Chapter 11
The Role of Ornamentals in Human Life

Jaap M. van Tuyl, Paul Arens, William B. Miller and Neil O. Anderson

Abstract The integration of flowers in daily human life has a long history and substantiates our appreciation for their delicacy and wide variation in possible shapes and colours. Since the very early civilizations flowers were used for medical purposes and above all have been part of important cultural and religious customs. Records of their use have been preserved over centuries in different parts of the world and in most if not all major religions flowers have a featuring role. Whereas in the past flower production for floral design was local and probably limited and restricted to wealthy and powerful people that could afford gardens for pleasure, nowadays floral production has become a knowledge and infrastructural intensive, highly specialised industry with trading networks on a global scale and floricultural exhibitions being organised all over the world. As with all intensive industry, concerns on environmental aspects including carbon footprints as well as the well-being of labourers have been raised and have led to certification programs that resulted in impressive reductions in energy and resources as well as environmental impact. It can be expected that given the global environmental and economic issues, ornamental production will have to even intensify these efforts substantially to provide flowers at low environmental costs for people to enjoy in and around their homes.

Keywords Floriculture · Flowers · Celebration · Exhibition · Carbon foot print

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Introduction

Flowers form an integral part of human life, they are presented at birthdays, weddings, graduations, funerals and other special occasions. Ornamental plants are grown for their beauty and function in gardens, parks, and homes of people. Production is in nurseries as bedding plants, pot plants, foliage or as cut flowers. Flowers are produced worldwide on a large scale for commercial purposes by growers and distributed to wholesale, markets and flower shops to be sold to the consumer. A second use of ornamental plants is their uses in gardening and landscaping. Ornamental plants are used by humans because of their beauty, symbolic significance (Mendonca de Carvalho 2011; Koehn 1952; Ferguson 1966), colour (Kaufman and Lohr 2008), fragrance, therapeutic (Matsuo et al. 2008) and emotional value.

In this chapter the role of ornamental plants in human life is summarized and focuses on cultural, environmental, horticultural and genetical aspects.

Cultural Aspects

Flowering plants (angiosperms) produce colourful, showy flowers as a mean of attracting insect, bird, bat or animal pollinators to produce seed for the continuation of the species. In contrast, wind pollinated plants, particularly conifers (gymnosperms), grasses, sedges and other woody shrubs/trees have less showy flowers. While foliage, plant shapes, and fruit frequently have ornamental qualities, flowers have always captured the attention of human eyes. As a result, flowers have been highly integrated into human cultures and societies throughout the world in all ages being used for art, adornment, decoration, fragrance, medicine, food and floral design.

Flowers come in a wide variety of sizes—from the microscopic duckweed (*Wolffia columbiana*) to the gigantic aroids (*Amormorphallus paeoniifolius*); shapes—star or actinomorphic, yolk or zygomorphic, actinomorphic flowers produced in a plant that normally is zygomorphic—also known as peloric types; colours—all are possible across the spectrum of plants, although some species and genera have only a few colours; black, blues and greens are rare in most species. In floral designing, the design elements (line, form, texture, colour and fragrance) are all provided by flowers and their stems used in each design (Hunter 2000). All flowers can be categorized into distinctive forms for floral designing: mass, line, form, and filler (Hunter 2000). Mass flowers have one or more flowers or florets clusters in a single spot at the tip of each stem, providing a mass appearance, such as:- dahlia (*Dahlia pinnata*), chrysanthemum (*Chrysanthemum x grandiflorum*), or rose (*Rosa x hybrida*). In floral designing, mass flowers are typically used for the focal point or centre of interest. Line flowers are stems with multiple flowers or florets occurring up and down each stem, e.g. gay feather (*Liatris spicata*), gladiolus (*Gladiolus x hybridus*), or snapdragon (*Antirrhinum majus*). In floral designing, line flowers help create geometric forms and provide a line of similarity for the viewer's eye to follow. Form flowers are unusually shaped and call attention to themselves due to

their exotic appearance, e.g. King or Queen proteas (*Protea cynaroides, P. magnifica*), banksias (*Banksia marginata*), or alstroemerias (*Alstroemeria pelegrina*). Filler flowers are smaller sized stems with multiple flower or florets and can be used to "fill in" floral designs, e.g. baby's breath (*Gypsophila paniculata*) or statice (*Limonium sinuatum*).

Historical Aspects

In ancient civilizations, flowers were widely used indoors. While many records of ancient uses have been lost, several significant cultures have detailed documentation of the cultural integration and use of flowers: for instance the Egyptian, Greek, Roman, and Byzantine cultures (Hunter 2000). Archaeological excavations in the Shanidar IV cave in Iraq uncovered the use of flowers as far back as the Neanderthals for sympathy floral designs and medicinal purposes (Solecki 1975). A variety of flower stem remnants (pollen clusters where the flowers would have been positioned) were found in male gravesites: yarrow (*Achillea spp.*), cornflower or bachelor's button (*Centaurea cyanus*), St. Barnaby's thistle (*C. solstitialis*), groundsel (*Senecio vulgaris*), grape hyacinth (*Muscari racemosum*), joint pine or woody horsetail (*Ephedra distachya*) and hollyhock (*Alcea rosea*) (Solecki 1975).

The earliest records of cultivating chrysanthemum flowers (*Chrysanthemum* x *grandiflorum*) date back 5,000 years to the ancient Chinese, who first valued its pharmaceutical properties and then its floral attributes (Ackerson 1967). Other flowers popular in ancient China, include spring flowering branches, camellia, aster, iris, lily, lotus, narcissus, orchid, peony, and rose. In 385 AD, chrysanthemum seeds were introduced to Japan as a gift from Korea (Ackerson 1967). The Japanese cultivated the chrysanthemum on such a large scale and incorporated it into their culture and annual festivals to such an extent—with the Japanese Emperor sitting on The Chrysanthemum Throne—they are more associated with it than the Chinese. Chrysanthemums were imported to Europe via Holland in 1688, then to England and the USA by the 1700s (Clark 1962) and have become one of the most appreciated flower crops worldwide.

Japanese use of flowers, particularly chrysanthemums, evolved into a highly specialized art form. The oldest floral design schools of Ikebana encouraged the arrangements of flowers in temples, for ceremonies and festivals, as well as the home (Hunter 2000). Flowers were used to depict religious and spiritual connections of humans in the Buddhist traditions. Current Japanese use of flowers reflects this methodical and philosophical connection of humans with their surroundings. In ancient Egypt, there were numerous reliefs, paintings and inscriptions in tombs and temples that depict the widespread love and use of flowers. In addition to cultivating native ornamentals such as papyrus and lotus flowers, other cultivated flowers were imported from foreign countries. For instance, cultivated chrysanthemums were brought back to Egypt from King Solomon's royal gardens by Pharaoh Thutmose III (ca. 900 BC) (Schweinfurth 1919). Thus, many early civilizations often cultivated common flowering plants such as rose, chrysanthemum, and lily. The

Fig. 11.1 Floral arrangements of flowers and foliage depicted in ancient Egyptian art. This painting shows the children (*right*) of King Ipuy and his wife (*left*) bringing lotus bouquets to them. (Source: Egyptian Expedition of the Metropolitan Museum of Art, Rogers Fund, 1930 (30.4.114), The Metropolitan Museum of Art, New York)

Gardens of ancient Egypt were, at first, designed for growing edible vegetables and fruit but later evolved into ornamental pleasure gardens with the inclusion of flowers and ornamental trees (Baridon 2000). These could be found in private residences, temples and palaces; funeral gardens were also common. Models of these gardens were also inscribed in tombs for enjoyment in the afterlife (Baridon 2000). Cut flowers and foliage arranged in floral designs were commonly depicted in ancient Egyptian wall paintings (Fig. 11.1). The classic Egyptian floral design period was from 2800 to 28 BC with flowers being used on banquet tables, in temples, self adornment (as wreaths, chaplets, garlands, flower collars), in religious or royal processions or given in honour of someone held in high regard (Hunter 2000). Egyptian floral designs commonly used flowers or fruit in orderly rows. Bowls of arranged lotus flowers, the flower of Goddess Isis, were placed on banquet tables. Other commonly used cut flowers (lily, rose, gladiolus, straw flowers) and foliage (ivy, myrtle, olive, palm, papyrus) are still widely used today across the globe (Hunter 2000). Wearing flowers in wreaths or chaplets rose to a higher level and usage in the ancient Greek floral period (600–46 BC). Professional wreath and garland makers were employed in the art since wreaths were widely used in Greek culture, and awarded to heroes of the arts, sciences, and athletics (Hunter 2000). Flower colour was less important to the Greeks, but they sought to incorporate herbs along with flowers for added fragrance. Commonly used flowers by the Greeks included lily, rose, honeysuckle, larkspur, hyacinth, violet, and tulip (Coats 1970). The Cornucopia or horn of plenty (Fig. 11.2) was one of the common mechanisms used to strew

Fig. 11.2 Greek uses of the Cornucopia or horn of plenty shown here raining flowers and fruit. (Photo credit: Neil Anderson)

flowers and fruits on the ground during festivals and grand festivities. Cornucopias are still used in modern celebrations to denote the abundant harvest, particularly on Thanksgiving Day in Canada and the USA. Florists in the Roman Empire (28 BC–325 AD) continued the Egyptian and Greek traditions of making wreaths and using garlands in celebrations. Roman wreaths and garlands became more decorative with brighter colours and fragrant flowers (Hunter 2000). Fragrant petals and flowers were commonly used at Roman banquets, in the streets and floated on lakes. As guests dined and reclined in the opulent Roman banquets, rose petals often rained from the ceilings and piled up at their feet—often as deep as ~0.5 m. The first artistic rendition of a naturalistic floral design can be found in a mosaic in the Vatican Museum. Sympathic floral traditions included the "*Dies Rosationis*" where the family would gather around the rose-covered grave of the recently deceased and place additional roses in remembrance (Nicol 1826). Another Roman floral tradition was the "*Sub Rosa*" where a wreath of white roses was hung from the ceiling and all conversations beneath it were to be kept secret.

European aristocratic and monastic usage of flowers through the Byzantine period, the Middle Ages, the Renaissance, Baroque and Dutch-Flemish periods, to the French, English and Victorian eras, all showed a progression of techniques, employment of principles and elements of design, and the creation of floral industries to supply the vases, containers, palaces or estates to enable florists to make the designs (Berrall 1968). Many such changes in the art and science of floral design are depicted in European paintings (Mitchell 1973; Newdick 1991).

The Byzantine period (320–600 AD), named after the city of Byzantium (later Constantinople and now Istanbul in Turkey) was in the eastern sector of the Roman Empire, and continued the Romantic flower uses and floral designs, although garlands evolved into floral or fruit banks alternating with foliage. Symmetrical

Fig. 11.3 Emilia in her medieval garden weaves a wreath of flowers for her hair. Painting entitled "Arcita and Palemone admire Emilia in her garden", from a manuscript of Boccaccio's Teseida (1339–1340), Vienna, Österreichische Nationalbibliothek, Cod. 2617 Han, 53r

floral design compositions resembling highly pruned trees and shrubs were kept in large containers (Hunter 2000). During the Middle Ages (476–1450 AD) flowers maintained their importance particularly in everyday medicinal, food, drink, and body freshening uses with Medieval gardens an important source of floral materials (Fig. 11.3).

In the Renaissance, which began in Italy in the fourteenth century, floral designs in vases commonly appeared in paintings and flowers for specific purposes and as a source of symbolism. For instance, in the painting "The Annunciation" by Leonardo da Vinci (1452–1519) and Andrea del Verrocchio (1435–1488), *Lilium candidum* became known as the Madonna lily and was associated with fertility as well as chastity (Brown 1998). Since that time, other flowers have symbolic meanings in paintings (Bos 2012; Segal 1990) and sculptures (Janick et al. 2010). The Language of Flowers developed after the publication of the monograph, *Le Language des Fleurs* by Madame Charlotte de la Tour in 1819, which was followed by Kate Greenaway's, *Language of Flowers,* in 1884, provides a list of over 200 plants and what they mean to people.

Mixed bouquets during the Renaissance period demonstrate that a wide variety of flowers were cultivated, ranging from daffodil, rose, carnation, lily, anemone, bell flower, iris, lily of the valley, lupin, pansy, poppy, primrose, and stock to tulip. During the Baroque and Dutch-Flemish periods (seventeenth to eighteenth centuries) the wide array of cultivated flowers continued with a particular interest in the "broken" tulips streaked with colours (Fig. 11.4; Segal 1990).

The Victorian era (1837–1901) was one of the most influential European periods that encouraged the use of flowers in everyday life (Maas 1969). This period greatly influenced the emerging American use of flowers in mass arrangements for

Fig. 11.4 Vases of flowers from the Baroque and Dutch-Flemish periods, displaying a wide variety of cut flowers preferred during this time. Flowers in a Niche, Ambrosius Bosschaert (1614–1654), The Hague, Holland, inv. Nr. 679

the home during the Federalist, Greek Revival and Art Nouveau periods (Marcus 1952; Benz 1960; Schmutzler 1962; Warren 1972; Anon 1997). In the Victorian Era, the Language of Flowers enhanced floral symbolism with the use of flowers and floral arrangements to send unspoken messages to the recipient. Current floral symbolisms abound and may be specific to particular cultures or countries rather than having a wider global meaning. For instance, red roses are indicative of passionate love, particularly for St. Valentine's Day (February 14), yellow for devotion and pink coloured flowers indicate a lesser interest.

Historic uses of flowers and their popularity have influenced current day usage. For instance, while there are thousands of flowering plant species and cultivars on the cut flower market, only a few are used widely for floral designing: rose, chrysanthemum, carnation, lily, gladiolus, and orchid are among some of the examples. All of these have been used since ancient times in China, Egypt, Rome, and Greece and largely due to their wide adaptability to cultivation in different environments, long vase and garden life, and their ability to be shipped long distances without a loss of integrity.

Around the world, modern countries have chosen their National Flower as a national symbol. During the National Day (of independence or unification) these flowers are promoted and printed on flags and other emblems. For instance, the rose is the national flower for several countries, i.e. England, the USA, Ecuador, Bulgaria, Iraq, Iran, the Czech Republic, and Slovakia (Fig. 11.5). The tulip is the National Flower for the Netherlands, Hungary and Turkey while the chrysanthemum and cherry are the National Flowers for Japan and China, respectively. France

Fig. 11.5 The rose is the national flower in a number of countries. (Photo credit: Jaap van Tuyl)

and Croatia chose the iris, while Brazil favours orchid (Anon 2013a, http://www.theflowerexpert.com/content/aboutflowers/national-flowers). *Usually the National Flower reflects some association of each country with the species, even though they may not be native to a respective country.*

Flowers in Traditions and Celebrations

In human life a number of traditions and celebrations are known in which flowers play an important role. Flower festivals are held typical in each country, like in the Netherlands during the flowering of the spring flowering bulbs (April/May) or the National Cherry Blossom Festival (March/April) in Washington, DC or in Japan over January/April. The annual Rose Bowl parade in Pasadena, California, on New Year's Day (January 1) incorporates the use of flowers and plant parts to decorate all floats entered into the parade. Conservatories, arboreta and municipalities throughout the world sponsor flower shows, exhibitions, and special celebrations to highlight particular flowers of the seasons or for special holidays (Easter, Christmas, Mothering Sunday). In northern latitudes these are particularly important during the winter months to bring fresh flowers into people's lives during the cold winter months. In China the most important floral holiday is the Chinese New Year, also known as the Spring Festival. Narcissus in pots and cut lilies are produced and exhibited in large numbers. In other countries, specific flowers may be invoked for religious celebrations such as the use of native marigolds (*Tagetes erecta, T. patula)* for the Mexican Day of the Dead or Día de los Muertos (31 October–2 November) which predated the Spanish invasion. Other countries have recurrent floral celebrations to honour specific native flowers that have played important historic roles. For instance, in the Chrysanthemum City, Xiaolan, millions of people come to see the chrysanthemum shows (Fig. 11.6).

Fig. 11.6 China Grafted and potted chrysanthemums are grown for the widely popular chrysanthemum exhibitions held every 4–6 years in the Chrysanthemum City, Xiaolan Town, PR. (Photo credit: Neil Anderson)

During the year a number of special days or events are famous for giving flowers as gifts: St. Valentine's Day (February 14), Mothering Sunday (4th Sunday in Lent), Mother's day (first Sunday in May), Julian and Orthodox Easters (Varying from end of March till beginning of May), All Saints Day (November 1), Jewish Hanukkah, which in 2013 falls from Sunday November 27 to nightfall December 5, and Christmas Day (December 25). Besides these annual celebrations other important moments in life for which flowers are used are birthdays, marriage and funerals. Sympathy work for funerals and memorials always involves flowers as they are reflective of the shortness and fragility of life. Floral gifts in many countries, either as potted flowering plants, fresh cut flowers, or flower arrangements are also popular hostess gifts when invited to someone's house. Their freshness, bright colours, artistic arrangements and fragrance are always welcome.

Floricultural Exhibitions

The most important modern-day flower production areas in the world have traditional national and international exhibitions in which industry professionals (breeders, producers, distributors, brokers, growers, retailers, and landscapers) are involved. In the Netherlands, the International Hortifair (Anon 2013b, http://www.hortifair.com/) is the most well-known, while the IPM (Messe Essen) in Essen, Germany Anon (2013c, http://www.ipm-messe.de/en/ipm_essen/index.html) is another important European event. The International Florist Organisation for the European ornamental plants industry (Fleuroselect) holds annual European Spring Park Trials for breeder, producer and distributor companies to display their new bedding plant cultivars Anon (2013c, http://www.ipm-messe.de/en/ipm_essen/index.html). Fleuroselect also awards outstanding new cultivars in these prestigious awards. In the USA, the comparable California Spring Trials occur in the early spring of each year across California so that breeder, producer and distributor companies can also display their new bedding plant cultivars Anon (2013d, http://www.ofa.org/OFA/Events/2013_California_Spring_Trials/ofa/Events/spring_trials.aspx) The All-America Selection (AAS) trials and awards in the USA are a national trialling

organization which awards AAS winners each year for their top-performing annual bedding and vegetable plants Anon (2013e, http://www.all-americaselections.org/). In the USA, numerous floral exhibitions and conferences include the Ohio Florists Association meeting in Columbus, Ohio Anon (2013f, http://www.ofa.org/), the Northwest Flower & Garden Show in Seattle, the Northwest Flower and Garden Show in Washington and the Philadelphia Flower Show in Pennsylvania Anon (2013g, http://www.gardenshow.com/; 2013h, www.theflowershow.com). Throughout the rest of the Americas, numerous floral events keep the public and industry up-to-date with the latest and best products and services. For example Agriflor, in Quito, Ecuador is usually held biennially during September to October highlighting an array of cut flowers, especially cut roses Anon (2013i, http://www.eventseye.com/fairs/f-florecuador-agriflor-8221-1.html; 2013j, http://www.youtube.com/watch?v=dT9BYsm7Pv0). Proflora is another central American conference held biennially in Bogota, Colombia to highlight numerous cut flower crops produced in Colombia Anon (2013n, http://www.proflora.org.co/home.php).

Horticultural Production

Historically many flowers were harvested from fields, forests, natural areas, and home gardens. As cities grew there was a corresponding cultural awareness and an increase in aristocratic demand for high quality flowers, there was a move to their commercial production in cultivated fields, and specifically controlled environment structures (e.g. cold frames, hot beds, shade houses, greenhouses, conservatories, low/high tunnels), all of which were designed and built for the growth and harvest of flower and food crops. The first structures preceding those of greenhouses were forcing houses for vegetables, built in 500 BC by the Romans. Seneca (who died in 65 AD) later described "…the use of window-panes [*specularia*] which admit the clear light through a translucent slab of mica (*lapis specularis*)" or transparent stone (*perspicua gemma*) as a glazing material (*cf.* Epistle XC; Bromehead 1943). Such specularia were used to let sunlight in but keep wind out, such that Emperors Nero (37–68 AD) and Tiberius (17–37 AD) both had cucumbers grown year round (Pliny the Younger, XXXVI 22 § 46; XIX 64; *cf.* Smith 1893; Bromehead 1943).

As the invention of walls with translucent mica, flues for heat circulation (100 AD) and sheet glass (300 AD) occurred, larger wall areas could be used for light although the roof was still solid with tiles or shingles. The building of orangeries commenced in 1545 (Padua, Italy) and by the early 1600s, all major castles and aristocratic families installed them across Europe (Nelson 2003). While the citrus flowers provided fragrance and the fruit Vitamin C for visiting guests, the main attraction was the botanical collection of flowering plants used to grace the banquet tables with floral designs. The development of the Golden Age of The Netherlands, with its immense sea power and the Dutch East and West India Companies in the 1600s, gave rise to the creation of the modern greenhouse industry (Nelson 2003). The Dutch discovered how to dig and force lilac bushes (*Syringa vulgaris*) into

Fig. 11.7 Lithograph by Ackerman of The Crystal Palace in London; view is from the northwest. (De Maré 1972)

flower, shipping the cut stems to the seventeenth century royal courts of Germany, France, and Great Britain (Nelson 2003).

The inventions of embedding glass in putty for greenhouse roof and walls was developed by company of Lord and Burnham in 1840 and casting plate glass in 1848 allowed for larger greenhouses to be built for exhibitions and commercial flower production. For instance, in 1851, The Crystal Palace was built in Hyde Park, London, England with an exterior surface area of 71,721 m^2 of glass (Fig. 11.7; de Maré 1972). Lord and Burham and other companies subsequently pioneered the building of numerous types of greenhouse structures for commercial and home production of flowers, fruits and vegetables (Figs. 11.8 and 11.9; Lord & Burnham Co. n.d.; The Weathered Company 1908).

Modern-day greenhouses (Fig. 11.10), used primarily for flower production throughout the world, are large expanses of structures that use sheet glass, flexible polyethylene, and rigid fibreglass, polycarbonate, or exolite as glazing materials (Nelson 2003). The three top greenhouse producers are The USA, Japan and The Netherlands, producing as much as 46 % of the global floriculture products (Nelson 2003). Typical crops grown in these structures include a range of cut flowers, cut foliage, potted flowering and foliage plants, bedding plants, and herbaceous perennials. Due to the advent of air transport, the evolution of flower production changed from local growers who produced all crops for local sales, to areas of global specialization. Specific field cut flowers are still produced in the warmer areas of the globe such as California or Florida, USA, and include crops such as stock (*Matthiola incana)*, baby's breath (*Gypsophila paniculata),* statice (*Limonium sinuatum)* and

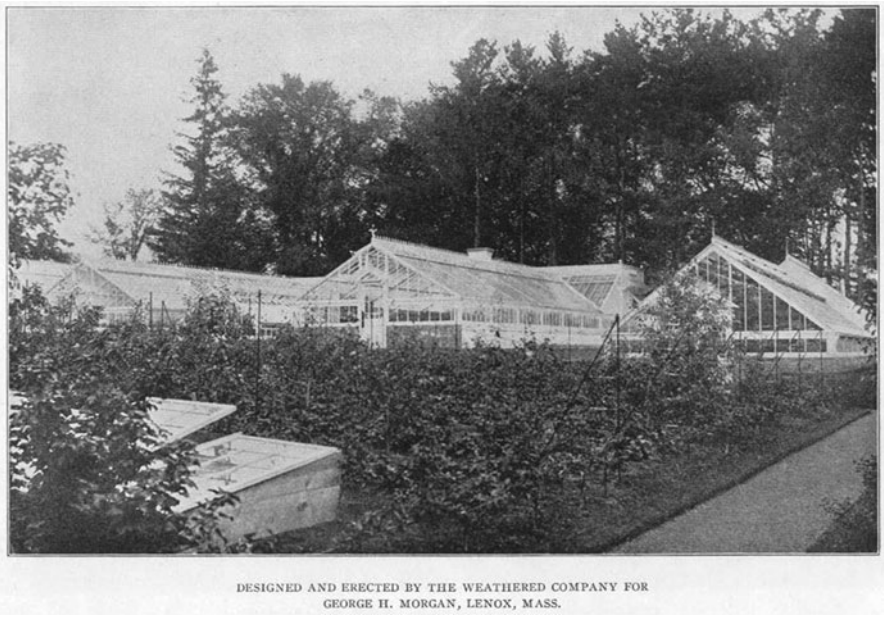

Fig. 11.8 Commercial, free-standing equal span greenhouses, typical of the early 20th century. (The Weathered Co. 1908)

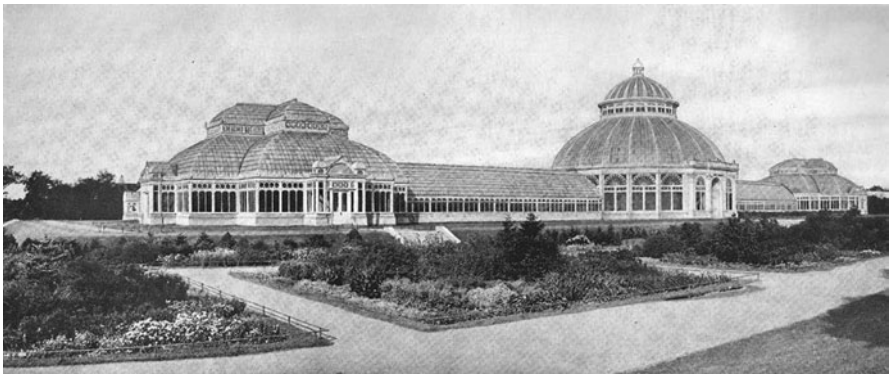

Fig. 11.9 Example of a conservatory, built for the New York Botanical Gardens by the Lord & Burnham Company. (Lord & Burnham Co. n.d.)

gladiolus (*Gladiolus x hybridus*) (Nelson 2003), while some cut flower crops requiring higher temperature or are more susceptible to insect and disease are moved into high tunnels or greenhouses (Ortiz et al. 2012). Cut tropical foliage and flowering plants such as the *Vanda, Oncidium, Cattleya*; *Anthurium* orchids) are grown in Thailand, Hawaii, and the USA with the more heat-loving Mediterranean crops, such as the protea and banksia, that both belong to the family Proteaceae, produced in California USA, Israel, South Africa, India and Australia. High quality cut green-

Fig. 11.10 Example interior of a modern-day greenhouse range in Canada, glazed with rigid Exolite for growing cut snapdragons, *Antirrhinum majus*. (Photo credit: Neil Anderson)

house crops such as the rose, carnation, and chrysanthemum are produced in two primary areas, due to their higher light and temperature levels: namely Central and South America (Colombia, Honduras, Guatemala, Ecuador, Mexico, Costa Rica) and Africa (Kenya, Tanzania, Zimbabwe, Zambia, Uganda, Morocco). Crops such as these are less costly to produce than cut flowers grown in greenhouses of northern latitudes due to expensive heating and lighting costs (Nelson 2003). Likewise, plug growers at northern latitudes, such as Wagner's Greenhouses (Minneapolis, MN, USA) may produce cool season bedding plants (pansy, viola, *Nemesia*) during the summer months for fall/winter sales in southern regions of the USA. Many northern latitude countries specialize in potted plant production (The Netherlands, Denmark) where cooler climates and lower light levels provide ideal conditions for the growth and development of *Cyclamen, Exacum, Calceolaria,* and other potted genera. China and Chile are two emerging floral production countries are now competing on the world market for these and other potted material. The net effect of these changes is year-round production for most commercially grown flower crops.

The flower industry is characterized by "flower power" and "convenience" (Anderson et al. 2006a, b) and numerous innovations have occurred which now aid in the global increase in sales and popularity of floricultural crops. Until the end of the nineteenth century, flowers were transported without refrigeration by bicycle, on foot, by ship or horses (Nelson 2003). The first major change was the creation of rail and road systems which increased transportation distances that floral and cut flower

Fig. 11.11 Claude Hope, one of the founders of PanAmerican Seed Company, whose flower breeding resulted in the first commercial F1 hybrid Impatiens walleriana and Petunia xhybrida. (Uchneat 2006)

products could move. Thus, three factors emerged for sustainable production: quality, production and transportation costs (Nelson 2003). Air transport developed post-World War II and dramatically affected shipping. A second major change was the creation of F_1 hybrid seed products, notably with *Impatiens walleriana* and *Petunia x hybrida* by the PanAmerican Seed Company (bred by Claude Hope) in the 1940s (Fig. 11.11; Uchneat 2006). These products displayed hybrid vigour or heterosis that outperformed the standard open-pollinated types. Currently a high proportion of seed-produced flower crops are hybrids. Another innovation was the Plug Revolution of the 1980s, which transformed the heavy, cumbersome clay or wooden containers into lightweight plastics (Figs. 11.12 and 11.13) (Armitage and Kaczperski 1994). Plug trays, all made the same size of 10″ × 20″ (25.4 × 30.5 cm) were created to grow and germinate seedlings or root cuttings and held from 32 to 512 small plants. Finishing containers (explain what these are for the reader) are moved from bulb, azalea and standard pots to 4- and 6-packs that fit into 10 × 20 trays in specific sets, each with their own trade code. This enabled automation to come to greenhouse production with the advent of automatic plug and container filling machines, seeders (drum, needle), transplanters, and benching systems as well as computerization for climate control (Nelson 2003). With the use of in-floor heating, soil temperatures of adjacent bays or areas could be set at differing values, allowing for the first-ever production of cool and warm season crops in one greenhouse (Fig. 11.14).

Current commercial production and marketing of floricultural crops follows a complicated, ever-changing horticultural distribution supply chain that has been created through globalization and highly specialized growing, brokerage and marketing firms (Drew et al. 2010). The chain begins with the collection of wild species with ornamental potential, their subsequent breeding and selection to create seed or vegetative products. Producers then sell on the propagules to distributors who subsequently sell directly or via brokers to grower types (plug producers, prefinishers, finishers). These products are then sold to the customers either through independent or big box store retailers, garden centres, nurseries and landscape contractors (Fig. 11.15; Drew et al. 2010). Another level of complexity arises when

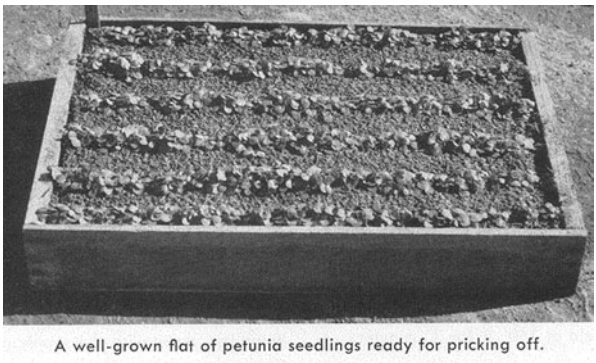

Fig. 11.12 Wooden flats typical of those used for sowing seeds, rooting cuttings until transplanting; such heavy wooden flats were used until the plastics plug revolution of the 1980s. (Sheldrake and Boodley 1965; Rowley 1978)

firms do more than one activity task, such as a breeder and producer company or act as a distributor and broker. Prior to 1960, all marketing of floral products occurred through full-service florist retail shops (Nelson 2003). Sales then moved to include groceries, discount stores and street corners followed by mass marketers (Nelson 2003). With global experience, a product could be grown in one country by a producer, distributed to another to be grown, and then final sales could occur in multiple countries.. For example, Easter lily bulbs for the USA market are grown in Smith River, California and Brookings, Oregon (USA), and are sold to greenhouse forcers and growers in Canada and then shipped back to the USA market. Cut flowers may pass through several countries, originating in one country where the grower is located, shipped and marketed through a large floral auction house (e.g. Aalsmeer in The Netherlands), and then brokered and distributed to any country on the globe. The marketing of flowers has become specialized with many products (cultivars, series) having specific websites, e.g. 'Purple Wave™' petunia Anon (2013k, http://www.wave-rave.com/), and Proven Winners branding Anon (2013l, http://www.provenwinners.com/). This creates consumer interest ascending back through the distribution chain, where they ask retailers for a specific product by name ('Purple Wave™' petunia) rather than simply a purple petunia type (Anderson et al. 2006a, b; Drew et al. 2010). Other forms of marketing, such as intellectual property (IP) have specific rights and have created interest and product value, such as Plant Patents, Plant Variety Protection, or Utility Patents in the USA vs. Plant Breeder's Rights in Canada, Europe, Australia and Japan. (Aguirre 2006).

Environmental Aspects

As a commercial venture, flower production, or floriculture, is a highly developed and specialized form of agriculture. For maximum value, a flower must be perfect, without disease or insect infestation, be free of physiological or physical injury, and possess maximal vase life or shelf life. The modern, global flower production industry has evolved over many decades to reflect these requirements. And in tandem,

Fig. 11.13 Example clay pots used to produce an Easter lily crop, wrapped for shipment, in 1912 at Minneapolis Floral Company, Minneapolis, MN USA. (Photo credit: Prof. Cady, University of Minnesota)

Fig. 11.14 A modern greenhouse with heated floor which can grow different temperature-requiring crops side-by-side in the same house. (Photo credit: Neil Anderson)

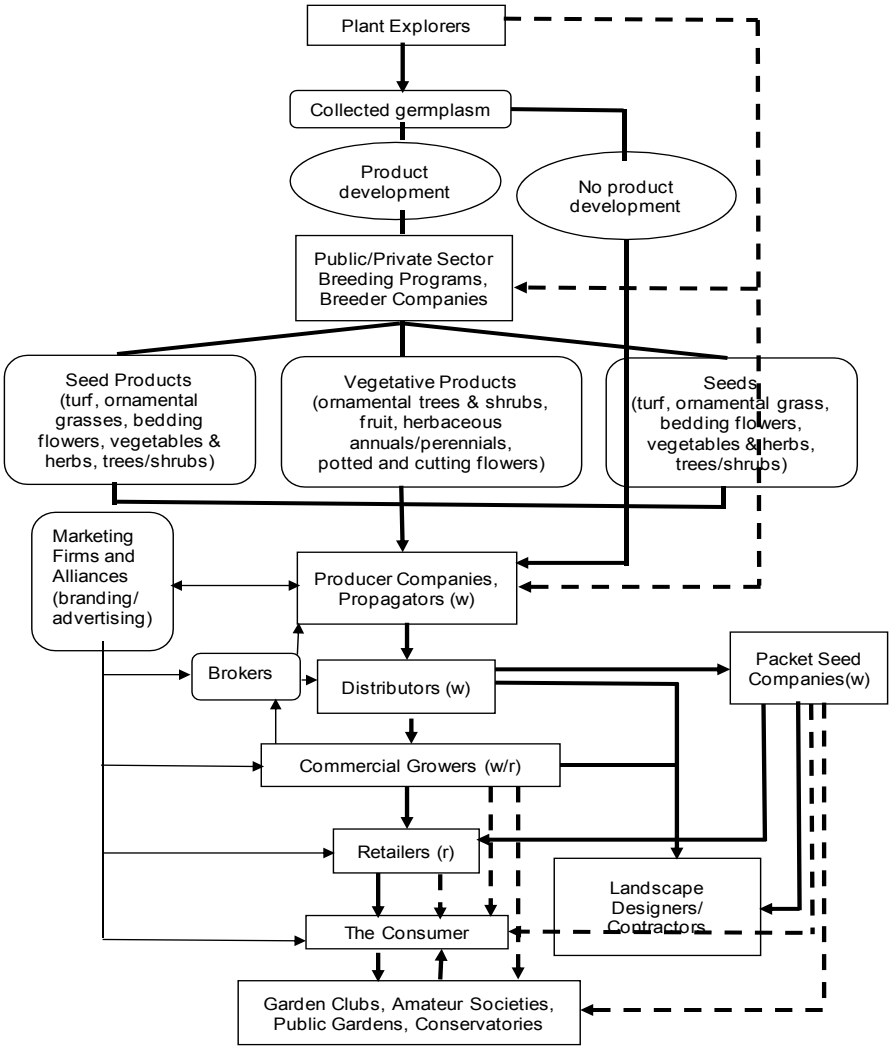

Fig. 11.15 The horticultural distribution chain showing linkages between varying firms and players involved in the collection, breeding, propagation, distribution and purchase of floricultural crops (Drew et al. 2010). *Dashed lines* indicate *e*-Commerce; *solid lines* are all other forms of distribution (truck, rail, air, ship)

as the capabilities of the industry for producing and delivering such products has improved, so have the demands on the product by the consumer. Large buyers of flowers or flowering plants place rather exacting standards on products delivered to them (e.g. number of flowers, or height). Until recently, these standards have been mostly related to visual or ornamental characteristics of the plant or flower. Commercial flower growers strive to maximize profit by operating their greenhouses

in a way so as to produce and deliver the required plants or flowers in the most economical manner possible.

Economists refer to "externalities" as the side effects or consequences of industrial or commercial activity. In many areas of horticulture, we have become increasingly aware of unintended effects of our activities, and floriculture production is no exception. In this chapter, we have already discussed the emotions and human linkages with flowers, but for some consumers, emotions related to the authenticity, environmental friendliness, sustainability or ecological purity are important drivers of a purchase decision. Against this background, floriculture producers are increasingly aware that promotion of ecological friendliness of flowers can influence purchase decisions. To this end, in recent years, there has been increased interest in programs that "certify" or "label" plants or flowers as having met specified requirements related to environmental and/or social responsibility. Most readers are probably familiar with such labelling, perhaps the most commonly known being "Fair Trade" for coffee and other delicacies (Table 11.1).

Certification Programs

In floriculture, the first certification program was the Milieu Programma Sierteelt (MPS), started in The Netherlands in 1994 (White 2012). At its inception, the main goal of MPS was to help the Dutch greenhouse industry reduce the use of pesticides and to this day remains an important goal. The MPS organization works with individual floriculture growers worldwide setting organizational goals that relate to chemical, water or fertilizer use, social responsibility and related areas. The MPS program has a number of levels depending on the complexity and depth of program the grower wants. The basic program is the "ABC" program, where MPS provides support to help growers record and monitor pesticide, fertilizer, energy (and other inputs) used on a monthly basis. The grower is responsible for collecting this information, and enters it onto a database. On a quarterly basis, MPS provides a simple grade (A, B or C) to the grower. This designation can be used by the grower for various purposes, including qualification for higher level certification (see nectalinea). A major value of MPS-ABC is the ability of growers to benchmark themselves to other similar businesses, or to growers in other countries. Part of this is because the system tracks the usage of chemicals, not money spent on them, so direct comparisons based on active ingredient applied are possible.

Beyond MPS-ABC, there are higher level certifications for worker safety, health, employment conditions and human rights (MPS-Socially Qualified). MPS-GAP (GAP stands for Good Agricultural Practice) aims to help growers anticipate market demands of the retail channel for safe, sustainably-cultivated, high-quality and traceable products that require Global GAP standards. MPS-Quality aims to assist growers in producing the highest possible quality crops. There are also specific certifications for the wholesaler and trader sides of the industry. The MPS program is the most extensive certification label within floriculture. Aside from MPS, at least 8 related programs exist in the realm of "flower certification" (Table 11.1). These

Table 11.1 Summary of the major certification programs in floriculture. (Adapted from White 2012)

Label/ certification	Web site	Comments
MPS-ABC	www.my-mps.com/	The original floriculture/greenhouse certification program. Widely established in many countries
GlobalGAP	www.globalgap.org/	A non-governmental organization that sets voluntary standards for the certification of agricultural products around the globe. Started in 1997 as EUREPGAP
Fair Flowers/Fair Plants	http://www.fairflowersfairplants.com/	Initially within MPS. Funded through the Dutch auction system. Requires the equivalent of MPS-A plus adherence to 10 social areas including the right to collective bargaining with the employer, right to a living wage, work guarantees, See (http://www.fairflowersfairplants.com/en/consumers/certification-requirements.aspx)
Fair Trade	http://www.fairtradeusa.org/	Fair trade labels are specifically for developing countries
Florverde Sustainable Flowers	http://www.florverde.org/	Widely used by Colombian flower growers and includes environmental and social, worker and family elements
Veriflora	http://www.veriflora.com/	Certification is by Scientific Certification Systems and is based on a number of horticultural, logistical and human and worker rights criteria
Flower Label Program	http://www.fairflowers.de/	A limited program (as of 2011 in 6 countries) that promotes "socially and environmentally responsible flower, fern, plant and foliage cultivation"
Food Alliance	http://foodalliance.org/nursery	A very new label (first used for greenhouse and nursery certification in 2012), mainly USA based, with more than 330 certified organizations managing 5.5 million acres of production
USDA Organic	http://www.ams.usda.gov/AMSv1.0/nop	USDA Organic certification only refers to methods of production and is not an endorsement or certification of "sustainability"

all have the common goal of affirming that labelled products meet the minimum standards as defined for each program. The existence of multiple standards within the industry has been confusing for growers and industry members who have questioned the ultimate importance (economic, environmental, societal) of certification. Anecdotal evidence from growers suggests that having a range of MPS opinions consider "it's the right thing to do" to "whether I like it or not, my large customers are or will soon demand it". Evidence from greenhouse producers in The Netherlands suggests a 23% reduction in the use of "crop protection agents", and 25% decrease in energy use between 1995 and 2005 (Hering 2012). It is unclear to what

extent this can be ascribed to the MPS program, or if other factors are involved. In any case, the existence of the program gives a very important platform for growers to document their production inputs and provides a firm basis for making other production and marketing decisions.

Presently, in the United States, there is little movement towards a label requirement by major grocery or big box retailers (Hering 2012), but this is subject to change. Conversely, the Fair Trade label system, that was initially for food products such as coffee and tea, but increasingly for spices and other food ingredients, has grown rapidly in the USA (Gunther 2011).

Growers and their individual customers are confronted with a number of competing labels, and it is hoped that over time one of just a few major labels will emerge. However no one really knows the importance of this issue to the end consumer. To what extent is "responsible", "sustainable" or "organic" important to the consumer? Our prediction for North America is that while such labels and products will increase in importance over time, price will be the ultimate determinant of product availability and selection. If labelled products are more expensive than standard product, the product will remain as a niche item.

Carbon Footprints in Floriculture

Well before we had highly developed transportation systems, local greenhouses grew flowers for use within a limited area. Greenhouse firms were located very close to cities and villages, and the flowers that were produced were available to the customer within hours of harvest. In the United States, the post World War II boom in transportation infrastructure saw the movement of large-scale cut flower production to areas such as Colorado where higher elevation meant cooler summer temperatures and generally higher light availability, both key environmental factors in the production of a higher quality product. Thus, growers could grow better quality flowers and deliver them more quickly due to improved technology and improvements in infrastructure.

By the early 1970's it became clear that other production areas could be developed to serve the North American market, principally in South America (Colombia and Ecuador). Their even higher elevations and near-equatorial location provide excellent growing conditions, with high light, even day length and cool growing conditions all year round. In addition there is adequate air transportation to get flowers to the consumer (or, at least the wholesaler) within a few days of harvest. An added benefit at the time was very low wages, a lack of environmental, worker safety and social regulations. This led to very low production costs, and the opportunity for large profits to be made.

Thus, the route to maximum profit was to exploit the best growing regions (minimal cost for greenhouse structures, remove the costs for ventilation or heat, artificial assimilation lighting, and r elaborate environmental control systems, and source greatly reduced labour costs as against the traditional North American or Northern European production system of expensive glass greenhouses, extensive heating and

cooling systems, elaborate environmental monitoring and controls, a need for artificial lighting, winter carbon dioxide supplementation, and very high labour costs). The main disadvantage of the low-cost production areas was the need for relatively long distance transportation of the harvested flowers (invariably air transport). In earlier times there was little visible consideration of the environmental footprint (externalities) of flower production in low-cost regions, or where large projects were built in developing countries, partially on the basis on the grounds of improving local employment, wages and living standards.

By the early 2000's, people began considering the carbon footprint of many products including transportation, lifestyle, food and, ultimately flower production. A carbon footprint may be defined as: "the quantity of greenhouse gases (GHG), expressed in carbon dioxide equivalent (CO_2e), emitted across the supply chain for a single unit of that product" (Bockel et al. 2011). Ideally, a cradle to grave, full life cycle assessment is made, including the consumer phase, but with many products, flowers being one, the CO_2 cost of nominally tossing them onto the compost pile is minimal compared with carbon costs for heating greenhouses, operating assimilation lights, air freight or surface delivery. By necessity, many assumptions are made when calculating the carbon footprint. The International Organization for Standardization (ISO) has guidelines to help determine the carbon footprint. The main steps are to (1) define the goal and scope of the study to define boundaries, limitations, exclusions and procedures for determining the impact of processes when multiple products or functions can contribute; and (2) create a life cycle inventory, which for carbon dioxide, is the flow of CO_2 to and from nature and which carefully considers all inputs from the natural or man-made supply chain and emissions back to nature. The third step assesses the impact of the life cycle impact of all factors noted in the inventory are compared in equivalent terms to determine their environmental impact. Factors may be normalized or weighted according to parameters set out in the goals and scope process. The fourth step interprets and summarizes the results of the assessment phase with the ultimate goal. The ultimate goal "identifies the data elements that contribute significantly to each impact category, evaluating the sensitivity of these significant data elements, assessing the completeness and consistency of the study, and drawing conclusions and recommendations based on a clear understanding of how the LCA was conducted and the results were developed" (Anon 2013m).

Based on the above, there are few full and accurate CO_2 footprint assessments of floricultural products. One of the few is the life cycle comparison of CO_2 emissions for rose production in Kenya (sunny, excellent climate, requiring only minimally protective greenhouses, but requiring air freight shipment of the roses) versus "local" production in the Netherlands (high technology greenhouses, assimilation lighting, large heat requirement, but minimal local transportation requirements). The study at Cranfield University, England (Williams 2007) was essentially a "cradle to gate" analysis that ended with delivery of Dutch or Kenyan flowers to a distribution centre in the Netherlands. This allowed a direct comparison of the CO_2 cost of each production system in the supply chain.

Key findings were that carbon dioxide represented more than 90 % of the global warming potential (GWP) emitted by both systems. Production of 12,000 roses in

Table 11.2 Comparison of CO2 emissions and global warming potential for roses produced in the Netherlands and Kenya, and delivered to a common point in The Netherlands

Emission	Relative magnitude of (Dutch emissions/Kenyan emissions)	Altitude effect included?
CO_2	16	No
CO_2A^1	5.8	Yes
$GWP_{100}A^{1,2}$	6.0	Yes

Kenya and air freighting them to Holland required 53,000 MJ of primary energy and the emission of 2,200 kg CO_2. Dutch production was much more expensive: 550,000 MJ primary energy and the emission of 35,000 kg carbon dioxide. Dutch production required large inputs of natural gas (greenhouse heating) and electricity (assimilation lighting for photosynthesis) and ultimately yielded significantly fewer stems/hectare. The major carbon dioxide cost for Kenyan roses was air freight. In total, growing roses "locally" in The Netherlands incurred ca. 6-fold greater carbon dioxide emissions than growing roses in Kenya, even including the carbon cost of airfreight and specifically, allowing for a greater GWP for Kenyan airfreight due to the high altitude of greenhouse gas emissions of the cargo jet. A summary of this comparison is in Table 11.2.

This is highly contrary to instinct, as most people would believe that the air-shipped flowers would incur a much greater carbon cost. But this is not the case. Other horticultural examples are available, including apples, where southern hemisphere production and ocean shipment incur less carbon dioxide cost than "local" northern hemisphere production coupled with long-term cold storage (DEFRA 2008). Based solely on GWP and carbon dioxide footprint, Kenyan roses are much better for the environment and discerning consumers would be expected to choose these products and avoid purchasing the "local" Dutch-grown product. It should be noted that the Cranfield study apparently omitted other possibly significant emissions, such as… from the Kenyan rose farms that could have effects on nearby Lake Naivasha, its wildlife and ecosystem. Certainly, some consumers do base their purchasing decisions on carbon dioxide footprints and other attributes, but the proportion is not significant. Results of air mile labelling by two major British food chains revealed that air mile stickers had no effect on overall consumer preference and relative sales, suggesting that consumers, were only concerned with price and were not so concerned with carbon emissions that they avoided air-freighted fresh produce (Shah 2008).

Within horticulture, and perhaps floriculture especially, we must be constantly concerned with highlighting the value and improvements to our quality of life that flowers, plants and landscaping provide to humans. Studies such as that from Cranfield, while dispelling notions that all "local" product is more environmentally friendly, also highlight just how costly floriculture production can be to both the grower and consumer. Protected cultivation and the constant availability of flowers and plants that improve our lives (to say nothing of fresh fruits and vegetables) do indeed have an environmental cost. One can visit websites informing us that boiling a litre of water is the equivalent of 40 min of a Briton's projected daily 2050 carbon allocation, that a single beer is

equivalent to 7 h, and a bunch of Dutch grown flowers a whopping 24 days carbon allocation, or more environmentally correctly, only 4 days carbon allocation for Kenyan flowers! (Green Ration Book 2013). Using or ignoring such data is a personal decision but should be of concern for those wishing to improve the environment of our planet.

Ultimately, consumers (people) are presented with a dilemma when making a purchase choice. Do I chose the more carbon friendly product that also helps to employ many people and improve the local economic base (Kenyan roses) or do I purchase roses grown "locally" (in the UK, or the Netherlands) at a greater carbon cost? Another question might be do I try to consider the entire environmental footprint of production, where externalities such as water use and general environmental damage (as in Kenya) are increasingly known? The choice is not an obvious one, and it is likely the vast majority of people are unaware of the issues and for those who are, there is a lack of consistent and credible information. The worst case scenario is a consumer who is dissuaded from making a flower or plant purchase at all, based on fragmentary knowledge of these issues. Few things in life come without costs. Flowers, fruits and vegetables are no exception.

Perhaps the decision is best summarized in the poem below (Doughty 2013):

A Conversation Between Two Roses
"Choose me" said the white rose from Holland
"I am grown in a greenhouse, covered under special polythene
To protect me from heavy rainfall and harsh sun beams.
My soil is prepared from farmyard manure
And I am raised on a bed to make me secure.
Gravel sand at my roots to provide better drainage,
With a lush, porous soil to provide air without shortage.
Grown for six weeks I remain disease free
Avoiding desiccation through 80 % humidity!
Irrigated with acidic low-saline water,
To pitch-perfect pH and just the right moisture.
Fertilized daily for the first 13 weeks,
I dine on micronutrients until I reach my peak.
As I blossom and spread I am cut by machine
Then packaged and sprayed with protective citrine.
I have travelled by air to lie here in your store—
Nature and science combine in my core."
"No, choose me" said the red rose of Kenya.
"I was born and matured under natural sun-rays,"
I felt the four winds' caresses throughout my days.
African workers earned money from me—
The fourth biggest export from Kenya's economy!
My only regret is flying four thousand miles
And the crystals and vapour I left in my trails.
Despite my long journey I am still young and fresh
As I kiss British nostrils with my vibrant scent.
Who needs glass-houses or strange sediment?
To traditional farming I pay testament.
Side by side the roses wait
For the customer to decide their fate.
Pondering, she picks the Kenyan rose
To delight her conscience as well as her nose.

Fig. 11.16 Genetic variation in a Chrysanthemum breeding programme. (Photo credit: Jaap van Tuyl)

Genetic Variation

The variation of ornamentals across the world is enormous. Thousands of species are used as ornamentation, as they occur in nature and as complex hybrid where the variation is enlarged by application of breeding techniques. In the case of some ornamental species like rose, chrysanthemum, tulip, lily, narcissus, tens of thousands of cultivars have been bred. The history of breeding of ornamental plants goes back many centuries, but only a few crops have been well documented (Kingsbury 2009). For tulip, hyacinth and narcissus it has been described for 300–400 years (Doorenbos 1954). For rose and chrysanthemum (Fig. 11.16) it can be traced back to around 200 years (Zlesak 2006; Anderson 2006a, b). This is in contrast to the lily with a relative short breeding history of less than 100 years (Van Tuyl and Arens 2011). During domestication of the cultivated ornamental plant both inter-specific hybridization and polyploidization played an important role. All available genetic variation was used and through recombination, mutation and selection the variation pool has been enlarged continuously. More recently modern breeding techniques and tools like induced mutation induction, embryo rescue, artificial chromosome doubling, haploidization, genetic modification, molecular assisted breeding and genetic mapping are applied in ornamental breeding as well. Nowadays The Netherlands is leading in professional ornamental breeding (Van Tuyl 2012).

Conclusions

Flowers form an integral part of human life. Flowers are beautiful, have important symbolic significance, therapeutic and emotional value. Historically flowers are used globally in traditions and celebrations in human life.

Current commercial production and marketing of floricultural crops follows a complicated, ever-changing horticultural distribution supply chain.

There is increased interest in certification programs in order to grow ornamentals environmental friendly.

Innovation of the flower assortment is a continuous process. At national and international exhibitions developments are presented.

Ornamentals are grown worldwide. The Netherlands plays a central role in the trade, production and breeding of ornamentals. The large scale production (of roses) takes place more and more in the countries with an optimal climate (Kenya, Ethiopia) followed by transportation to the auction of Aalsmeer.

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