Chapter 12
New Ornamental Plants for Horticulture

Kevin Seaton, Andreas Bettin and Heiner Grüneberg

Abstract Introduction of new plants is critical to the survival and profitability of the horticultural industries. These provide a marketing edge and can offer real benefits in terms of utilisation to fill special needs, such as providing screening a residential area from traffic noise, using living walls of plants, or providing an area to remove nutrient run-off from suburbia and prevent nitrification of sensitive wetlands. This chapter discusses the diversity of plants in the world's biomes from tropical, cool and warm temperate forests to deserts and alpine tundra environments. It covers a wide diversity of new plant material that includes the magnolia (*Magnolia* spp.), the Christmas poinsettia (*Euphorbia pulcherrima*), the conifers (pines, firs and cedars), the holly (*Ilex* spp.) to the diverse and unusual Australian and African xerophytic wildflowers such as the banksias (*Banksia* spp.), and kangaroo paws (*Anigozanthos* and *Macropidia* spp.). There has been a world history of discovery and selecting plants from known plant hot spots. This search started in earnest from the 1500s and continues to the present day with collectors looking to find new forms and colours and to introduce new qualities into established plants. It also introduces the developments in breeding new cultivars from existing genomes, including straight crossing to cellular techniques. Introducing a new plant is a complex process involving a number of steps from establishing a market, meeting production requirements to ensuring that the new plant survives and flourishes, often in a different environment to its native habitat and can involve use of greenhouse and chemical treatments. Considerable research has been expended on tailoring production management systems best suited to a particular plant given the diverse range of plant responses possible. This involves the development of propagation techniques such as tissue culture where cutting propagation fails, and the

K. Seaton (✉)
Department of Agriculture and Food Western Australia, South Perth, WA, Australia
e-mail: kevin.seaton@agric.wa.gov.au

A. Bettin
Faculty of Agricultural Sciences and Landscape Architecture,
University of Applied Sciences Osnabruck, Osnabrück, Germany
e-mail: a.bettin@hs-osnabrueck.de

H. Grüneberg
Department of Horticultural Plant Systems,
Humboldt-Universität zu Berlin, Berlin, Germany
e-mail: hgrueneberg@agrar.hu-berlin.de

G. R. Dixon, D. E. Aldous (eds.), *Horticulture: Plants for People and Places, Volume 1,*
DOI 10.1007/978-94-017-8578-5_12,

development of correct irrigationand nutrient scheduling to maximise production and manage growth stages. It also involves ensuring the plant achieves the level of performance expected in terms of vase life or yield and maintaining the right form and colour. These requirements are particularly critical where trade and transport is involved. An area often difficult to get right is to ensure that the new plant is actively protected, ensuring that the investment is properly rewarded and provides value to ensure continuation of further plant development.

Keywords Biomes · Production schedules · Marketing · Novelty · Diversity · New cultivars · Bedding plants · Cut flowers · Plant introduction · Intellectual property

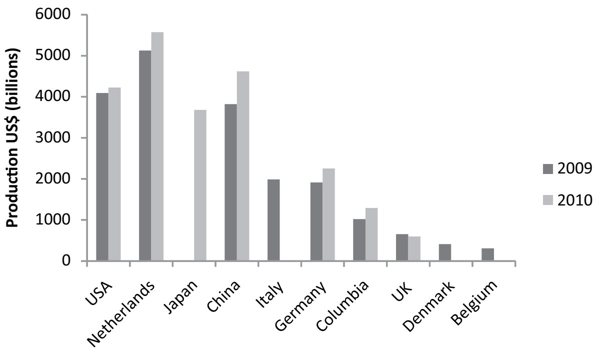
Introduction

Demand for nursery plants as container, amenity and cultivated crops has encouraged an increase in world trade in floriculture estimated to be worth between US$ 11 and US$ 60 billion in 2003 (van Uffelen et al. 2005). World floriculture trade in 2009 and 2010 was worth over US$ 24 billion (APIH/Union Fleurs 2011), with over half occurring in the Netherlands, USA and China followed by Japan, Germany and Italy (Fig. 12.1). Thailand, Malaysia, Singapore and India are becoming increasingly important export suppliers of floricultural crops (Hadiwigeno 1995).

As cities and towns become more crowded with high density living there is an increasing consciousness to utilise the free space of parks and buildings to improve their aesthetic value. This space can be inside or on top of buildings (such as roof gardens) or in the green open space found in cities and towns. Ornamental plant use can vary from potted plants in the home, to amenity plants along verges in parks and public recreation areas, plants in conservatories, on the roofs of buildings, formalised vertical garden walls on buildings, to field-grown flowers that provide cut flowers and foliage for use in displays in conventions and hotel foyers and vases in homes and hospitals.

Introducing the right new plant is complex, given the diverse range of plant species available and the wide range of selection characters that can be utilised. These include greenery plants with different coloured foliage, compact plants with natural dwarf characters as potted or border plants, e.g. box (*Buxus* sp. and other hedging plants), to plants with large showy flowers e.g. the red hibiscus (*Hibiscus rosa-sinensis*) and the hybrid tea rose (*Rosaceae*). Plants can also be grown *en masse* producing a magnificent display such as everlasting flowers (*Asteraceae—Helichrysum, A. lawrencella* and *A. rhodanthea*). Other opportunities are planting out contrasting beds using a range of kangaroo paws (*Anigozanthos* spp.) with stems varying in height from 0.5 to 1 m in height i.e. 'Bush Ranger' to stems to 2.5 m high of either red or yellow kangaroo paws. There is also available the striking black kangaroo paw (*Macropidia fuliginosa*). Other plants suitable for hanging baskets and floral walls, include climbing plants such as ivy (*Hedera helix*) or tall architectural

Fig. 12.1 Value of production of flowers and pot plants in selected countries using an exchange rate of US$ 1.357 to EUR (Source: Adapted from Association Internationale des Producteurs l'Horticulture AIPH/Union Fleurs 2011)



plants that command attention in the garden such as oaks (*Quercus* spp), various eucalyptus trees (*Eucalyptus* spp.) and the red flowering gum (*Corymbia ficifolia*), cone-shaped conifers and pines and the large flowered *Magnolia grandifolia*. There are also plants that provide a changing vista such as the Japanese maples (*Acer* spp.) with leaves that turn lime green, yellow to golden colours in the fall. Still other plants provide sharp distinct foliage such as the dragon plant (*Dracaena draco*)) or the variegated the canna (*Canna* x *generalis* hybrids) with large coloured flowers (Burke 2002).

One area that needs to be continually well managed to ensure that there is continuous funding for investment in breeding and developing new plant material is the protection of intellectual property rights (Dixon and Ogier 2007). This is a means of ensuring the science and effort by the breeder is rewarded although this can be difficult because intellectual property can easily be eroded. The establishment of international agreements, such as The International Union for the Protection of New Varieties of Plants (UPOV) and the development of intellectual property rights such as Plant Breeding Rights and Patents, are ways of ensuring this protection.

Plant Diversity

To fulfil the market need there has been increasing effort to secure new types and cultivars of plants. This has involved selecting new species from wild populations as well as breeding programs to improve existing cultivars and develop new ones. The world flora numbers some 282,000 species (Chapman 2009), and can be divided into a number of floral taxa or geographical areas each with a number of biomes or dominant forms of vegetation (biographical regions depending on climatic factors) that include tropical rain forest, sub-tropical forest, warm and cool temperate forest, desert, and tundra (Reich et al. 1997) (Fig. 12.2).

These can be broadly grouped into six biomes based on Fig. 12.2.

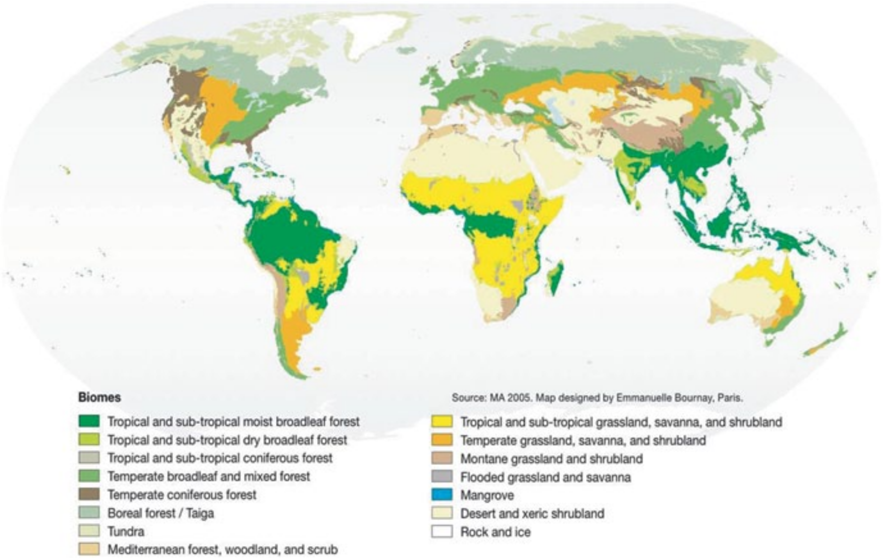


Fig. 12.2 The main biomes of the world. (Source: United Nations Environmental Program (GRID-Arendal UNEP), http://www.grida.no/graphicslib/detail/the-main-biomes-of-the-world_f8c1 Vital Forest Graphics, 2009. Rekacewicz et al. 2009)

- *Tropical rain forest*-in middle America and Gulf of Mexico, Venezuela, West Africa, South East Asia, far northern Australia. Ferns with high rainfall (2,000 mm) requirements throughout the year include Amazon basin of South America, the Congo basin of central Africa, Indonesia, and New Guinea.
- *Subtropical moist deciduous forest*-with less than 2,000 mm of rainfall in South America, in Central America and around the Caribbean, in coastal West Africa, parts of the Indian subcontinent, and across much of Indochina.
- *Cool temperate forest*coniferous trees (pines, firs and cedars) or mostly deciduous broad (thin) leaved evergreens that shed leaves in winter or examples of olive, holly, tea and eucalyptus) which have thick leaves resistant to water loss with rainfall over 1,400 mm in North Europe South America, South Africa, Europe, Asia (Iran, Taiwan, Japan) and Australia (Victoria and Tasmania).
- *Warm temperate forest*-Mediterranean woodlands and scrubland, a climate characterised by wet winters and dry summers, trees that have some xerophytic characters but where winters are not severe and plants are evergreen. These occur in the Mediterranean basin, Chilean Matorral, Californian chaparral, Cape Province, Southwest Australia with a high diversity of plant species dominated by broadleaf trees (oak woodland) and evergreen sclerophyll forests and shrubland including fynbos in South Africa and kwongan in Southwest Australia.
- *Deserts*-in New Mexico, Sahara (North Africa), Gobi (Mongolia and China), Kalahari (Angola), Patagonian (Argentina and Chile), Great Victoria, Great

Sandy and Simpson (Australia) and Great Basin and Colorado (United States) typically grow cacti and having < 250 mm of rainfall annually.
- *Alpine tundra*-subalpine forest occur near the north pole with winter 34°C and summers 3-12°C being warm enough in the alpine tundra for plant growth such as stunted plants like sedges, mosses and grasses when the surface layer of permafrost melts, rainfall and snow 150 to 250 mm.

There are also mountainous zones such as the Andes and Himalayas and grasslands steppes in Eurasia and across Russia, prairies of north America, pampas in south America and savanna grasslands in northern Australia, and the veldt in South Africa that complete the world bioms.

The diversity of habitats for plant growth is highest in the equatorial zones in tropical rainforests (Schmitt et al. 2010) and lowest in higher latitudes of the arctic zones with most ornamental plants selected from tropical rainforest or cool temperate zones. For instance, pines (*Pinus* spp.)*,* firs (*Abies* spp.) and spruces (*Picea* spp.) are selected from Europe and North America with the United States selling 25 million trees over the Christmas season and predicted to be sold for around US$ 800 million in 2011 (Euteneuer and Campbell 2011). These plants are well suited to a cool temperate climate and are able to withstand cold winters. Also the tropical poinsettia (*Euphorbia pulcherrima*) from Mexico and the South American rainforest are extremely important potted plants, sold in Europe over the Christmas season and as a garden plant in warm temperate regions.

Some notable examples of families of ornamentals that have been domesticated and grown around the world are:

- China and SE Asia, Costa Rica, Guatemala, Mexico, Panama, Peru and Ecuador feature hydrangeas (*Hydrangea* spp.); a popular ornamental plant with over 1,000 cultivars from 220 species originating mainly from Asia (China, Taiwan, Japan, the Himalayas, and Indonesia).
- China, Colombia, Latin America and the Caribbean prefer the magnolia (*Magnolia* spp.) with 245 species of which 48 % are in cultivation (Botanical Gardens Conservation International 2008). The cultivation of the magnolia appears to be adapted to a narrow temperature range growing best below 18 ºC with growth decreasing at higher temperatures (van Iersel and Lindstrom 1999).
- Himalayas and SE Asia are largely responsible for the Rhododendron (*Rhododendron* spp.) with 1,157 species (Botanical Gardens Conservation International (2007) that range from creeping plants to tall trees. The main centres of diversity originate in the mountain ecosystems of North America, Himalaya, Myanmar, Southern China and Europe, growing mainly on acidic soils in regions of high rainfall, high humidity and a temperate climate. Some 25 % of species are under threat (Gibbs et al. 2011) including the scented tender Vireya type rhododendrons.
- USA with the honeysuckle (*Lonicera* spp.) from southern United States and Mexico and the Chilean butterfly bush (Buddleia americana) from south eastern United States to Chile.

- South American poinsettias largely originate from Mexico and South American tropical forests and feature a range of coloured bracts (Barrett et al. 2009).
- Australian wildflowers include Geraldton waxflower (*Chamelaucium uncinatum*), Hooker's banksia (*Banksia hookeriana*), the red kangaroo paw (*Anigozanthos rufus*), Qualup bell (*Pimelea physodes*), scaevolas (*Scaevola aemula*), leschenaultia (*Lechenaultia biloba*) and the Cootamundra wattle (*Acacia baileyana*) (Horlock et al. 2000; Seaton 2005; Anon 2013a).
- South African flora include the proteas (*Proteaceae*), the restios (*Restionaceae*), cape grasses and reeds, and lachenalia (*Lachenalia* spp.).
- New Zealand species include the foxglove (*Hebe* spp.) and the New Zealand teatree (*Leptospermum scoparium*).
- Western and southern Europe, northwest Africa, and southwest Asia includes the European holly (Ilex aquifolium) which is drought and frost tolerant down to −15 °C.

In developing new plants for use by people for different places, opportunities exist to select from a diverse range of new plants from warm temperate and arid regions in Australia and South Africa when compared to well used tropical and sub-tropical ornamentals. Plants from these areas have evolved by adapting to a range of different and often harsh habitats of temperature, humidity, salinity, soil water limitations and space. In doing so they have produced some unusual plant forms, flower shapes and colours such as the Australian Qualup bell (*Pimelea physodes*) with has enlarged burgundy coloured bracts (Fig. 12.3), the smoke bush (*Conospermum* spp.) with smoky grey racemes, Oleria (*Helichrysum* spp.) with grey green soft foliage tolerant of coastal environments, the paper daisy (*Helichrysum bracteatum*) with large golden daisy flowers, *Atriplex* saltbush with glaucous spongy jagged leaves, the desert eremophila (*Eremophila glabra*) which is covered in white dense hairs and the diverse range of eucalyptus species with interesting fruit such as the mottlecah (*Eucalyptus macrocarpa*) with large showy red flowers and large white leathery leaves, the large red compound bracts of the waratah (*Telopea speciosissima*) and the small tough leathery leaves of the drought and frost tolerant rice flower (*Ozothamnus diosmifolius*). Also of interest are the large red flowers of the South African proteas (*Proteacea* family) with highly developed colourful bracts such as the King protea (*Protea cynaroides*).

In terms of the value of ornamental plant species to the consumer, their suitability and selection depends on their marketability and ability to adapt to different climates and habitats as well as conditions imposed by the man-made city environment. By careful plant selection and manipulation of the soil media and environmental conditions in the glasshouse it has been possible to grow an increasing number of plant species in locations distant to their origin where they perform well as ornamental plants. This has allowed the transference of germplasm globally to regions where these plants would not normally survive and give people the opportunity of enjoying the rich diversity of another country's native plants in their everyday lives.

Fig. 12.3 Western Australian Qualup bells (*Pimelea physodes*) flowering stems. (Photo courtesy of K. Seaton, Department of Agriculture and Food, Western Australia)

Ways to Source Variation in Plants

Plant hunting has been pursued from Europe, North America, Australasia, and Asia since the fifteenth century sourcing new plant forms for ornamentals, agriculture, horticulture and medicinal purposes. This has led to the collection of new plants in botanic gardens around the world particularly throughout Europe. Plant hunting has also provided new products that compliment diets, such the introduction of tea (*Camellia sinensis*) sourced from Asia, the Himalayas, Japan and Indonesia. Some notable early plant collectors were Hans Sloane (1660–1753) from the West Indies; James Cunningham (died 1709) to China; Georg Eberhard Rumpf (Rumphius) (1627–1702) the Moluccas; Sir Joseph Banks (1743–1820) Newfoundland, Labrador, South America, Tahiti, New Zealand, Australia, the Malay Archipelago, Hebrides, and Iceland; Francis Masson (1741–1805) and Carl Per Thunberg (1743–1828) to South Africa; David Douglas (1799–1843) to North America and Alexander von Humboldt (1769–1859) to Spanish America (Janick 2007; Fry 2009). The early botanic gardens were established to propagate and display a wide array of exotic plant material such as the Royal Botanic Garden, Kew in London where 7 million herbarium specimens included the collections of Charles Darwin (1809–1882), Joseph Hooker (1814–1879), David Livingstone (1813–1873), Ernest Wilson (1876–1930) and Joseph Berkeley (1803–1889), (Kew 2012). The Berlin Botanic Garden at Dahlem is another world class botanic garden with 22,000 living plants in cultivation (Anon 2010). An example of a special plant collecting expedition included those of Sir Joseph Banks (1743–1820), who accompanied James Cook (1728–1779) from 1668 to 1771 to the southern ocean, in HM Bark *Endeavour* which included Rio de Janeiro, in Brazil, Tahiti, New Zealand, and Australia where he collected many new plant specimens and gave them to Kew Gardens on his return from the expeditions (Gilbert 1966; Kew 2012).

Sourcing new forms of plants for commercialisation can be achieved either from plant selection from natural populations or by direct breeding.

Surveying natural populations In the first instance sourcing variation involves surveying natural populations to find different and unusual plants that are of interest to the ardent collector, botanist and nursery person for commercialisation. A rich diversity of plant species occurs around the world for instance. The Australian floral kingdoms contain 19,324 species that include flowering plants (18,706), fern and allies (498) and gymnosperms (120) (Chapman 2009) Significant designated biosphere reserves around the world now contain much of this diversity. Such plant material can be found in the south west of Western Australia, the tropical rainforests of North Queensland, South Africa's fynbos, the tropical rainforests of the Amazon basin in South America, and in California, USA. For example The Fitzgerald River National and Park Biosphere Reserve (Moore et al. 2001), on the south coast of Western Australia covers 329,039 ha and comprises only 0.2 % of Western Australia's land surface, but contains over 20 % of that State's plant species. This includes nearly 1,800 species of flowering plants, and some 75 plant species and offers a rich diversity of plants such as *Banksia* spp., bottlebrush (*Callistemon* spp.), feather flowers (*Verticordia* spp.), and the unique Qualup bell (*Pimelea physodes*). Similarly a rich diversity of plants exists in the Cape Biosphere Reserve north of Cape Town in South Africa and includes the fynbos. This park is 378,240 ha in size and includes ca. 8,900 flowering plant species, some 6,000 being endemic to the region. It includes a number of plants that have developed under harsh conditions such as Sea Guarrie (*Euclea racemosa*), Cape Hyacinths (*Lachenaliai bulbifera*), *Aspalathus callosa* and the Cape reed (*Restionaceae*). Cape heaths include the white to mauve *Erica caffra*, the red to pink *E. mammosa* and the red *E. coccinea*, as well as *Proteas, Leucospermums* and *Serrurias* such as *P. repens*, *P. cynaroides, Leucospermum conocarpodendron* and *Serrurias trilopha* that offer exciting possibilities for selection and domestication (Goldblatt and Manning 2000; UNESCO 2005).

Surveying natural populations involves a number of steps including locating populations, surveying the extent of variation, the collection and propagation of material, and evaluating the plants' performance in a cultivated environment. Locating populations can be done through existing databases that provide historical records of where specimens have been collected and preserved as herbarium voucher specimens. In Western Australia these records and some specimens date back over 100 years. Not always but often, these records have been updated by more recent surveys or from information from collectors or bush pickers. The next task is to select from these records a location for a species, obtaining appropriate licences and visit sites. This can be a frustrating process as often for such old sites the original flora have long since disappeared through settlement, disturbance or herbivore and weed infestation. Frequent visits are often necessary as different flora may dominate in different seasons. It is usually best to visit the site during the predicted flowering season for a particular flower. There is also the question of phases of dominance

Fig. 12.4 *Impatiens walleriana* hybrids ready for sale. (Photo courtesy of A. Bettin)

as one type of flower may dominate for a period to the exclusion of other flowers. Under temperate Australian conditions it may take a major event such as a bushfire to clean out competing vegetation and stimulate the germination of the plants being sought. For example, in Western Australia approximately half of the *Banksia* species in the family *Proteaceae* are killed by fire (Collins et al. 2009). Seed germination and seed dispersal are also stimulated by fire, while other species regenerate quickly re-sprout from ligno tubers (i.e. new growth from old surviving buds) and dominating recruitment.

Direct breeding The second source of domestication is the direct breeding of new plants using existing genetic diversity. This has been highly successful for a number of plants especially producing new roses. De Vries and Dubois (1997) show that the rose is the highest sold cut flower in the Netherlands with 499 ha being grown under glass and in the open in 2010 (APIH/Union Fleurs 2011), with chrysanthemums (*Chrysanthemum* spp*.)* and lillies *(Lilium* spp.) and gerberas in order of popularity. In the US pot plant industry the most produced indoor plants are orchids (13.3 million pots), poinsettias (7.6 million pots) and floral roses (5.6 million pots) and for annual bedding and garden plants, the *Impatiens* and New *Impatiens*–New Guinea hybrids (Fig. 12.4), as well as pansies and violas, petunias, begonias and marigolds were most popular (APIH/Union Fleurs 2011). Other flowers such as the camellia (*Camellia sasanqua*), carnations (*Dianthus* spp.), gerbera, hydrangea (*Hydrangea macrophylla*) and rhododendron (*Rhododendron* spp.) are also popular and have undergone considerable breeding to produce new

Fig. 12.5 Fields of cultivated Geraldton wax (*Chamelaucium uncinatum*) flowers in Western Australia. (Photo courtesy of K. Seaton, Department of Agriculture and Food, Western Australia)

cultivars. The *Impatiens*-New Guinea hybrids have become a very popular summer bedding plant similar to petunias (von Hentig 1995), and in general new cultivars of *Impatiens* have been more popular with 9 million pots sold in the US in 2010 (APIH/Union Fleurs 2011).

There have also been successes in hybridising Geraldton wax (*Chamelaucium* spp.) (Growns et al. 2000; Shan and Seaton 2009), teatree (*Leptospermum* spp.) and kangaroo paw (*Anigozanthos* spp.) from Australian wildflower collections. Some of these plants, such as Geraldton wax hybrids, are now being grown commercially as cut flowers in California, Israel and Peru as well as Australia (Fig. 12.5).

Breeding can involve simple crosses to more complex processes such as early embryo rescue and tissue culture to overcome dormancy restraints to germination. Breeding can also involve direct intervention to overcome pollen-ovary incompatibility when parents from wide species are to be hybridised. Somatic hybridisation techniques are being applied to *Chamelaucium* breeding to produce wide hybrids (Ratanasanobon and Seaton 2010). The breeder has the advantage of some control by selecting particular parents to determine the outcome of the progeny, although with native flora the outcome of crosses is not as predictable as rose breeding which has a considerably longer history.

Keys to Successful New Plant Introduction

Opportunities to develop new ornamental plants are immense with the vast and diverse range of the world's botanical heritage. Selecting and introducing the right plant for a particular situation is more complex. To be successful there are a number of requirements for new plant introductions (Table 12.1).

Marketability The first step is to determine the market needs of a new plant and how best to meet these needs. This information can be obtained from discussions with nurseries and the breeders to seek out sales statistics that with determine where and what is likely to sell. Questions are asked on popularity and why is it popular? Past

Table 12.1 Requirements for successful introduction of high productivity new crops. (Source: K. Seaton unpublished)

Development area	Requirements and considerations
Marketability	Offering new and exciting plant characteristics
	Filling a unique niche
	Promoting special features of new plants
	Maintaining sales and plant introduction schemes
Customer requirements	Need for novelty
	Continuity of supply
	Consistent performance
Production requirements	Ability to flower profusely if a flowering plant and the environmental conditions, and possible chemical treatments, are required to ensure they flower
	Suitability of form or is there a need to manipulate this by pruning or chemical manipulation to produce a suitable form
	Special water and nutritional requirements and agronomic intolerances
	Ease of propagation or are special techniques needed
	Resistance to pest and disease in the new environment
	Ability to withstand extremes of temperatures and weather when plants grown outdoors or indoors
	Restrained by short production time, especially if grown in heated greenhouses
	Type of specialisation—is the nursery specialised on the complete production of a few plants or specialised in certain steps of the propagation.(e.g. does a plant fit within a production program of the supplier
	Meeting environmental constraints to production in terms of poor soil texture, high nutrient loads and adverse pH, as well as temperature and water extremes. Especially in urban environments with associated pollution
Plant introduction schemes	Develop schemes to successfully introduce plants
	Evaluate the effectiveness of the introduction
	Possibilities of automated production (e.g. plant climbers need a lot of manual work, automated spacing difficult, uniform plant production necessary, low genetic variability)
	Royalties and the ability to protect the breeder of new plants, collection of royalties (this provides the supplier with an advantage that make the plant commercially viable to provide an advantage compared with competitors)
Trade requirements	Ensuring that during export cut flowers or pot plants maintain vase life and that dormant plants are primed to be flower evenly on arrival at their destination
	Ensuring plants are easily transported and maintain their quality on arrival at their destination through packaging and environmental conditions in containers
	Selecting plant shape to minimise freight costs and met the need for minimum dense packaging as required in Europe and Asia

success in an area can be used as a guide, but may not always provide the answer. The market niche needs to be carefully defined to determine where a particular plant can be successfully marketed. It requires determining the distinguishing feature of a plant, the end user requirements and where the plant will have the biggest impact on the market. For an established ornamental plant such as hydrangea or poinsettia, which has already a large established market, plant breeding is used to produce the new features such as inflorescence shape or petal colour shades while maintaining all the desirable features such as pot plant compactness, bract shape, and profuse flowering.

The end use of the plant, and in particular its functionality, is critical to its marketability. It may be best used as a bedding plant, pot plant, border or hedge row, or as a mass planting or as a feature plant or background greenery. In deciding on this use, account needs to be taken of the plants cultural and management requirements. Some plants are easy to manage while others may require more detailed management which may limit their use. For example some robust plants are best suited to hedge-rows or green-cover or use as focal point plants. These are generally hardy deciduous plants that once produced, will survive in the outdoors. For example the deciduous Japanese barberry or Thunberg's barberry (*Berberis thunbergia*) is a hedge-row plant tolerant of pollutants with over 30 cultivars available; including a reddish-purple leaves "Harlequin" and yellow "Aurea" forms (2012b, c, d) which have been successfully introduced into Europe as hedge row plants, green-cover or focal point plants. Originating in Japan and being deciduous, the Japanese barberry are much easier to manage than many other evergreen plants which can't survive outside the severe frost conditions of winter in temperate northern Europe. This illustrates that the horticulturist needs to be aware of the climatic conditions from where the plants come from and the need to modify that climate before they are introduced. Another example are the Australian native plants from the dry Mediterranean climatic region of Western Australia such as the Geraldton waxflower (*Chamelaucium* spp.) and banksia species such as *Banksia menziesii* and *B. prionotes*. Geraldton wax are hardy plants that have low water requirement, provide a long flowering period of 50 to 60 days and provide vibrant colours in late winter to late spring. In addition this plant has a level of frost and drought tolerance and is able to survive during hot dry summers (20 to 30°C) with minimal maintenance. Hence this species are suitable for dry climates of moderate temperatures but will not tolerate severe frost having evolved under a dry Mediterranean climate of cool wet winters and hot/dry summers. The Geraldton waxflowers are sold as cut flowers and exported to Europe, USA, Canada and Japan, and are becoming popular as amenity or garden plants in California, thriving as garden plants in San Diego (Fitzsimmons 2001; Wigand 2007; Walker 2010) such as the cultivar 'Matilda' (San Marcos Growers 2011; Ball 2013) and as border amenity plants in golf courses in California surviving through the dry summers.

In Australia, overseas and elsewhere, successful nursery businesses, *Plant introduction schemes* have been employed, which have been developed to maintain interest and continuity of product. This enables expansion of the market by continuous introducing new variants of a particular type of plant based around a specific theme i.e. hardy plants from Australia, or in the US where of the highly successful

Fig. 12.6 Potted poinsettia with cream and red flowered bracts. (Photo courtesy of K. Seaton, Department of Agriculture and Food, Western Australia)

poinsettia (*Euphorbia pulcherrima*) pot plant offers new colour forms (Fig. 12.6) (Ecke et al. 2004).

In 1985 the United Kingdom introduced HAPIE or the Hardy Amenity Plant Introduction and Evaluation scheme. This was based on the realisation that there were a large number of plants in existing botanic gardens that were unused or not realised by the nursery and garden industry. Through agreement between nurserymen, scientists and the Royal Botanic Garden, Edinburgh, the HAPIE Plants were developed to trial and develop methods to propagate, grow and evaluate these plants to introduce the most suitable of these plants into the nursery and garden trade (Dixon 1989). The Canadian scheme: University of British Columbia Plant introduction Scheme of the Botanical Garden (PISGB) was run by the late Bruce MacDonald at Vancouver Botanical Gardens and was very successful at bringing new plants to the garden, trialling, propagating and distributing them to local nurseries. These were sourced from plant enthusiasts and working with overseas collections and collectors. These plants included *Arctostaphylos uva-ursi* 'Vancouver Jade' and *Genista pilosa* 'Vancouver Gold' collected from Vancouver Island by E.H. Lohbrunner, and *Penstemon fruticosus* 'Purple Haze', a wild collection by Al Rose from British Columbia. New forms of orange flowered honey suckle (*Lonicera* spp.) 'Mandarin' hybridised by Wilf Nicholls, the *Clematis chiisanensis* 'Lemon Bells' from Korean seed 'Blue Ravine' were tested and promoted (Justice 2002).

Customer requirements One of the most difficult questions is working out what the customer wants in purchasing ornamental plants. This can often be gauged by introducing new plants to trade fairs and demonstrating the range and uses of a plant. Working groups are an effective way of achieving a consensus of new plants to introduce into the market. In 1981 Germany involved the cooperation of a large group of people including growers, botanical garden personnel, researchers and others concerned with plant development in the establishment of their working group (WG) New Ornamental Plants in seeking consensus of new plant material (von Hentig 1995). These working groups now exist in most of the developed world, where the exchange of information occurs on the performance of a large number of plants tested from numerous overseas collections. The participants regularly met to decide the best candidates to promote and work with in the following year. Working groups also support research institutions to conduct programmes to determine production and biological studies into ornamental plants. In Australia funding has been provided by the Federal Government by the Rural Industries Research and Development Corporation (RIRDC). This has supported many research projects in the development of Australian wildflowers. One project has been the Best Bet Program in which exporters collectively list crops of high demand that are undersupplied (Slater and Carson 2003).

However, to answer the question “does the plant have exciting and unique plant characters?” means often that plants must be sought from the more exotic climates. This has been used as a way of sourcing something new. This however can pose a number of challenges; namely, will these features of the plant, appeal to people in another city or country, and if they do will the introduced plant successfully fit into a new environment and be able to flourish under different climatic constraints.

New characters have been a driving force for many plant introductions. These include the new colours and forms of *Brachyscome multifida, Helichrysum bracteatum,* and *Lobelia erinus* from South Africa and *Scaevola* (*aemula*) originating from Australia, as well as *Impatiens*–New Guinea hybrids (von Hentig et al. 1995). Many members of the hydrangea family, such as *Hydrangea paniculata, H. macropylla, H. quercifolia and H. serrata* came originally come from tropical regions. Other examples include *Helichrysum bracteatum* which provides striking tall stems with large golden coloured compound flowers and *Scaevola saligna* which provides striking blue flowers. The particularly showy display of lobelia can be attractive as it cascades over pots and hanging baskets and can make a striking bedding plant. Introducing a new ornamental requires detailed work by the horticulturist to explore all the forms and shades of the plant to maximise the flower’s impact such as the different shades of colour which may have an impact on the market. This is best illustrated with the introduction of the hydrangea into Europe. These flowers have been successfully marketed for a long time and part of the reason is the wide flower choice available and the continuing development of new cultivars. In 2012 European different nurseries listed 18 to 32 cultivars for sale that included colours ranging from red, white, pink, pink/white and blue (Vandeputte 2012; Wiley De Nolf 2012).

In recent years new ornamentals were successfully introduced into Europe because of the following reasons:

Novelty In the late 1980s *Centradenia* (*Heterocentron*) *inaequilateralis* ‘Cascade’ was introduced as a bedding plant to Central Europe. It is a day-neutral plant which needs temperatures of 12 to 15 °C to induce prolific flowering (Friis and Christensen 1989). Because temperatures are well above this range in summer (i.e. 21 °C) the plants remain largely vegetative, losing potential market appeal during this season. These impact on sales and customers replace the plant for others, and then sales have to be reignited in the following summer. To achieve ornamental value of the plant throughout the whole season, selection and careful management should be provided for healthy vegetative growth over summer and sustainable flowering over winter. Similarly in the late 1990s a *Plectranthus* form was introduced and advertised to have a repellent effect against cats and dogs. It is still offered, but sales numbers dropped as internet platforms pointed out that the repellent effect is not as clear as promised. However, these example show clearly that customers buy plants not only for ornamental value but also for other novelty purposes such as being a repellent.

Production requirements To meet production requirements and to introduce a plant successfully requires an understanding of plant growth and development that includes methods to control growth, flowering and form manipulation so as to suit the market. For example, in the US, rose production is geared around Valentine's Day. These techniques are gained through a combination of experience and scientific endeavour. It also requires practical knowledge of the growing requirements, soil or potting media, temperature, light and shade regulation.

Ability to flower This depends on the environmental factors driving the phenological (vegetative/flowering) phases. Plants varying in their photoperiodic requirements regulate their flowering response to day length. This process is complex and can involve sensitivity to infra-red signalling (Weller et al. 1997). In addition plants may have specific temperature requirements which determine the rate at which flowering occurs. Flowering can also be promoted by application of hormones and fertilisers. This will allow early flowering to be synchronised to produce flowers ready for a special calendar day, such as Mother's day. Plants are either short-day (less than 12 hours), day-neutral or long-day (14 to 16 hours). For example, flowering in Qualup bell (*Pimelea physodes*) under short-day conditions (10 hour day length) can be promoted by a cool pulse for 2 weeks at 10/15°C followed by warm temperatures (24/12°C) (Seaton and Plumber 2004). This technique can then be used also for *P. ferruginea.* Another example is the marigolds which are obligate short-day plants requiring day length shorter than a certain critical length to flower with some being facultative flowering faster with shorter days. Whereas the snapdragon, sunflower, salvia, and petunia are considered long-day annuals, other plants such as the zinnia are day-neutral with flowering not being affected by day length. There can be considerable variation in photoperiod response between cultivars and the grower needs to recognize the response of individual cultivars to match display and location requirements. For many bedding plants the use of black cloth may be necessary to initiate flowering. Other techniques available are to produce plants ready for planting by providing black cloth in the case of short-day plants supplementary high pressure sodium lights (HPS) if plant plugs are grown during winter in heated glasshouses during the last 2 weeks before transplanting (Cox 2009). Research has shown that there can be side effects of supplementary lighting such as extension growth which may need to be controlled to retain plant compact form.

Plant form Having the right shape of plant is critical to the range of uses plants can be put to in the landscape. Plant form such as height and bushiness can be manipulated by chemical application, pruning and pinching strategies. For example Geraldton wax, which is normally grown as a cut flower producing long stems, can be shortened and made more bushy with more flowers per plant by application of the growth inhibitor paclobutrazol (if permitted) while cytokinin 6-benzylaminopurine (if permitted) can reduce plant height but does not increase flower numbers (Seaton et al. 2007). Other approaches are to manipulate plant gibberellin biosynthesis genetically to control plant height (Bhattacharya et al. 2010).

Fig. 12.7 Zamio (*Zamioculcas zamiifolia*) leaf cuttings being propagated (left) and at 32 weeks ready for sale (right). (Photo courtesy of A. Bettin)

Propagation Each plant presents a challenge. There are several methods available including seed, vegetative cuttings, and tissue culture. The most appropriate method needs to be selected for each species as in the case of the single species of Zamio (*Zamioculcas zamiifolia*) (Fig. 12.7). The Wollemi pine (*Wollemia nobilis*) has been a success producing many plants by tip cuttings and is sold as an ornamental plant around the world (Trueman and Peters 2006). The use of *in vitro* propagation techniques has rescued the endangered *Rhododendron maddenii* from the Himalayas (Kumar et al. 2004) and the use of vegetative techniques saved the threatened pencil cedar (*Juniperus procera*) (Negash 2002). The application of biotechnology that includes innovations in tissue culture micropropagation technology has the potential to preserve and produce a number of valuable plants for floriculture that include Christmas Bells (*Sandersonia aurantiaca*) (Finnie and van Staden 1989), the artificial seed encapsulation; transgenic technology for *Pinus patula* (Jones et al. 1993; Jones and van Staden 1995; Sparg et al. 2002; Malabadi and van Staden 2005) and Nigro et al. (2004) and agriculture as in the case of the rare South African plant *Lapeirousia silenoides* (Louw 1989; Moyo et al. 2011).

Cultivation schedules Successful introduction of a plant into an environment requires the development of an effective production schedule. This requires that the timing and type of treatments applied result in a successful display as a bedding or pot plant. The schedule must take account of the climate, soil medium, position or aspect the plants are grown in and any stress factors that may impinge on the plants' survival and display. Successful schedules have plants flowering or fruiting in time for the market.

Water and nutritional requirements The essential features of water requirements depend on the plant and the environment in which it grows. The need for water and nutrients can be greatly influenced by the media in which the plant is to be grown. The drainage, slope and clay or percentage organic content of the soil in which the plant is grown have a large bearing on the success of cultivating the new plant. On sandy plain soils in Western Australia that contain less than 5 % water-holding capacity, special irrigation and fertiliser management techniques have been developed for growing the wild waxflower (*Chamelaucium* spp.) in Australian plantations (Seaton and Poulish 2010). This has resulted in yield increases of 30 to 45 % (Seaton et al. 2007) and allowed large scale sustainable cut flower production. In some cases it may be necessary to introduce new soil media more suited

Fig. 12.8 Roof garden containing a range of Sedum pp. (Photograph courtesy of A. Bettin)

to a particular plant. Reclaimed gardens set up on waste land pose a particular challenge and may require special amelioration to make them suitable for ornamental plants. Another special consideration is roof top gardens where soil depth is limited, or where containerised plants have been established in shopping malls. The presence of green space in cities has been found to make important contributions to the sustainable development of urban and peri-urban communities by improving the environment and contributing to conservation and helping to reduce global warming, remove pollutants and reducing dust and carbon dioxide, as well as reduce sound while reducing stress levels of city dwellers (Aldous 2007). The inclusion of ornamental vegetables, medicinal and aromatic plants have also been known to benefit city communities (Arslan and Yanmaz 2010). Development of roof top gardens (Fig. 12.8) requires special attention to be sustainable, choosing the right plants such as sedum (*Sedum* spp.) to tolerate the more severe conditions as well as species of *Zoysia matrella, Verbena* hybrids, *Thymus vulgaris* and *Targetes* sp. (Sendo et al. 2007). The sedum species have been known to survive on shallow substrates on roof top gardens in Germany (Monterusso et al. 2005).

Environment The environment plays a crucial part in the growing of ornamental plants, particularly the right temperature and light conditions suitable for flowering. For instance, to grow Geraldton wax in Europe would require careful manipulation of local temperatures to ensure that the plants flower. Alternatively, these plants could be grown in a warmer climate such as Portugal or Spain then transported to Northern Europe. Figs. 12.9a and b demonstrate the appropriate internal and external temperatures that initiate flower development of Geraldton wax. Production involves a 16 month life cycle to produce plants of sufficient size and flower cover.

Special case environments Many landscapes pose a challenging environment for growing plants. Within a city environment the thermal mass of buildings, roads and pavements introduces a heat load and with traffic the air can be higher in carbon dioxide carbon monoxide, sulphur dioxide and nitrous oxide levels as well as altered light levels. All these features can affect plant growth and development in confined areas. In these situations careful design of gardens is needed to cope with or maximise the benefits of these environments. There are many good examples of successfully domesticating plants for people in cities where plants can improve environments that pose a challenge from extreme heat from radiant heating or from

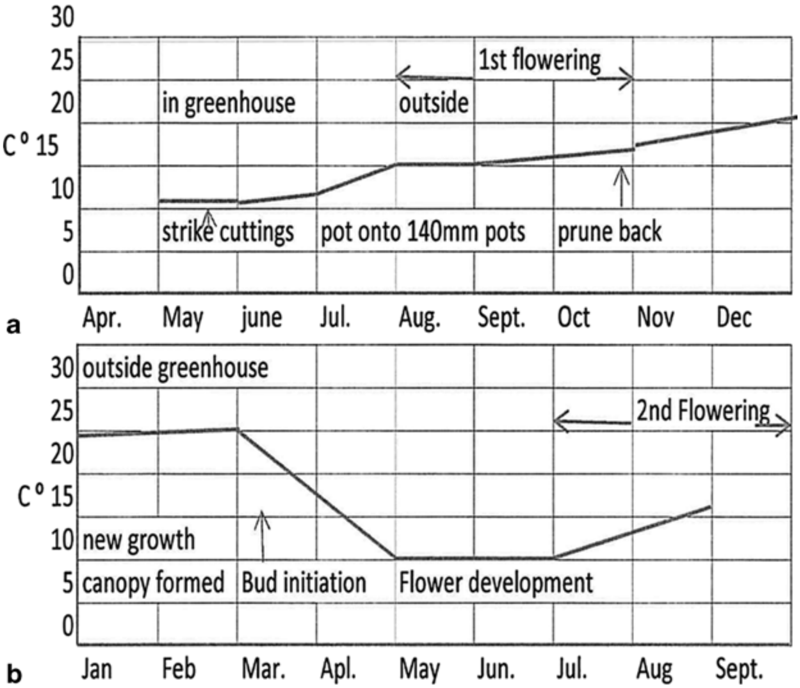


Fig. 12.9 **a** and **b** Production schedule for producing Geraldton wax pot plants in the northern hemisphere. (Seaton unpublished data 2012)

the effects of wind Exposure to salt in seaside environments is another consideration where special plants find purpose. Plants can also be used to moderate climate in indoors, roof greening and green wall buffer environments.

Trade requirements It is critical that plant quality is maintained during transport to markets. This may require special packaging and post-harvest conditions, to ensure that the quality of plants is preserved. It is also essential that all trade/quarantine conditions are adhered to ensure the smooth flow of product to the market. Plants should be clearly labelled and have all necessary paperwork completed prior to transportation. It is also essential that freight costs are minimised to retain profits prior to and during transit.

Plant Production Systems—Some Case Studies

Bedding and pot plants The major advantages of bedding plants are that they are transportable, capable of being grown in one place, easy to grow using natural light and space, and can be readily transported to the point of sale, such as a city market where they are not normally grown. Transport may involve rail or trucking across country or overseas sea transport unless not allowed due to the presence of soil (like potplants or beeddinplants) such as bring plants with soil into the EU from other countries. In many Asian countries, such as the Philippines, they grow and ship large quantities of orchids to Europe and Japan. Further the availability of cheap land and labour and resources in India have enabled this country them to be competitive in the production of orchids, *Anthurium* spp. and carnations (Dadlani 1995).

With all plant production processes a production schedule needs to worked out to be successful. The production schedule needs to fit into the current conditions of the production region especially if the plant is to be grown outside its home environment. The production schedule requires a detailed understanding of seasonal conditions and managing plants to work within those conditions. The same applies to Europe where one is adapting plants from warm temperate to tropical environments. Operational options available to meet these environmental restraints include growing plants in heated houses for part of their life cycle during winter then taken outdoors during summer. One example is the *poinsettia* (*Euphorbia pulcherrima*), a very popular Christmas flower with 7.6 million pots produced in the United States in 2010, 25.9 million in Germany in 2008 and 6 million in Sweden in 2010 (AIPH/Union Feurs 2011) and one nursery in the United Kingdom that produces 220,000 plants a year (Daily Mail 2011). Poinsettias are also much sought after in Europe because of their red bracts and green foliage with many colours and forms available on the market (Ecke et al. 2004; Barrett et al. 2009). To produce these tropical plants in cool temperate regions relies on a production schedule in a heated glasshouse timed to achieve full display over the Christmas season. To achieve this, softwood cuttings are taken in spring-summer. These cuttings will root in 10 to 14 days, under ideal conditions, after sticking into a propagation mix. Rooting can be more uniform with the addition of rooting hormones such as indole-3-butyric acid. Applying growth regulators such as paclobutrazol, chlormequat or ethephon can retard elongation and make for more compact plants (Ecke et al. 2004). Grow young plants in a warm (15–20 °C) humid environment. Pinching-back plant material may also be necessary to maintain a compact form and combined with short days will induce flowering. Plants should not be overwatered and need to be transferred out of the glasshouse over summer, then returned to the greenhouse until Christmas in the northern hemisphere or remain outside in the southern hemisphere until Christmas. High light tends to intensify the colour of the bracts.

Other operational successes have been with *Hydrangea paniculata, H. macropylla, H. quercifolia and H. serrata* which originated from the wet tropical regions of Costa Rica and Ecuador and need to be carefully managed within the cool temperate conditions of Europe, where the severe winters may decline down to −20 °C. Hydrangea production takes two seasons to produce a flowering plant and is achieved over two stages. The first stage involves taking semi-hardwood cuttings in greenhouses from April to May in the northern hemisphere. The plants are potted on and grown outside from May to October in containers to develop plant structure, then returned to the greenhouse over winter. The second step occurs in the following year where plants are grown in a greenhouse to achieve early flowering (March to May in the northern hemisphere) to set flowers over July to August before temperatures drop in winter (Morel 1999) The plants are then ready for sale for Christmas.

By this process consumers are able to buy plants in full flower and enjoy these as potted indoor plants over the Christmas season.

For other plants the process is less complicated as production is completed within one year as in the case of annuals such as pansies. The plants are propagated from seed in April to May, and the seedlings potted on the heated greenhouse until June to July. The seedlings are then either planted up outside for a display, held in the greenhouse or moved back into the greenhouse in August to September to flower and to be sold.

Cut flowers In recent years a number of native Australian warm temperate cut flowers have been introduced into Europe and the US and include examples such as pink mulla mulla (*Ptilotus exaltatus*) which has large tapered pink-mauve flower spikes and is used as a bedding plant, pot plant and cut flower (von Hentig 1985) in Europe. Ptilotus "Joey®" was released by the German seed breeding company Benary (Degraaf 2008) onto the European market. *Ptilotus* species originate from the central Australian desert and north-west Western Australia and have been successfully grown in Europe by carefully adapting their production schedule to the different conditions. As such they will crop within approximately 12 to 16 weeks from sowing (Degraaf 2008). To achieve a summer flowering target of June through to August seed is sown and grown at 21°C in April of the same year for pot plants (Fig. 12.10a) or in November of the previous year for cut flowers (Fig. 12.10b) when grown under greenhouse growing conditions. Supplementary lighting may need to be applied in winter to extend day length and surface heating applied to 22°C to encourage growth in central Europe. These plants are ready for pricking out and potting on into large pots and then planted out for a summer flowering (von Hentig et al. 1995)

Introduction of warm temperate plants to Europe In recent years the introduction of ornamentals into Europe has to be planned and scheduled with precision. Most young or emerging plant companies in Central Europe undertake extensive breeding and testing to avoid negative feedback from their customers. Two world-wide examples of the extent of this planning shows on the development of vegetative propagated petunias and verbenas, as well as angelonia (*Angelonia angustifolia*). The numbers of these new species and hybrids became so vast in the 1990s that the Chamber of Agriculture in Germany advised customers on how plants could be arranged and managed on balconies. A concept involved horticultural companies providing their colleagues with early planted balconies of these species to demonstrate to the customers how their balcony plants could provide early flowering after the summer holidays. Similarly, several companies dealing with young plants took the innovative step of looking for perennials and small shrubs, where the leaves have a decorative value (variegated and coloured), and put them together in series for autumn plantings. Plants with berries and late flowering species have been added as well as grasses. The early flowering cultivars of Christmas rose (*Helleborus niger*) and the eastern teaberry (*Gaultheria procumbens*) have become popular for autumn production over the last two decades. These plants also offer the producer a saving in heating costs. To extend the bedding plant season in Europe, a number of plants for late winter and early spring have been tested and introduced into the mar-

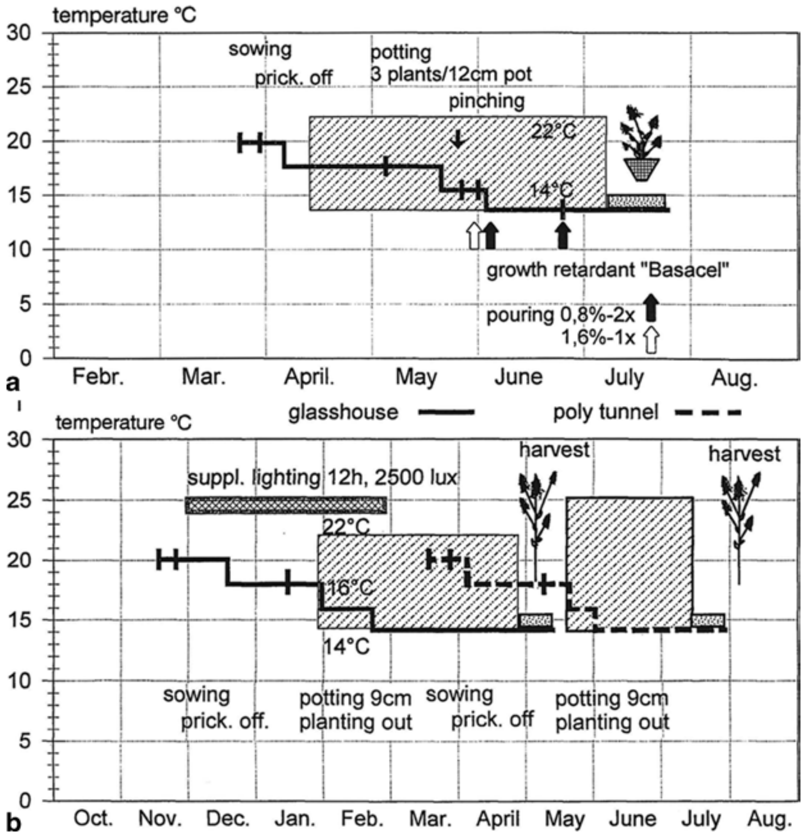


Fig. 12.10 **a** Cultivation schedule for small pot plants of *Ptilotus exaltatus* Nees **b** Cultivation schedule for small cut flowers of *Ptilotus exaltatus* Nees. (Source: von Hentig et al. 1995)

ket. These include the bedside bulbs, pansies (*Viola tricolour*), primrose (*Primula vulgaris*) and early flowering perennials such as *Aquilegia* cv., *Tiarella* cv., *Lewisia cotyledon*, *Pulmonaria* sp., *Armeria maritima*, *Astilbe* cv., and *Saxifraga x arendsii*. While the number of new types of bedding plants is vast, the selection and number of seasonal indoor plants offered for the Christmas season has been relatively small in Europe. The market still has potential for new material and is largely dominated by the red and white colours of the poinsettias, hippeastrums and hellebores.

In Europe the introduction of new permanent indoor plants and plantings has also been limited. However, some very successful examples can be cited. These include the new spiral form of *Dracaena sanderiana*, and *Zamioculcas zamiifolia,* a tropical plant from Africa, that was introduced from Dutch nurseries in the mid-1990s and has exhibited good tolerance to drought and low light, and is relatively resistant to a range of pests and pathogens. Although their flowers last for more than a week the flower is insignificant. These plants in the first decade of the new millennium have emerged as important pot plants.

Introduction of warm temperate plants to the Mediterranean region Introducing warm temperate plants into the Mediterranean-type countries of Australia, South Africa, California and South America has been an easier task. Here the major consideration has been to develop systems that ensure the plant can cope with extremely dry conditions, often experienced over summer. In Mediterranean environments high saturation deficits can be frequent and rapidly dry out plants in pots. A responsive irrigation system is critical to prevent this occurring. The use of soil moisture sensors has been very effective in controlling irrigation variables of timing, amount and frequency. Examples of amenity plants that have been successful in these locations are the *interspecific hybrids* between *Chamelaucium uncinatum* and *C. megalopetalum* which have been bred in south west Western Australia and has been grown successfully in California as an amenity plant (San Marcos Growers 2011), where it enjoys a similar climate to Western Australia and tolerates the hot summers and infrequent rainfall. The Geraldton waxflower (*Chamelaucium uncinatum*) is one of the main Australian wildflowers to be grown for cut flowers and sold on the domestic and international markets with many new cultivars becoming available (Helix Australia 2014)

Urban Environments

In the urban landscape a number of ornamental plants have been found to be environmentally valuable in providing climatic amelioration to courtyards, street scapes, roof gardens, balconies, walls and pavements to enhance the use of these inner city spaces and increase building value. Defining the best use of these plants is critical. This will determine whether a pot plant, amenity or bedding plants, or cut flower are most suited and the way they enhance the experience of people living in urban locations. For example, the use of conifers, such as the *Abies* spp., *Cedrus* spp. have value in providing a focal point within an urban landscape or dwarf forms used as hedging plants.

Roof gardens Another way to use plants in an urban environment is in development of roof gardens that can enhance the quality of limited space. These can cover the whole roof with plant materials such as turf, or planter boxes to display different foliage colours or seasonal flowers. Roof gardens have required engineering solutions as well as innovative approaches in the development of suitable planting media that include substrates with superabsorbent polymers, and irrigation systems. One notable development has been the use of specially designed and blended growing media which has a suitable water-holding capacity (WHC) and air-filled porosity (AFP), and the use of organic fertilisers. The design of green roofs have been well established in Germany (Lösgen 2008) with prescribed Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V. (FLL) guidlines developed originally by The German Landscape Research, Development and Construction Society. Development of technology to produce sustainable green roofs is becoming increasingly important in other countries including USA and Australia.

There are a number of requirements for plants to perform in roof gardens including their ability to withstand heat and high temperatures, and exposure to pollutants and wind. Plant survival can be compromised by a shallow soil media. Changes in temperature and shading may affect flowering. The increasing use of plants to trap and absorb both run off and pollutants in inner city parks has been seen as a new and valuable use of plants. The incorporation of a waste water treatment system that passes through a well designed garden allows for community use and filtering of an otherwise source of pollution. For example the creation of absorption beds connected to run-off areas within street scapes involving hit and miss paving where porous areas with turf grass to allow storm water to infiltrate are connected to a reed bed before entry into the groundwater. Horizontal and vertical filtration beds with gravel and macrophytes typically with members of the *sedge* family (*Cyperaceae*), can also accommodate plantings of reeds such as common reed (*Phragmites australis*) and Giant reed (*Arundo donax*) and members of the rush family (*Juncaceae*), as high nutrient absorbers that remove nitrogen, orthophosphates, ammonia and total soluble salts (TST) and pathogens (Mink et al. 2002). Other macrophytes such as *Baumea* spp., *Juncus* spp., and *Cyperus* spp. are effective in removal of phosphorus and prevent their transport into rivers or lakes where they can cause algal blooms. These systems have been employed by the Melbourne City Council in Victoria, Australia to manage nutrient inflows to the Ramsar Edithvale-Seaforth wetlands in the Port Phillip and Western Port Bays (Melbourne Water 2013). Floating reed beds on Gold Coast, Queensland, are also used to manage high nutrient levels (Anon 2013b).

Living wall gardens There is an increasing use of plants as living walls that have been shown to provide environment benefits, such as noise barriers, aesthetics, wind, pollution, and insulation of buildings when used in association with these structures and do contribute to the longer term sustainability of the urban environment. These can take the form of trees such as the Australian native plant drooping she oak (*Allocasuarina verticillata*) or *A. cunninghamii*, the *Melaleucas* and *Grevilleas* as well as the woolly bush *(Adenanthos sericea).* All make excellent barriers depending on the height to be screened or as a plant growing on artificial structures. In the case of a vertical greening system plants such as common ivy (*Hedera helix*) creepers (Ottelé et al. 2010), aromatic plants such as the true myrtle (*Myrtus communis*) and the Australian native lilac (*Hardenbergia comptoniana)* all make good natural barriers and can soften a building's facade. Stress tolerant plants such as those from the Mediterranean region can be more successful in reducing the energy requirements in managing these plants.

A number of plants have been introduced into Australia from overseas as hedgerow plants or as green cover. The red barberry (*Berberis thunbergii*) is a native to Japan and eastern Asia, generally hardy, deciduous and tolerant of pollutants. There are well over 30 cultivars available of *Berberis thunbergii* including a reddish-purple leaved "Harlequin" and the yellow "Aurea" forms (Missouri Botanic Gardens 2012, Vandeputte 2012, Wiley De Nolf 2012). The red barberry grows 1 to 1.2 m and tolerates cool temperate conditions and has proven to be very popular plant in Europe.

Indoor environments These conditions require careful choice of plants that tolerate low light and dry conditions of low humidity produced by air conditioners. Many rainforest plants such as the dumb cane (*Dieffenbachia* spp.) are suitable as indoor plants. However, to overcome the low light conditions it is necessary to rotate or replace plants in the indoor environment to maintain their longevity. This can be done on a programmed basis with the plants being grown outside or in heated glasshouses and then moved inside for a period. in winter. enabling plants to survive an environment where they would not normally grow.

Cut flowers People across the globe have enjoyed a wide range of Australian native flowering plants, often available through the cut flower trade. Such plants may be grown in their native country or countries with similar climates and then airfreighted to destinations sometimes with a considerably different climate, or to fill in during the opposite growing season in either hemisphere.

Many native Australian flowers grow best in mild winters (2 to 18ºC) and warm to hot summers (24 to 35ºC). These plants grow mainly on sandy or friable soils in the field on a broad scale making them more economical to grow in comparison to greenhouse grown material. The main cost is the freight that contributes approximately a third of the cost. The main flower species are Geraldton waxflower (*Chamelaucium* spp.), *Banksia* spp. and the kangaroo paw (*Anigozanthos* spp.), with the major foliages being Christmas bush (*Ceratopetalum gummiferum*), emu grass (*Podocarpus drouynianus*) and koala fern (*Caustis blakei*).

Considerable research has been expended on selecting, breeding, and maximising production and postharvest quality. Each species has been shown to have specific production and postharvest requirements. In terms of selection and breeding there are now over 100 cultivars of Geraldton wax which have been produced from natural populations and cultivars developed as well as deliberate crossing within species, between species and also between genera.

The production requirements for Geraldton wax include:

- Need for short days and cool temperatures (10°C) to flower
- Propagation from cuttings
- Production of long stems and terminal flower heads
- Low susceptibility to pests and pathogens, or methods available to treat pests and pathogens and
- Good vase life and respond to an allowable anti-ethylene treatment.

In order for growers and exporters to achieve the best production of quality flowers a number of manuals and technical notes have been produced. For example the Production of Premium Waxflower by Seaton and Poulish (2010) and the Banksia Production Manual by Parlevliet (2009) document every stage in the production system from selecting the right growing mix, propagating quality plants, and appropriate nutrition, irrigation, pest and disease management and postharvest treatments. These documents are themselves a form of intellectual property and some producers are protecting these by copyright, where sufficient novelty is apparent by patents (Dixon and Ogier 2007).

Reinventing Plants for Novel Uses

To capture the market, plants not only need to be produced environmentally, and economically but also need to be well publicised (von Hentig 1995). Often plants are reinvented to suit the market. It may not always be necessary to breed new cultivars but rather show new uses for an old previously popular cultivar. For example pansies (*Viola tricolor*) and scaevola (*Scaevola coriacea*) have been used as potted plants in providing a kaleidoscope of colours in a landscape setting. However, by combining different colours in larger pots to represent a theme, e.g. a country's flag during an exposition, it is possible to provide a whole new impact. In addition, by combining plants of different heights, textures and colours an immediate visual effect can be achieved.

Intellectual Property Considerations

To ensure the continued maintenance of plant quality, there is a need to protect intellectual property and safeguard investment providing return to the plant breeder (Dixon and Ogier 2011), the industry has developed the International Union for the Protection of New Varieties of Plants (UPOV Convention http://upov.int). The protocols of UPOV were adopted in Paris in 1961 and revised in 1991 (UPOV 2012). The member countries, of which Australia is one, have agreed to adhere to the principles of plant protection for the benefit of society to ensure that any new cultivars are afforded protection. This protection can also be afforded, depending on the country, by some form of Plant Breeder Rights (PBR) or a patent. For instance, within Australia a PBR is used to protect new cultivars that are distinguishable, uniform and stable (IP Australia 2012). PBR involves an application that describes the origin, parents, and a field examination that compares the new strain with similar cultivars. Results of successful PBR are published in the *Plant Varieties Journal* (IP Australia 2012). The collection of royalties that provide for an ongoing income stream for new cultivars for breeding and development may involve a pot plant levy placed on the plant material together with a licensing agreement for a nursery to produce the plant material. The World Trade Organisation (WTO 2012) and World Intellectual Property Organisation (WIPO 2013) provide the legislation to protect intellectual property rights and investment in a new cultivar and encourage global trade (Dixon and Ogier 2011). Other approaches to offer protection of new cultivars has been the use of devitalisation techniques to render the stems unable to be propagated as a quarantine requirement to keep out foreign diseases (DAFF 2012). This technique has been applied in the export of wildflowers from Australia where cut flower stems are devitalised using a solution of glyphosate (Seaton et al. 2010) to render the flowers unable to be propagated where new cultivars are being exported. Developing efficient and cost-effective commercial production processes is a challenge for industry longevity and being able to utilise the vast genetic heritage available across the world's biomes.

References

Aldous DE (2007) Social, environmental, economic, and health benefits of green spaces. In: Lumpkin TA, Warrington IJ (eds) ISHS 2007 Proceedings of the XXVII IHC-Horticultural Plants in Urban and Peri-Urban Life. Acta Hortic 762:171–186

Anon (2010) Botanic garden and Botanical Museum Berlin-Dahlem, Freie Universität Berlin. http://www.bgbm.org/BGBM/garden/default_e.htm. Accessed 2 March 2013

Anon (2013a) Florabase. The Western Australian Flora. Department of Parks and Wildlife. Western Australian Herbarium Perth, Western Australia. http://florabase.dec.wa.gov.au/. Accessed 14 Mar 2013

Anon (2013b) Gold coast city council-floating reed beds. http://www.goldcoast.qld.gov.au/_print/environment/floating-reed-beds-10086.pdf. Accessed 23 March 2013

APIH/Union Fleurs (2011) International statistics flowers and plants 2011. Vol 59 APIH/Union Fleurs. Complied by Anne Schubach. Zentrum für Betriebswirtschaft im Gartenbau e. V. An der Leibniz Universität Hanover. ISBN:978-90-74486-00-2

Arslan M, Yanmaz R (2010) Use of ornamental vegetables, medicinal and aromatic plants in urban landscape design. In: Gianquinto G. Prosdocimi, Orsini F (eds) ISHS 2010 Proceedings of the IInd Interntional Conference on Landscape and Urban Horticulture. Acta Hortic 881:207–211

Ball (2013) Ball® Chamelaucium Matilda. http://www.ballhort.com/Growers/plant_info.aspx?phid=149100001016136&dispmode=. Accessed 1 March 2013

Barrett J, Dole J, Lopez RG (2009) New poinsettia releases for 2009. Greenh Prod News 19(2):18, 20, 22, 24

Bhattacharya A, Kourmpetli S, Davey MR (2010) Agriculture Network Information Centre. (AgNIC) National Agricultural Library. Practical applications of manipulating plant architecture by regulating gibberellin metabolism. J Plant Growth Regul 29(2):249–256. www.agnic.org/search/IND44374811. http://dx.doi.org/10.1007/s00344-009-9126-3. Accessed 13 March 2013

Botanical Gardens Conservation International (2007) http://www.bgci.org/ourwork/1521/. Accessed 1 March 2013

Botanical Gardens Conservation International (2008) Global survey of ex situ Magnoliaceae collections. http://www.magnoliasociety.org/resources/Documents/bgci_ex_situ_magnoliaceae.pdf. Accessed 12 March 2013

Burke D (2002) Canna lilies fact sheet. Burke's Backyard. http://www.burkesbackyard.com.au/factsheets/Flowering-Plants-and-Shrubs/Canna-Lilies/91. Accessed 21 Jan 2013

Chapman AD (2009) Numbers of living species in Australia and the world. Australian Biodiversity Information Services Toowoomba, Australia 2nd ed. Report for the Australia biological resources study Canberra, Australia, September 2009. http://www.environment.gov.au/biodiversity/abrs/publications/other/species-numbers/2009/pubs/nlsaw-2nd-complete.pdf. Accessed 15 March 2013

Collins K, Collins K, George A (2009) Banksias. Bloomings Books Pty Ltd, CSIRO, Melbourne. ISBN:9781876473587

Cox D (2009) Photoperiod and bedding plants. Flor Notes Newsl 22(1):2–4. (A publication of the UMass Extension Floriculture Program July–August 2009)

Dadlani NK (1995) Cut flower production in India-cut flower production in Asia. FAO Corporate document repository. Regional Office for Asia and the Pacific. www.fao.org/docrep/005/ac452e/ac452e04.htm. Accessed 15 March 2013

Daily Mail 2011. MailOnline. Britain goes poinsettia potty: demand for traditional Christmas plant forces grower to build four more acres of greenhouse. http://www.dailymail.co.uk/news/article-2061357/Christmas-demand-poinsettia-forces-grower-build-4-acres-greenhouse.html#ixzz24Qls6Cyf. Accessed 15 March 2013

DAFF (2012) Imported cut flower treatment guide October 2012-version 1 Australian Government-Department of Agriculture, Fisheries and Forestry. Canberra. 9 pages

Degraaf J (2008) *Ptilotus exaltatus* Joey. In Grower Talks magazine. Culture note. Ball Publishing. vol 76, No 4. www.ballpublishing.com/GrowerTalks/ViewArticle.aspx?articleid=16640. Accessed 18 March 2013

De Vries DP, Dubois LAM (1996) Rose breeding: past, present, prospects. Acta Hortic 424:241–248
Dixon GR (1989) HAPIE Plants give leisure products. Aust Hortic 87(7):56–59 (July)
Dixon GR, Ogier J (2011) Intellectual Property: defining horticultural assets and implications for horticultural research and development. Chronica Horticulturae 51(2):7–10
Ecke P, Faust JE, Williams J, Higgins A (2004) The Ecke poinsettia manual. Ball Publishing Batavia, Illinois
Euteneuer B, Campbell E (2011) Christmas-tree spending rises to highest since pre-recession. Bloomberg Television Dec 6 2011. http://www.bloomberg.com/news/2011-12-06/christmas-tree-spending-rises-to-highest-since-before-recession.html. Accessed 1 Jan 2013
Fitzsimmons J (2001) New waxflowers' appeal brings new life to landscape. Hort J Aust June 2001. www.greenerpublshing.co.au. Accessed 12 Feb 2013
Finnie JF, van Staden J (1989) In vitro propagation of Sandersonia and Gloriosa. Plant Cell Tissue Organ Cult 19:151–158
Friis K, Christensen OV (1989) Flowering of Centradenia inaequatorialis Cascade as influenced by temperature and photoperiod. Sci Hortic 41:125–130
Fry C (2009) The plant hunters. The adventures of the world's greatest botanical explorers. In association with Kew Royal Botanical Gardens. Andre Deutsch publ. ISSN:978 0 233 00356 6
Gibbs D, Chamberlain D, Argent G (2011) The red list of Rhododendrons. Botanic Gardens Conservation International, Richmond UK. ISBN:978-1-905164-35-6. 128 pages. http://www.bgci.org/files/Worldwide/Publications/PDFs/RhododendronsRedList-lowRes.pdf. Accessed 15 Feb 2013
Gilbert LA (1966) Banks, Sir J (1743-1820), Australian Dictionary of Biography, National Centre of Biography, Australian National University. http://adb.anu.edu.au/biography/banks-sir-joseph-1737/text1917. Accessed March 2013
Goldblatt P, Manning J (2000) Cape Plants: a conspectus of the Cape flora of South Africa. Strelitzia 9. National Botanical Institute of South Africa. ISBN 0-620-26236–2
Growns DJ, Newell C, Considine JA, Yan G (2000) Waxflower selection, breeding and development- an overview. Acta Hortic 541:119–124
Hadiwigeno S (1995) Welcome address-cut flower production in Asia. FAO Corporate document repository. Regional Office for Asia and the Pacific. http://www.fao.org/docrep/005/ac452e/ac452e02.htm. Accessed 21 Jan 2013
Helix Australia (2014) The future in waxflowers. Groundswell 22(7) (Nursery & Garden Industry Victoria July 5–6). www.helixaustralia.com.au. Accessed 21 Feb 2014
Horlock F, Faragher J, Jones R (2000) Acacia cut flower and foliage. Production Manual RIRDC Publication No 00/57 ISSN 1440-6845. Rural Industries Research and Development Corporation, Project No. DAV–91A
IP Australia (2012) Plant Breeder's Rights. Australian Government IP Australia. http://www.ipaustralia.gov.au/get-the-right-ip/plant-breeders-rights/. Accessed 15 March 2013
Janick J (2007) Plant exploration: from Queen Hatshepsut to Sir Joseph Banks. HortScience 42(2):191–196
Jones NB, van Staden J, Bayiley AD (1993) Somatic embryogenesis of *Pinus patula*. J Plant Physiol 142:366–372
Jones NB, van Staden J (1995) Planted production from somatic embryos of Pinus patula. J Plant Physiol 145:519–525
Justice D (2002) Finding new plants for introduction-the UBC Plant Introduction Scheme of the Botanical Garden (PISGB). Davidsonia 13(1-2):15–24
Kew (2012) Kew Royal Botanic Gardens. Available from http://www.kew.org/collections/plants.html Accessed 17 March 2012
Kumar S, Singh KK, Rai LK (2004) *In Vitro* propagation of an endangered Sikkim Himalayan *rhododendron (R. maddenii)* from cotyledonary nodal segments. J American Rrhododendron Society 58(2):101–105
Lösgen G (2008) Richtlinie für die Planung, Ausführung und Pflege von Dachbegrünungen, Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau, Bonn, Germany, ISBN:978-3-940122-08-7. www.fll.de/shop/bauwerksbegruenung/dachbegrunungsrichtlinie-2008-download-edition.html. Accessed 12 March 2012

Louw E (1989) In vitro propagation of Lapeirousia silenoides. S Afr J Bot 55:369–371
Malabadi RB, van Staden J (2005) Storability and germination of sodium alginate encapsulated somatic embryos derived from the vegetative shoot apices of mature Pinus patula trees. Plant Cell Tissue Organ Cult 82:259–265
Melbourne Water (2013) Wetlands-what are they. http://www.melbournewater.com.au/content/rivers_and_creeks/the_rivers_and_creeks_system/wetlands_-_what_are_they.asp?bhcp=1. Accessed 23 Jan 2013
Mink L, Heusser C, Brannon E (2002) Use of surface and subsurface wetlands for treatment of municipal waste water. In Water Quality Conference 2002 Red lion Inn at the Quay Feb 20–21, Vancouver, Washington. 3 pages
Missouri Botanic Gardens (2012) *Berberis thunbergii* Aurea. www.missouribotanicalgarden.org/gardens-gardening/your-garden/plant-finder/plant-details/kc/b428/berberis-thunbergii-aurea.aspx. Accessed 22 Jan 2013
Monterusso MA, Rowe DB, Rugh CL 2005. Establishment and persistence of Sedum spp. and native taxa for green roof applications. HortScience 40:391–396
Morel P (1999) Growth control of Hydrangea macrophylla through water restriction. ISHS Acta Hortic 548: International Symposium on Growing Media and Hydroponics. http://www.actahort.org/books/548/548_3.htm. Accessed 15 March 2012
Moore S, Cavana M, Gillen K, Hart C, Hopper S, Orr K, Schmidt W (2001) Fitzgerald River National Park management plan 1991–2001. Department of Conservation and Land management for the National Parks and Nature Conservation Authority Perth, Western Australia
Moyo M, Bairu MW, Amoo SO, Van Staden J (2011) Plant biotechnology in South Africa: Micropropagation research endeavours, prospects and challenges. S Afr J Bot 77:996–1011
Negash L (2002) Successful vegetative propagation techniques for the threatened African pencil cedar (*Juniperus procera*) Hoechst. Endl Forst Ecol Manag 161:53–64
Nigro SA, Makunga NP, Jones NB, Van Staden J (2004) A biolistic approach towards producing transgenic *Pinus patula* embryonal suspensor masses. Plant Growth Regul 44:187–197
Ottelé M, van Bohemen HD, Fraaij ALA (2010) Quantifying the deposition of particulate matter on climber vegetation on living wall. Ecol Eng 36:154–162
Parlevliet G (2009) Banksia manual. Western Australian Department of Agriculture. Bulletin no. 4710. ISSN:1833–7236
Ratanasanobon K, Seaton KA (2010) Development of in vitro plant regeneration of Australian native waxflowers (Chamelaucium spp.) via somatic embryogenesis. Plant Cell Tissue Organ Cult 100:59-64
Rekacewicz P, Marin C, Stienne A, Frigieri G, Pravettoni R, Margueritte L, Lecoquierre M (2009) Vital Forest Graphics. UNEP (publs). http://www.grida.no/graphicslib/detail/the-main-biomes-of-the-world_f8c1. Accessed 1 Jan 2012
Reich P, Walters MB, Ellsworth DS, Runkle E (1997) From tropics to tundra: global convergence in plant functioning. Proc Natl Acad Sci U S A 94:13730-13734. (Dec 1997 Ecology)
San Marcos Growers (2011) Chamelaucium Matilda PP20,816. http://www.smgrowers.com/products/plants/plantdisplay.asp?plant_id=3407. Accessed 1 Jan 2012
Seaton KA (2005) Qualup bell (*Pimelea physodes*) for cut flower production. Department of Agriculture and Food. Farmnote. No111/99
Seaton KA, Plummer JA (2004) Observations on environmental control of flowering of Qualup bell (*Pimelea physodes*). Aust J Exp Agric 44:821–826
Seaton KA, Parlevliet G, Crowhurst M (2007) Develop of new varieties of Australian native plants for cut flower and pot plant markets. ISHS Acta Hortic 813: VI International Symposium on New Floricultural Crops
Seaton KA, Poulish N (2010) Production of premium waxflowers. Bulletin 4778. ISSN:1833-7236. Perth, Department of Agriculture and Food, Western Australia
Seaton KA, Lee J, Tan B (2010) Vase life and root propagation of Geraldton wax (*Chamelaucium* spp.) cut flowers treated with glyphosate. J Hortic Env Biotech 51(6):545–550
Sendo T, Uno Y, Kanechi M, Inagaki N (2007) What kind of plant species are the best for urban rooftop gardening? In: Lumpkin TA, Warrington IJ (eds) Proceedings of the XXVII IHC-Horticultural Plants in Urban and Peri-Urban Life ISHS 2007. Acta Hortic 762:333–340

Schmitt B, Denich M, Demissew S, Friis I, Boehmer J (2010) Floristic diversity in fragmented Afromontane rainforests: altitudinal variation and conservation importance. Appl Veg Sci 13:291–304. doi:10.11 11/j.1654-109X.2009.0167x

Shan F, Seaton KA (2009) Enhancing waxflower breeding efficiency through early embryo rescue. Proceedings of the VIth International Symposium on In Vitro Culture and Horticultural Breeding ISHS 2009.Geijskes RJ et al (eds) Acta Hortic 829:183–187

Slater A, Carson C (2003) Australian cut flower programs: a report for the Rural Industries Research and Development Corporation. Victoria Department of Primary Industries and Department of Primary Industries Queensland Government. RIRDC Publication No 03/055

Sparg SG, Jones NB, Van Staden J (2002) Artificial seed from *Pinus patula* somatic embryos. S Afr J Bot 68:234–238

Trueman S, Peters R (2006) Propagation of Wollemi pine from tip cuttings and lower segment cuttings does not require rooting hormones. Sci Hortic 109:394–397

UNESCO (2005) Bioshere Reserve Information-South Africa Cape West Coast. The MAB Biosphere Reserves Directory. www.unesco.org/mabdb/br/brdir/directory/biores.asp?code=SAF+02&mode=all. Accessed 1 Jan 2012

UPOV (2012) The International Union for the Protection of New Varieties of Plants. http://www.upov.int/upovlex/en/upov_convention.html. Accessed 1 Jan 2012

Vandeputte (2012) List of plants available in pots for sale from Vandeputte NV 2011-2012. www.vandeputteenv.be. Accessed 1 Jan 2012

van Iersel M, Linstrom OM (1999) Temperature response of whole-plant CO_2 exchange rates of three magnolia cultivars. J Am Soc Hortic Sci 124(3):277–282

van Uffelen, Ruud LM, de G, Nico SP (2005) Floriculture worldwide; production, trade and consumption patterns show market opportunities and challenges. Agricultural Economics Research Institute Paper (LEI) > Paper series. Wageningen University. http://purl.umn.edu/29148. Accessed 21 Jan 2013

von Hentig W-U (1995) The development of new ornamental plants in Europe. Acta Hortic (ISHS) 397:9–29. http://www.actahort.org/books/397/397_16.htm. Accessed 1 Jan 2012

von Hentig W-U, Ehlers D, Hennig F, Seyring M, (1995) The development of *Ptilotus exaltatus* R.Br. under central European conditions. Acta Hortic (ISHS) 397:163–180. www.actahort.org/books/397/397_16.htm. Accessed 1 Jan 2012

Walker J (2010) Obra Verde Growers. http://www.obraverde-flowers.com/aboutus.html. Accessed 1 Jan 2012

Weller JL, Murfet IC, Reid JB (1997) Pea mutants with reduced sensitivity to far-red light define an important role for Phytochrome A in day-length detection. Plant Physiol 114:1225–1236. http://www.plantphysiol.org/content/114/4/1225.short. Accessed 15 Jan 2012

Wigand J (2007) Australian waxflowers are at home in California Judy's Perennials U-T San Diego. http://www.utsandiego.com/uniontrib/20070304/news_lz1hs04judys.html. 15 Jan 2012

Wiley De Nolf W (2012) Boomkwekerij Pépinière Nursery Baumschule 2011–2012. www.denolf.com. Accessed 1 Jan 2012

WIPO (2013) World Intellectual Property Organisation. http://www.wipo.int/portal/index.html.en. Accessed 12 March 2013

WTO (2012) World Trade Organisation. http://www.wto.org/. Accessed 2 Feb 2012