deciduous shade trees were container-grown (Anon 2007). Containers provide many advantages over field (in-ground) production of nursery crops, including convenience of marketing and transportation, consumer appeal, product longevity, and establishment success after transplanting (Ingram et al. 1993; Gilman 2001). When field-grown plants are harvested, approximately 30 % of root area is lost or damaged, whereas containerized plants are sold with their root systems intact (Harris and Gilman 1991, 1993; Thomas 2000). Container production requires considerably less land than field production. Relative to field-produced ornamentals, containerized plants are easier to transport and suffer less injury during shipping and handling. Container-grown ornamentals therefore have a larger "window of marketability" for saleable plants, due to their improved longevity in the retail market (Mathers et al. 2007).

Field nurseries incur costs associated with labor and equipment needed to dig plants for sale that are not needed in container nurseries (Whitcomb 1984); however, container nurseries require more intense management. One reason for this is that their root systems, confined in containers with high surface area to volume ratio, are subject to greater temperature extremes and fluctuations than in-ground plants (Ingram et al. 1993).

Container production is overwhelmingly popular for certain types of woody ornamentals (most notably broadleaf evergreens and deciduous shrubs), but other categories still rely on field production (deciduous flowering trees and, especially, deciduous shade trees). Many of these trees are grown for the landscape industry, which often requires larger plant material than could be produced efficiently in containers (LeBude and Bilderback 2007).

Propagation

For the practical use of woody ornamentals as specimen plants or utilization in landscape plantings, economical multiplication of sufficient numbers to meet planting demands is a critical part of woody ornamental production and use. As noted in 2, huge numbers of woody ornamental plants must be generated in the U.S. alone, with an obvious concomitant need for similarly large numbers in other developed countries. Propagation methods may include, but are not limited to, the use of seeds, cuttings, grafting, layering and micropropagation (in vitro, or tissue culture) (Soyler and Khamer 2006). When asexual methods are employed instead of sexual (usually seeds), many advantages are accrued, including speed of production, circumvention or elimination of the juvenile phase, propagation of plants that do not produce seeds or that have seeds that are not viable, and taking advantage of characteristics that can be achieved by use of rootstocks. Efficiency of production and high product quality, including uniformity, are parameters requisite to choice of propagation method (Read et al 1986).

Seed Propagation

Seed propagation is the most ancient and often is the simplest of methods for propagation of woody ornamentals. Seed provenance, location of geographic origin, must be considered if collected from naturally occurring stands; source of seed must be considered in order to assure trueness to type (genetic fidelity) and freedom from contamination from pollen of undesirable genotypes. In many species, freshly harvested seed can be planted immediately following harvest. However, seed dormancy may prevent such an approach and special techniques must be employed to encourage satisfactory germination capability. Seeds such as *Ginkgo* may have immature embryos at harvest time, but the embryos of most seeds are mature when harvested. Simple cleaning practices can assist the propagator in realizing good propagation success.

Seed dormancy consists of several types. Germination may be inhibited by seed physiology, anatomy or both. If seeds are dormant immediately after harvest, they are considered to exhibit primary dormancy, whereas if external environmental factors induce dormancy, it is referred to as secondary dormancy. Whether seeds exhibit primary or secondary dormancy, if physiologically dormant, special treatments may be necessary. Seeds with under-developed embryos (e.g., *Fraxinus excelsior*) require an after-ripening treatment of 20–30°C for 3 months. High temperature after-ripening treatments are necessary for some palm seeds (38–40°C) for 30 to 90 days. Other types of physiological dormancy may be overcome by a moist chilling treatment referred to as stratification (Soyler and Khawar 2006). Examples include *Berberis thunbergii,* which requires 90 days at 0–5°C and *Malus* seeds need to be exposed to temperatures of 3–5°C for up to 60 days, depending upon species and cultivar.

Many woody ornamentals have hard seed coats that prevent imbibition of water, obstruct gaseous exchange or may physically prevent the embryo from exiting the seed coat. Such seed coats must be penetrated by physical or chemical means, a process referred to as *scarification*. Many woody ornamental members of the *Fabaceae*, such as *Cercis, Gymnocladus* and *Gleditsia*, have hard seed coats and require scarification. *Cercis canadensis* also exhibits double dormancy, that is, it requires both scarification and stratification. Another type of double dormancy is found in some *Fraxinus* species because they have immature embryos and also need to be stratified. Once seed dormancy requirements are met or if seeds are not dormant, seed sowing can take place in a suitable medium. Medium characteristics for container production are discussed under that topic, while seeds destined for field production need to be planted into an appropriate seed bed. For seed bed preparation, see Sect. 5.

Cutting Propagation

Propagation by cuttings involves severing a part of the plant from the parent plant (stock plant) and providing conditions that encourage regeneration of the missing parts of the plant. For example, when propagating by stem cuttings, stimulation of adventitious roots is necessary, while root cuttings require generation of a shoot. A critical component for successful propagation by cuttings is the condition of the stock plant; that is, cuttings should only be taken from healthy, disease-free parent plants that are true to the desired plant phenotype to be cloned. Types of cuttings that are used to propagate woody ornamentals include leafy stem cuttings, softwood cuttings, semi-hardwood cuttings, hardwood deciduous cuttings, hardwood evergreen cuttings and root cuttings. For successful propagation by cuttings,

Fig. 17.3 Close-up of a mist nozzle employed to mist leafy cuttings. (Photo courtesy of John Preece, National Clonal Germplasm Repository, USDA)

Fig. 17.4 Cuttings of a variety of woody landscape plants being rooted under mist in a commercial nursery. (Photo courtesy of John Preece, National Clonal Germplasm Repository, USDA)

environmental conditions must be provided that are conducive to production of the requisite missing plant parts.

For leafy stem cuttings such as softwood cuttings and semi-hardwood cuttings, because the leaves will be losing moisture through transpiration, high relative humidity must be maintained near the leaf lamina to reduce moisture loss related to transpiration. To provide the necessary high humidity, several methods may be employed. Perhaps the most common method is the use of intermittent mist. Such systems employ a time clock to control a fine mist spray of water applied intermittently, e.g., 15 seconds of spray every 30 minutes during the daylight hours (see Figs. 17.3 and 17.4). This timing may vary, depending upon species, condition of the cuttings, growth regulator treatment (if any), day-length, porosity of the rooting medium and ambient and root-zone temperature. Systems that provide fog, an atmosphere that is nearly 100 % relative humidity, are also commonly employed.

Fog may be introduced into an entire greenhouse or under a tent over a greenhouse bench. Some propagators use hand spraying of the cuttings, but this approach is labor intensive and difficult to maintain consistent humidity control. On a small scale, such as for home propagators, a pot with cuttings in its medium may be enclosed in a plastic bag. Another technique to reduce transpiration losses is to remove some of the leaves, or parts of the leaves, to reduce the amount of surface that will be transpiring. Hardwood cuttings usually do not require humidity modification until new leafy growth emerges from the buds on the cuttings.

Regardless of the type of stem cutting, application of an auxin-type plant growth regulator (hormone) to the base of the cutting may be useful. Although indole acetic acid (IAA) is the naturally occurring hormone in nearly all higher plants, because it is light labile, analogs of IAA are generally preferred for application to stimulate adventitious roots. Examples include indole butyric acid (IBA) and naphthalene acetic acid (NAA); either IBA or NAA, or combinations, are often found as the active ingredients in commercially available rooting powders or root stimulating solutions. Effective concentrations and methods of application vary with species, cultivar, type of cutting and environmental conditions under which the cuttings are being rooted. Some cuttings will root faster than those not treated, while others can be stimulated to (King et al 2012) root that are difficult or impossible to root without growth regulator applications. Most root cuttings do not respond to growth regulator applications (Blythe and Sibley 2012).

Examples of woody ornamentals that can be propagated by softwood cuttings include *Syringa* (lilac) and various maples (*Acer* spp.), while many *Rhodendron* and *Citrus* species can be rooted as semi-hardwood cuttings. Many species are propagated by deciduous hardwood cuttings (e.g., *Vitis, Cornus, Salix*) and evergreen hardwood propagation is commonly employed for *Taxus, Juniperus* and *Thuja*. Sumac (*Rhus* spp.) types and *Chaenomeles japonica* are easily propagated by root cuttings, as are many members of the *Populus* and *Rubus* genera.

Grafting and Budding

Propagation by grafting and budding (a form of grafting) is accomplished by the joining together of two plants or plant parts so that they will ultimately grow as one. Although grafting occurs occasionally in nature, grafting requires specialized skill on the part of the propagator and is generally both more labor intensive and expensive than propagation by cuttings or seeds. Therefore, grafting is employed for plants that are difficult to propagate by other means or to take advantage of characteristics imparted by the rootstock. The desirable upper portion of a graft is called the scion, while the lower part is referred to as the rootstock. When another piece of stem is included between the scion and the rootstock, it is referred to as an interstock or interstem. Interstocks are sometimes used to impart growth regulating effects on the scion or the rootstock, but often are used to overcome graft incompatibility of scion and rootstock as in the use of 'Old Home' pear interstem to overcome incompatibility between scions of 'Bartlett' (also known as 'Williams') pear and quince rootstocks.It is nearly impossible to mention all types of grafting, but a few worthy of note include the cleft graft, whip and tongue graft, approach graft, saddle graft, wedge graft and various types of bud grafts, such as T-budding and chip budding. Bud grafting is a more economical use of plant material and may be chosen if propagating material of the desired scion is in limited supply. Each technique requires different skills and may be the appropriate choice, depending on species, cultivar and even season of the year. Regardless of grafting method or type, it is critical for the cambium of the scion to be aligned with the cambium of the rootstock and that the union not be allowed to become dried out or attacked by insects or disease organisms. Many unique woody ornamentals are grafted in order to capture their unique traits, such as color sports and shrubs and trees with variegated leaf patterns. Details of grafting are covered more completely in other resources (Hartmann et al. 2010).

Propagation by Layering; Layerage

Layering, or layerage, involves propagation of a cutting while it is still attached to the mother plant. Mound layering is a commonly employed practice, although layerage is rapidly becoming supplanted by improved cutting propagation methods or by micropropagation. Mound layering has been historically used for propagation of clonal apple rootstocks, quince and *Ribes* spp. such as currants and gooseberries, but can also be useful for propagating some ornamental members of the *Rosaceae*. The method begins by planting a healthy stock plant in well-drained soil a year before propagation is to commence. In the spring of the second year, the mother plant is cut back to a few centimeters above the ground, where a few shoots will begin growth. After they have reached about 8–12 cm in length, sawdust, loose soil or other suitable medium is mounded to about half the height of the shoots, followed by a second mounding a few weeks later. A third mounding will usually take place in mid to late summer to about one-half the height of the shoots. The layered shoots usually will have produced adventitious roots by the end of the summer. They can then be removed from the parent plant and lined out in the nursery row, i.e., treated as transplants.

Micropropagation

As plant tissue culture technology has grown from its humble beginnings when Haberlandt (1902) reported on his attempts to produce plants in vitro, through the identification of indole acetic acid (IAA) a naturally occurring auxin (Thimann and Went 1934), and the discovery of cytokinins by Skoog's group (Skoog and Miller 1957), it soon became apparent that micropropagation, or propagation of plants in vitro, has become another powerful tool available to the plant propagator. The

Fig. 17.5 Proliferating shoot culture of *Hibiscus Moscheutos*. (Photo courtesy of John Preece, National Clonal Germplasm Repository, USDA)

process of micropropagation involves placement of small plant pieces *(*explants), somewhat like a miniature cutting, aseptically onto a medium designed to encourage axillary bud growth in vitro. Typically, the medium consists of various materials dissolved or suspended in water, including macronutrient salts, micronutrients, amino acids, vitamins, an energy source such as sucrose, and plant growth regulators. The medium is often gelled with a gelling agent such as agar, but some micropropagation takes place in a liquid medium. A great deal of research reports have been generated since the landmark publication describing what is today a standard medium, MS medium (Murashige and Skoog 1962). The primary goal is to enhance the growth and multiplication of existing meristems, usually axillary buds that are part of the explant. The balance of cytokinin to auxin content of the medium determines whether bud and shoot growth or root growth will occur. A high cytokinin to auxin ratio favors shoot growth, with high auxin stimulating root growth (Murashige 1974).

Commercial nurseries utilize micropropagation to produce large numbers of woody ornamentals. Examples include *Cercis*, *Hibiscus*, *Rhododendron* and *Berberis*, while research has continued on numerous additional species (e.g., *Acanthopanax*, Yang and Read 1997; *Acer,* Preece et al. 1991; and *Quercus*, Fishel et al. 2003; Fig. 17.5). In addition to manipulating the medium constituents and environmental conditions (Read 1990, 1992), methodology has been developed to encourage softwood out-growth from dormant stems placed in a forcing solution (Yang et al 1986; Yang and Read 1989; Fig. 17.6), while forced large branch segments of mature woody species such as *Quercus* and *Acer* have produced shoots from epicormic buds suitable for use as explant material (Henry and Preece 1997). An interesting recent development in studies of invasive plants has stimulated use of in vitro systems to create sterile (seedless) plants, thus making them non-invasive. Examples include ‘Lilac Chip’ *Buddleia* spp. (Zampini 2013 and *Euonymus alatus* (Thamina et al. 2011), the latter resulting from regeneration of triploid plants from endosperm tissues (Knapp et al 2001). For further reading on micropropagation,

Fig. 17.6 Woody stems of *Viburnum* x *rhytidophylloides* '*Willowwood*' being forced to promote softwood growth for use as explant material for micropropagation.

consider Cloning Plants—Micropropagation/Tissue Culture, a chapter soon to be published in the Encyclopedia of Agriculture and Food Systems (Read and Preece 2013).

Site Selection

Poor choice of the location where woody ornamentals are to be grown, whether commercially or for home landscape use, is perhaps the most common cause of failure. A suitable site must be in a location that has a climate conducive to healthy growth and development of the plant for its desired purpose. It must also provide appropriate levels of light (full sun for many species), water availability with good internal soil drainage and protection from environmental stresses such as extremes of cold or heat, drying winds or potential animal depredation (see Sect. 6). Low lying areas that can become frost pockets are undesirable and should be avoided. Since cold air is heavier than warm air, it will flow to the low areas where it is trapped and can cause damage because of the cold temperatures. The properties of the existing soil for woody ornamentals to be grown in the ground can be important, as is the composition of the medium for container-grown ornamentals. Water-holding ability; cation exchange capacity (the ability to hold and provide nutrients); soil reaction (pH); freedom from pathogens, insects and their eggs, weed seeds and toxic substances are also critical elements to consider when selecting a site for production of woody ornamentals. Studying the characteristics of the location to which the particular species is endemic can be instructive in determining the appropriate site conditions for that plant. Ease of access to the site for conducting management practices is also important.

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