Bhavya Bhargava
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Vipasha Verma *Editors*

Ornamental Horticulture: Latest Cultivation Practices and Breeding Technologies

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Preface

Ornamental horticulture has undergone a transformative journey, evolving into a multidisciplinary field encompassing cutting-edge technologies and innovative practices. This edited volume, *Ornamental Horticulture: Latest Cultivation Practices and Breeding Technologies*, delves into the diverse realms of ornamental plant science, providing a comprehensive overview of the latest advancements. The chapters within this book navigate through the intricacies of ornamental horticulture and landscape gardening, presenting an insightful introduction to the field. The journey begins with a meticulous exploration of protected cultivation, unraveling the details of microclimate control, fertilization, and the integration of artificial intelligence and robotics in ornamental crop cultivation. The subsequent chapters illuminate the landscape of ornamental plant breeding, where traditional and molecular breeding converge to create cultivars with enhanced floral attributes. Molecular breeding emerges as a transformative force, utilizing CRISPR-Cas9, TALENs, and ZFNs to fortify stress tolerance/resistance and diversify the spectrum of ornamental plants. The narrative unfolds further, exploring strategies for biotic and abiotic stress resistance breeding, emphasizing the imperative need for sustainable practices in floriculture. A spotlight is then cast on recent developments in soilless cultivation, elucidating its implications in floriculture. The chapters seamlessly transition into the realm of micropropagation, unraveling the particulars of plant tissue culture techniques as powerful tools for mass propagation and genetic improvement of ornamental plants. The subsequent exploration of tissue culture-mediated interventions brings forth the necessity of biotechnological approaches for conservation and development, mitigating the loss of genetic diversity. The narrative progresses into the future with chapters on transgenic approaches and genome editing, unlocking the potential to accelerate the breeding of ornamental crops. The integration of omics technologies paints a comprehensive picture of ornamental plant research, while smart farming systems unveil the potential for sustainable cultivation practices in the floriculture sector. As we delve into the later chapters, the focus shifts to preharvest and postharvest technologies, revealing strategies to enhance crop longevity and quality. The concluding section of the book delves into the integration of wild plant species in ornamental horticulture, paving the way for a promising future. Following this, the discussion transitions to the innovative use of ornamental plants in urban infrastructure, highlighting their role in enhancing biodiversity and mitigating environmental challenges through green walls, green

roofs, and urban city landscapes as naturebased ecological solutions. The emphasis then shifts to the importance of knowledge transfer and collaboration among researchers, practitioners, and the public to foster innovation and best practices in the field. Finally, the book delves into the cutting-edge applications of nanotechnology in ornamental horticulture, showcasing its potential to revolutionize research in ornamental crops. The richness of this edited book lies not only in its detailed exploration of each facet of ornamental horticulture but also in its cohesive structure that weaves together the diverse threads of scientific progress. Each chapter serves as a building block in the construction of knowledge, fostering a deeper understanding of the intricate science behind the cultivation and breeding of ornamental plants. This compilation stands as a testament to the collaborative efforts of experts in the field, offering a valuable resource for researchers, academicians, and practitioners alike, striving to propel ornamental horticulture into a future of sustainable and innovative practices.

Palampur, India — Bhavya Bhargava
Solan, India — Pankaj Kumar
Palampur, India — Vipasha Verma

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Pankaj Kumar is currently an Assistant Professor in Biotechnology at Dr. Yashwant Singh Parmar University of Horticulture and Forestry in Solan, Himachal Pradesh, India, and holds a rich academic background. With postdoctoral stints at the National Institute of Plant Genome Research in New Delhi and the Council of Scientific and Industrial Research—Institute of Himalayan Bioresource Technology in Palampur, Himachal Pradesh, he brings over 12 years of expertise in horticulture biotechnology. He has contributed significantly to developing technology for insect pest-resistant transgenic plants in important vegetable crops and has a remarkable publication record, including numerous papers, book chapters, and patents. His scientific contributions have earned him prestigious awards like the DST INSPIRE Fellowship and recognition from organizations like ICMR and CSIR.

Vipasha Verma is currently a CSIR-Senior Research Associate (CSIR-Pool Scientist) at the Agrotechnology Division, CSIR-IHBT, Palampur, India. She worked as a Principal Project Associate in the CSIR-Floriculture Mission-I at the same institute. Previously, Dr. Vipasha conducted her postdoctoral research under the mentorship of Prof. Jian Kang Zhu at the Shanghai Center for Plant Stress Biology, a testament to her expertise and dedication to plant science. With extensive postdoctoral research experience in both national and international laboratories, Dr. Vipasha has specialized in plant genetic engineering and stress biology. She is a recipient of the prestigious DST INSPIRE-JRF Fellowship and has qualified the ICAR-ASRB National Eligibility Test. Her academic contributions are extensive, including two patents (international and national), 16 research papers, four book chapters, and three popular articles. Her work has been recognized and presented at numerous international and national conferences.

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1 Ornamental Horticulture and Landscape Gardening: An Overview and Introduction

A. Sumalatha, Kalkame Ch. Momin, and V. Bhargav

Abstract

The production of ornamental plants and floriculture is by far the most diverse sector of horticulture. Relying on a long tradition of cultivar selection and improvement, highly specialized subsectors have emerged. The ornamental horticulture comprises two parts, viz. ornamental plants which encompasses a wide array of plants and includes the production and marketing of herbaceous plants, bedding plants, flowering plants, foliage plants or houseplants, cut cultivated greens, and cut flowers and landscape gardening industry that involves the cultivation, maintenance of plants, and beautification of an area. Ornamental horticulture and landscape gardening has blossomed into commercial activity with considerable growth and a useful crop diversification option, particularly for small farmers over the past three decades. The ornamental industry has witnessed commendable changes with the growth of cities, population explosion, and with the growing habit of "saying it with flowers." Due to the changing lifestyle, the present-day ornamental and landscape industry has become one of the most dynamic and fast-growing sectors with a significant rate of growth and achievement during the past few years and has extended worldwide with the major production centers shifting, i.e., from developed to developing countries.

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Keywords

Flowers · Landscape · Garden · Ornamental · Future · Trends · Technology

1.1 Introduction

Floriculture encompasses four primary elements: cut flowers, potted plants (including potted flowers and potted greens), cut leaves, and bedding/garden plants. Floricultural items necessitate a greater initial investment in comparison to fruits and vegetables. Consequently, their profitability per unit area surpasses that of other crops used for agriculture. Over 120 countries worldwide actively engage in floriculture production. Japan has the highest production value of $3.7 billion, followed by The Netherlands with $3.6 billion and the USA with $3.3 billion. Together, these three countries contribute to almost half of the world's total production value (Papademetriou and Dadlani 1998). Over the course of the last three decades, floriculture has grown significantly into a commercial industry and has become a valuable crop diversification alternative, especially for small farmers. Ornamental horticulture and landscape gardening are closely related fields within the broader domain of horticulture that focus on the cultivation, design, and maintenance of plants for aesthetic purposes in outdoor spaces. Both disciplines involve the deliberate arrangement and care of plants to enhance the visual appeal of gardens, parks, and other landscapes. Ornamental horticulture is a branch of horticulture that deals with the production, propagation, and management of plants primarily for decorative and aesthetic purposes. It encompasses a wide range of plants, including flowers, ornamental trees, shrubs, climbers, and other planting materials such as bulbous plants, pot plants, lawn grass, and ground cover. (Ingels 2000). On the other hand, landscape gardening involves the planning, design, installation, and maintenance of outdoor spaces with a focus on aesthetic, environmental, and functional considerations. It includes the selection and arrangement of plants as well as the integration of hardscape elements like pathways, water features, and structures to create visually pleasing and functional landscapes (Brown and Corry 2011).

1.2 Importance of Ornamental Horticulture and Landscape Gardening

Ornamental horticulture and landscape gardening contribute to various aspects of human well-being, environmental sustainability, and community development creating healthier, more livable spaces. It has given rise to a multifaceted sector that includes growing and raising plants for ornamental purposes, landscaping, producing growing media, pots, and other accessories, among other things. This has greatly increased employment opportunities while also encouraging environmentally beneficial activities. Whether in urban areas or rural areas, the use of ornamental plants in landscaping and various green spaces (parks, gardens, and roads) greatly enhances

the quality of people's lives (Rocha et al. 2022). The importance of ornamental horticulture and landscape gardening can be discussed under the following headings:

1.2.1 Aesthetic Enhancement

Ornamental horticulture and landscape gardening play a crucial role in enhancing the visual appeal of outdoor spaces. Well-designed landscapes contribute to the beauty of residential areas, public parks and urban environments, creating aesthetically pleasing surroundings (Hartig et al. 2011). Every country's wealth is correlated with the people's health. By providing open green spaces for clean air via bio-aesthetic design and landscape gardening, we can assure the healthy growth of the citizens, particularly the younger generation and establish a thriving nation and healthy society.

1.2.2 Environmental Benefits

At all spatial scales, global, local and individual, ornamental plants continue to offer environmental advantages that are critical to human survival. Plants contribute to the oxygen production, maintain the carbon sinks, combat pollution, improves the erosion control, water management, and indoor air quality, maintains the biodiversity, acts as a windbreak, provides urban shade and green space (Okunlola et al. 2016).

1.2.3 Psychological Well-being

Access to well-designed outdoor spaces positively impacts mental health and well-being. Ornamental horticulture and landscape gardening create environments that offer opportunities for relaxation, stress reduction and emotional rejuvenation (Velarde et al. 2007). Horticulture therapy is being utilized in psychiatric hospitals, general hospitals, physical rehabilitation centers, homes for elderly, prisons and schools for achieving higher level of personal development and satisfaction.

1.2.4 Property Value Appreciation

Landscaped properties are often more attractive to potential buyers and tenants, leading to increased property values. A well-maintained and aesthetically pleasing landscape can be a significant asset in the real estate market (Coder 2011). Higher the presence of the green cover or green space, higher will be its property value. For instance, presence of a tree cover in the surrounding areas or presence of well-maintained hedge along with a landscaped wall raises the economic value of the house.

1.2.5 Social and Community Benefits

Landscaped areas provide communal spaces for social interactions and community activities. Parks, gardens, and green spaces become focal points for community gatherings, fostering a feeling of unity and belonging in society (Carmona 2021). Additionally, the locals value and take pride in it, providing opportunities for sharing value interest and commitments. Engaging the community in beautification initiatives also improves the overall well-being of the neighborhood.

1.2.6 Urban Heat Island Mitigation

Well-designed landscapes with a mix of trees and greenery help mitigate the urban heat island effect by providing shade, reducing surface temperatures, and enhancing overall thermal comfort in urban areas (Akbari 2005). The urban heat island raises the temperature in cities and suburbs by 1–6 °C in comparison to the nearby rural areas (Jabbar et al. 2023). Creating "green roofs" on top of the buildings in urban areas can help in reducing the urban heat where by turning water into vapor, the plants can absorb heat energy which would usually heat the air around them (McPherson 2005).

1.3 Historical Perspective

Ornamental horticulture has a rich and diverse history that spans centuries, shaped by the cultural, artistic, and scientific influences of different societies. The cultivation of plants for aesthetic purposes dates back to ancient civilizations, with a gradual evolution that has continued to the present day. Additionally, the origin of ornamental horticulture can be traced to ancient civilizations such as Mesopotamia, Egypt, and China. In these cultures, gardens were created for both practical and decorative purposes, showcasing a variety of plants for their beauty and symbolism. These early gardens combined practical and aesthetic elements, featuring water features, symmetrical layouts, and an array of ornamental plants (Ciarallo 2000).

Among the different cultures from history, ancient Greece and Rome made significant contributions to ornamental horticulture. The Greeks cultivated gardens with an emphasis on symmetry and balance, while the Romans incorporated elaborate gardens into their villas, featuring various plants, fountains, and sculptures. The Greeks favored the concept of sacred groves, while the Romans incorporated elements such as terraces, statues, and columns into their gardens, setting the stage for later European landscape traditions (Hunt 1992). Later on during the Islamic Golden Age, ornamental horticulture reached new heights with the development of intricate gardens. Islamic gardens, characterized by geometric patterns, water features, and fragrant plants, highlighted a fusion of art, science, and nature (Ruggles 2008). Similarly, medieval gardens were often associated with monasteries and castles.

These gardens featured herbs, medicinal plants often had a symbolic or religious significance, reflecting the societal values of the time (Landsberg 2003).

The Renaissance era witnessed a revival of interest in classical aesthetics, leading to the creation of formal gardens in Europe. Influential garden designers like André Le Nôtre in France and Capability Brown in England played key roles in shaping the ornamental landscapes of this period. In the eighteenth century, the English Landscape Movement emerged as a reaction against the rigid formality of French gardens. Designers like Capability Brown emphasized naturalistic landscapes, incorporating rolling hills, lakes, and carefully placed trees to create picturesque scenery (Colvin 1978; Hunt 2016). The Age of Exploration in the eighteenth and nineteenth centuries contributed to the introduction of exotic plants through botanical expeditions. Botanical gardens emerged as centers for plant collection, research, and the exchange of horticultural knowledge among the different genera of the world (Moss 2018). The Victorian era saw a resurgence of interest in ornate and highly embellished gardens and their design became an expression of social status and the inclusion of intricate features such as gazebos, ornamental structures, and exotic plants became popular (Chambers 1988). During the later part of the 20th century, professional horticultural organizations started, new plant cultivars were developed through crop improvement programs and ornamental plants were integrated into urban planning that marked a revolutionary effect of gardening and landscaping in urban areas. Today, ornamental horticulture encompasses a lot of practices from landscape design to floriculture and urban greening. The modern principles influence landscape design with an emphasis on functionality, simplicity, and a closer integration of outdoor spaces with architecture (Rickard 2011). This brief history highlights the evolution of ornamental horticulture from its ancient roots to the present, reflecting the dynamic interplay between cultural, artistic, and scientific influences over time.

1.3.1 Influential Figures in the Field of Ornamental Horticulture and Landscape Gardening at a Global Level

André Le Nôtre (1613–1700) was a French landscape architect, is renowned for his work on the Gardens of Versailles. He perfected the classical French formal garden style, characterized by geometric layouts, grand avenues, and meticulously manicured lawns. Lancelot Capability Brown (1716–1783) was an English landscape architect who played a pivotal role in the English Landscape Movement. His designs focused on naturalistic landscapes, using flowing water, strategically placed trees and open vistas to create visually stunning and harmonious environments. Frederick Law Olmsted (1822–1903) also considered the father of American landscape architecture, co-designed Central Park in New York City. His work emphasized the integration of natural elements with urban planning and he championed the idea that well-designed public spaces contribute to the well-being of city dwellers. Gertrude Jekyll (1843–1932) was an influential English garden designer, and Jekyll was a key figure in the Arts and Crafts movement. She is known for her innovative use of

color, texture, and plant combinations in cottage-style gardens and her ideas have had a lasting impact on garden design. Roberto Burle Marx (1909–1994) was a Brazilian landscape architect, and Marx was a pioneer in modernist landscape design. He integrated indigenous plants and art into his designs, contributing significantly to the development of tropical modernist landscapes. Piet Oudolf (Born 1944) was a contemporary Dutch garden designer, Oudolf is known for his naturalistic and sustainable planting designs. His work often emphasizes the use of perennial plants, seasonal interest, and a focus on ecological principles in garden design. Beth Chatto (1923–2018) was a British plant woman and garden designer, Chatto was known for her expertise in using plants suited to specific environmental conditions. Her gardens showcased the concept of ecological gardening and the importance of understanding and respecting natural habitats.

1.3.2 Influential Horticulturists in the Field of Ornamental Horticulture and Landscape Gardening in India

India has a rich tradition of ornamental horticulture and landscape gardening, with several influential figures who have contributed significantly to the development and promotion of these disciplines. These individuals have played key roles in shaping the aesthetic and environmental aspects of gardens and landscapes across the country.

M. S. Randhawa (1909–1982) known as the "Father of Horticulture in India," M. S. Randhawa made significant contributions to the field of ornamental horticulture during post-independence era of Indian history. He served as the Director of Horticulture for the Indian government and played a pivotal role in the growth of numerous gardens, which includes Mughal Gardens in Rashtrapati Bhavan, New Delhi. Prabha Shankar Shukla (1912–1986) was an eminent landscape architect; Prabha Shankar Shukla was a pioneer in the field of landscape architecture in India. He contributed to the design of various public spaces, including the landscaping of major institutions and the planning of urban parks. His work emphasized a harmonious blend of traditional Indian elements with modern design principles. Geoffrey Jellicoe (1900–1996) was a British by birth though he has great influence in Indian landscape architecture. He collaborated on projects such as the Rock Garden of Chandigarh with Nek Chand, that reflection of a synthesis of Western and Indian design philosophies. Nek Chand (1924–2015) was a self-taught artist and visionary, created the Rock Garden of Chandigarh, a unique and expansive garden featuring sculptures made from industrial and home waste. His innovative approach to landscaping transformed a neglected area into an artistic and ecological masterpiece. Gulab Bai (1910–2001) also known as the "Rose Lady of India"; Gulab Bai was a renowned horticulturist who dedicated her life to the cultivation and promotion of roses. Her efforts led to the establishment of the National Rose Garden in Chandigarh, showcasing an extensive collection of rose varieties. Agha Khan Trust for Culture (AKTC) has played a significant role in the restoration and revitalization of historical gardens and landscapes in India. Through projects like the restoration of Sunder

Nursery in Delhi, the AKTC has contributed to the preservation of cultural and environmental heritage. Lalbagh's Horticulturists (Hyder Ali and Tipu Sultan) established Botanical Garden in Bangalore owes much of its design and development to the efforts of Hyder Ali and Tipu Sultan. These rulers of the Kingdom of Mysore were passionate horticulturists and established Lalbagh as a center for the cultivation of rare plants and the promotion of horticultural practices.

These influential figures have left a lasting impact on the field of ornamental horticulture and landscape gardening in India. Their work continues to inspire contemporary practitioners and contributes to the cultural and environmental heritage of the country.

1.4 Scenario of Floriculture in the World

The global floriculture market has been reported to exhibit an annual growth rate of 6.3% and is expected to increase approximately twofold by 2033 from USD 57.5 billion in 2023 and is projected to reach USD 106.1 billion (Future Market Insights 2023). There are nearly 90 countries actively involved in worldwide floriculture trade. Cut flowers and bedding plants together account for a voluminous share of nearly 70% of the trade. Flowers are becoming more and more popular, especially in developing economies like East Asia, China, India, and Russia as well as Eastern Europe. Developed nations in North America, Europe, and Asia meet almost 90% of the global demand. The majority of international floriculture trade is structured along regional lines. Japan and Hong Kong's are the primary suppliers in the Asia-Pacific region. The largest suppliers to the major European markets are from Africa, the Middle East, and other European nations; Ecuador and Colombia rule the flower markets in the USA (Annonymous 2023).

In order to cater to international markets, florists are gradually switching from standard cut flowers to specialized cut flowers. Global consumption has increased, but consumers' demands for new products have also evolved as they have become more sophisticated. Production has continued to shift from historically consumer and grower-focused nations like the Netherlands to more newly producing nations like Ecuador, Colombia, Ethiopia, and Kenya in order to supply this expanding and shifting demand. With an overall share of almost 70% of the global cut flower and foliage export market, Europe continues to hold its top export position. The Netherlands remains the largest exporter of flowers and live plants around the world with nearly 52% share in the global trade. It is followed by countries like Columbia (15%), Ecuador (9%), Kenya (7%), Belgium (3%), Ethiopia (2%), Malaysia, Italy, Germany, and Israel (1% each) (Faust and Dole 2021). When it comes to the global export value for orchid flowers, Thailand comes in second place with an estimated value of 31.6%, while the Netherlands comes in first place with a total value of exports of 111.7 million US dollars (48.2%).

According to the Flower Council Holland, preference of consumers toward potted plants is increasing. Flower labeling alters the consumer preferences. Sustainability labels strengthen consumer confidence and are an incentive for more

sustainable choices. Six out of ten (59%) of respondents has noticed sustainability labels when purchasing flowers and plants. Of those, 43% indicates they trust the sustainability label (Flower Council Holland 2023). The global dried flower market size is USD 0.135 billion in 2023. Dried Flowers Market size is projected to reach Multimillion USD by 2029, In comparison to 2022, at unexpected CAGR during 2022–2029. India leads the world in dry flower exports with 4279 shipments, then comes China with 2563 shipments and Ecuador in third place with 1609 shipments (Volza 2023).

1.5 Status of Floriculture in India

The 1980s and 1990s saw a rise in the commercial floral trade in India. The floriculture industry has benefited greatly from the implementation of economic reforms and linearization policies in 1991 as well as from the amended EXIM policies of 1995–1996 and 1999–2002. With a 0.6% contribution to the worldwide floriculture trade, India is ranked eighteenth. In the last 10 years, exports grew at a 4.33% compound annual growth rate. According to Vahoniya et al. (2018), the Indian domestic market is expanding at a rate of 25% annually throughout the entire nation. According to IMARC (2023), the value of the Indian floriculture market was Rs. 262.1 billion. Although flower growers are still mostly driven by exports, domestic flower demand is rising at an exponential rate, particularly in major cities and metro areas. Consumers now purchase flowers for many occasions, including Valentine's Day, weddings, birthdays, anniversaries, friendship days, Mother's Day, Father's Day, and so on, as a result of modernization and the spread of western cultural influence. During religious celebrations, there is also widespread flower consumption throughout the nation. Flowers are grown in an area of 2.76 lakh ha with a production of 29.36 lakh MT (includes 22.98 lakh MT of Loose flowers and 6.38 lakh MT of cut flowers during the year 2017–2018 (NHB Database 2023). Nearly 60–70% of Indian floriculture exports (USD 4.17 million) comprise of dry flowers in 2020–2021. The export markets for dry flowers are mainly concentrated in European Union (Germany majorly) and the USA. West Bengal (India) accounts for about 70% of the dried flower export from India (Bose et al. 2022). In the year 2022–2023, India has exported 21,024.21 MT of floriculture products worth of Rs. 707.81 crores (88.38 million USD) and a share of 0.03% of the total exports. The major export destinations are the USA, the Netherlands, UAE, United Kingdom, Germany, and Malaysia (APEDA 2023). The large demand from Europe and the UK exists for Indian Roses grown in Pune and Bengaluru.

India's floriculture business is known for its traditional flowers and cut flowers, which are raised in open fields and protected environments, respectively. India has the potential to have a significant dried flower business that contributes significantly to global trade. The rise of the floriculture sector in India has also been significantly aided by other sectors, including value-added products, fillers, plant pots, seeds and planting materials, the turf grass industry, and fillers.

The growth in the global floriculture market has taken a major fillip due to the recent advances in the field of plant biotechnology, genetic engineering, genome sequencing, digitization, and e-commerce. Further the adoption of new and novel techniques, the use of modern farm practices, and the creation of blooming plants with genetic modifications have raised food productivity and increased the profitability of farmers engaged in floriculture.

1.6 The Future

The future of ornamental horticulture holds exciting possibilities as technology, environmental awareness, and changing consumer preferences continue to shape the industry. Ornamental horticulture, which involves the cultivation and management of plants for aesthetic purposes, encompasses a wide range of activities, from landscaping to floral design. Several trends are likely to influence the future of ornamental horticulture:

Sustainable landscaping involves design and maintenance practices that aim to create and maintain healthy, functional landscapes while minimizing negative environmental impacts through implementing water-efficient irrigation systems, utilizing rainwater harvesting, and choosing drought-tolerant plants (Ghazal 2019), using organic mulches, compost, and avoiding excessive use of synthetic fertilizers to promote soil fertility and structure (Sorvig and Thompson 2018), incorporating native plants, adapted to local conditions, to promote biodiversity and reduce water and chemical inputs (Sellmer 2010), minimizing the use of pesticides and herbicides (Bethke 2009). Additionally, Wildlife-friendly gardens are designed to attract, support, and sustain various forms of wildlife, including birds, insects, and other fauna by introduction of native plants that provide habitat and food for local wildlife along plants, shrubs, and trees that offer nesting sites and shelter for birds and insects.

Energy-efficient through landscaping aims to reduce energy consumption in buildings and outdoor spaces (Conner 2009) including planting trees strategically to provide shade to buildings, reducing the need for air conditioning, improved windbreaks, viz., shrubs or trees, to reduce heat loss and wind chill around buildings. Moreover, incorporation green roofs and walls to provide insulation and reduce heat absorption in buildings will have great effect in energy conservation. Incorporating sustainable landscaping practices, wildlife-friendly elements, and energy-efficient strategies not only is beneficial to the environment but also creates healthier, more resilient outdoor spaces. These practices align with principles of conservation, ecological balance, and responsible land management.

Advancements in technology are reshaping ornamental horticulture, offering innovative solutions for plant care, landscape design, and overall garden management. Integration of sensor-based irrigation systems that adjust watering schedules based on real-time weather conditions, soil moisture levels, and plant requirements along with use of precision agriculture technologies, such as drones and satellite imaging, for detailed analysis of plant health, pest infestations, and overall

landscape conditions. There has been advancements in the field of biotechnology like the CRISPR technology for precise editing of plant genomes, enabling the development of new plant varieties with enhanced aesthetic qualities and resilience. In the field of landscape designing, advanced technologies like integration of augmented reality (AR) tools allows the clients and designers to visualize and plan garden designs and to experience virtual landscapes before implementation of the design.

1.7 Emerging Design Trends in Ornamental Horticulture

Design trends in ornamental horticulture reflect evolving preferences for aesthetics, sustainability, and the integration of natural elements. Some of the key emerging design trends influencing the realm of ornamental horticulture are as follows.

1.7.1 Wildlife-Friendly Landscapes

Wildlife-friendly landscapes play a crucial role in fostering biodiversity, maintaining ecological balance, and enhancing our connection with nature. By incorporating native plants, creating bird habitats, and incorporating insect-friendly features, these designs support a thriving ecosystem.

In India, initiatives like the "Butterfly Garden" at the Bengaluru, Bannerghatta Biological Park showcase the importance of native plants in attracting diverse butterfly species, contributing to pollination and overall biodiversity. Such landscapes not only protect endangered species but also create resilient ecosystems that benefit the environment and human well-being. The emphasis on wildlife-friendly designs aligns with India's commitment to sustainable development and conservation efforts.

1.7.2 Edible Landscapes

Edible landscapes represent a fusion of aesthetics and functionality, where ornamental spaces are designed to incorporate edible plants. This approach not only enhances the visual appeal of landscapes but also contributes to sustainable food production, promotes urban agriculture, and provides opportunities for garden-to-table experiences.

In India, terrace gardens with a variety of edible plants, including herbs, fruits, and vegetables, exemplify the concept of edible landscapes. These spaces not only offer fresh produce but also contribute to food security, encourage self-sufficiency, and foster a deeper connection between individuals and their food sources. Embracing edible landscapes aligns with India's growing interest in sustainable living practices and the promotion of locally sourced, organic foods.

1.7.3 Biophilic Design

Biophilic design is crucial as it recognizes the innate human need for a connection with nature. By incorporating natural elements like materials, textures, and patterns into outdoor spaces, it has a profound impact on mental well-being and productivity. This approach creates environments that resonate with people on a fundamental level, fostering a sense of harmony and tranquility.

In India, the Lodha Group's Palava City project in Mumbai exemplifies biophilic design principles. The development integrates green spaces, natural materials, and water features, promoting a closer connection with the environment. Such initiatives contribute not only to the visual appeal of spaces but also enhance the overall quality of life for residents, aligning with the importance of biophilic design in creating sustainable and people-centric urban landscapes.

1.7.4 Vertical Gardening and Green Walls

Vertical gardening and green walls are gaining popularity for their ability to maximize limited space, provide environmental benefits, and enhance the visual appeal of landscapes. The importance of these features lies in their multifaceted impact on space optimization, improved air quality, and aesthetic enhancement.

In densely populated urban areas in India, vertical gardens on building facades and green walls in public spaces are becoming common. These installations not only beautify the surroundings but also contribute to air purification, noise reduction, and temperature regulation. As urbanization increases, incorporating vertical greenery becomes essential for creating healthier and more sustainable living environments. At the same time, in India, examples like the Green Wall at the Bengaluru International Airport showcase how vertical gardens enhance urban environments, improving air quality and providing visual appeal. These designs address the growing challenge of urbanization while contributing to a sustainable and green future. Vertical gardening aligns with India's push for green infrastructure and urban planning that prioritizes both aesthetics and ecological well-being.

1.7.5 Climate-Resilient Landscaping

As climate change becomes a critical factor, there is a growing focus on landscaping practices that enhance resilience and adaptability. Some of the emerging design trends shaping the landscape of climate-resilient ornamental horticulture are:

1.7.5.1 Drought-Tolerant Planting

Drought-tolerant planting is crucial for water conservation and minimizing environmental stress on plants, especially in regions facing water scarcity. By using plants adapted to low-water conditions, this approach contributes to sustainable landscaping and resilience in the face of dry periods.

In India, where several regions experience water shortages, adopting drought-tolerant plants is imperative. Examples include the use of native succulents, like Aloe Vera and Agave, in landscaping projects. These plants not only thrive in arid conditions but also require minimal irrigation, promoting water efficiency. Embracing drought-tolerant planting aligns with India's commitment to sustainable water management and helps create landscapes that are both visually appealing and environmentally responsible.

1.7.5.2 Climate-Adaptive Plant Selection

Climate-adaptive plant selection is vital for landscaping in the face of climate change. By choosing plant varieties that can thrive in a spectrum of climatic conditions, including temperature extremes and changing precipitation patterns, this approach enhances the resilience of landscapes and minimizes maintenance challenges.

In India, where diverse climatic zones exist, the importance of climate-adaptive plant selection is evident. For instance, the use of native trees like Neem (*Azadirachta indica*) and adaptable flowering plants like Bougainvillea exemplifies a strategy that can withstand varying environmental conditions. Such selections not only ensure increased plant survival rates but also reduce the need for intensive maintenance, contributing to sustainable and resilient landscaping practices. This approach aligns with India's efforts to adapt to climate change and create landscapes that can thrive despite unpredictable weather patterns.

1.7.5.3 Green Infrastructure Implementation

Implementing green infrastructure, encompassing elements like permeable pavements, rain gardens, and bioswales, is crucial for effective storm water management and reducing flooding risks. The importance lies in improving water management practices and enhancing urban resilience in the face of changing climate patterns.

In India, where rapid urbanization often strains existing drainage systems, green infrastructure plays a vital role. Examples include the incorporation of permeable pavements in parking lots and the creation of rain gardens alongside roads. These strategies help absorb rainwater, reduce runoff, and prevent flooding in urban areas. As climate-related challenges increase, integrating green infrastructure becomes essential for sustainable urban development, aligning with India's commitment to resilient and eco-friendly cities.

1.7.5.4 Data-Driven Decision-Making

Data-driven decision-making in landscaping involves leveraging climate data and predictive analytics to inform design choices and plant selection based on anticipated climate scenarios. This approach is crucial for proactive adaptation and minimizing the risk of plant loss due to extreme weather events.

In India, where climate variability poses significant challenges, using data-driven insights is becoming increasingly important. Landscape architects and urban planners can utilize climate data to anticipate temperature fluctuations, rainfall patterns, and other environmental factors. For example, selecting heat-tolerant plants in

anticipation of rising temperatures or choosing drought-resistant species based on predicted changes in precipitation. This proactive approach aligns with India's efforts to build climate-resilient landscapes and ensures sustainable, long-term success in the face of climate uncertainties.

The future of ornamental horticulture is marked by a convergence of technology, sustainable design, and climate-resilient practices. These trends reflect a holistic approach to creating aesthetically pleasing, ecologically responsible, and adaptable outdoor spaces.

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2 Protected Cultivation of Floriculture Crops: Innovative Technologies and Future Challenges

Rishu Sharma, Simrat Singh, Kritika Pant, Harkirat Kaur Mashiana, and R. K. Dubey

Abstract

There is a vast potential for the export of high-value ornamental crops in the global floriculture trade owing to the novelty of flower crops. A rapid increase in population, increasing impact of climate change, reduction in land holdings, indiscriminate use of natural resources, and increased quality flower production have resulted in a shift towards protected cultivation. In protected cultivation microclimate surrounding, the plant body is controlled partially or fully, which regulates and provides optimum conditions of light, temperature, humidity, CO_2, and air circulation, besides the precise application of inputs, for ideal growth and development of plants. This chapter highlights recent advances that have been made in protected cultivation of ornamentals in the field of environment regulation, fertilizer application, use of plant growth regulators, substrate mixes, and use of AI and robotics in cultivation of ornamental crops.

Keywords

Ornamentals · Floriculture · Light · Microclimate · PGRs

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