A Review of the Growth of Flowering Plants in A Greenhouse Under Different Climatic Conditions

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Abstract:

In the last 20 years, global ornamental production and consumption have surmounted significant obstacles. Floriculture and landscape horticulture are two types of ornamental horticulture. Each is concerned with plant cultivation and sales, as well as the allied professions of floral and landscape design. Sustainable development of floriculture requires modern and environmentally friendly solutions that would maximize the plant's potential. Substrates, fertilisers, Plant Growth Regulators (PGRs), and bio stimulants all play a key part in upgrading ornamental crop production. Light, temperature, and humidity are all important aspects of plant care. The objective of this review article is to show how to attain commercial floriculture production sustainability. This takes place regarding the problems of climatic conditions connected with the biology of ornamental growth and flowering of (Rose, Hibiscus and Marigold) in the greenhouse. This method of cultivation positively affects plant quality and works out modern cultivation technology. Moreover, this review identifies the physiological and molecular foundation of flowering processes, as well as the primary tactics used in greenhouse floriculture for cut flowers and blooming ornamental production scheduling. Climate conditioning techniques such as temperature management (before or during plant cultivation) and light environment control, in terms of both quantity (intensity or duration) and quality, were given special emphasis. The goal of this method is to provide the scientific basis for the most popular practical strategies for driving greenhouse crops into commercial floriculture. In addition to greenhouse redesign, the technique of optimal greenhouse environment control was investigated.

Keywords: *Plant Biology, Greenhouse, Floriculture, Plant Growth Regulators, Biostimulants, Rosa Hybrida, Tagetes Erecta, Hibiscus Sabdarifa, Climatic Factors.*

1. INTRODUCTION TO PLANT BIOLOGY

Plant biology includes both fundamental and applied plant sciences that build on basic scientific findings and develop cutting-edge technology through innovation and agricultural application. Plant anatomy, morphology, and evolution, plant physiology, and plant molecular and cellular biology are the four main categories that derive from the core topics of Plant Biology [1]. Many more subfields within the applied plant sciences have been divided into major subfields, including vegetable, fruit, and nut crops; floriculture; horticulture; postharvest physiology; agronomy and weed science; plant pathology and plant breeding; and genetic modification of crops, as well as broader research areas like plants and the environment; tropical crops and ecosystems; forestry; and sustainability.

Floriculture is the cultivation and trade of flowers. It encompasses flower production, processing, marketing, and distribution. The first recorded evidence of Floriculture dates back to the early 1500s when flowers were grown in greenhouses in Holland. Today, Floriculture is a multibillion-dollar industry with a global reach. In the United States, Floriculture is a nearly $20 billion industry, with California being the top producer of flowers. The Netherlands is the world's largest exporter of flowers, followed by Germany and Italy and production systems; and conservation biology of crop plants. Floriculture is a branch of ornamental horticulture concerned with the cultivation, sale, and display of flowers and decorative plants. Blooms and potted plants are primarily grown in plant-growing systems in temperate areas, while some flowers are cultivated outdoors in nurseries or crop fields. Indian culture and society have traditionally valued flowers [2]. Floriculture has achieved industrial status and acquired a significant pace in recent years as a result of globalisation and the free market economy. However, this industry is still in its infancy and contributes just a small portion of worldwide exports. For the next generation of farmers, floriculture is a feasible and profitable option. India has a good opportunity of achieving a significant place on the global floriculture platform if it recognises its full potential. This involves both bedding plant cultivation and the creation of cuttings for growing in greenhouses or as indoor houseplants.

1.1 Types of Flowers Grown for Floriculture

The types of flowers grown for Floriculture are largely dictated by the climate and the market demand. However, roses and orchids (which also happen to be the highest value flowers in the floriculture industry) are grown throughout the world. Certain varieties of these high-value crops have been developed for specific climates as well. The types of floriculture are listed below. [3]: -

Bedding Plants: Annual plants produced for use in flower beds outside are known as bedding plants. It all starts with sowing seeds indoors throughout the winter and transplanting the plants later in the growth season.

Hanging Plants: Flowering or foliage roses in attractive pots are suspended from the ceiling in the patio, the gateway area, or from artistic plant poles by magnificent ropes.

Potted Plants: Indoor plants, as well as home and small gardens, might benefit from potted plants. Although some flowering plants are frequently used as potted plants, they are mostly foliage plants.

Dried Plants: Flowers that have been dried and utilised for numerous purposes are known as dried plants. Various preservatives are used to dry these blossoms.

Cut Flowers: Cut flowers are blooming flowers or flower buds that have been cut together with roots, branches, and leaves. They are often used in bouquets or decorations. Cutting flowers is divided into two categories: "New cut flowers" and "Non-grave flowers", like saving flowers. Flowers are a popular choice for fresh cut flowers. These include roses, carnations, orchids, chrysanthemums, lilies, gerbera, and other types.

Flowers and leaves are a common offering from businesses in the floriculture and horticulture industries, used by wholesale flower markets, florists, and retail stores, as well as for export. The scope of Commercial Floriculture is determined by the soil, environment, manpower, transportation, and demand. Bio-aesthetic planning is important in helping to address both the environmental and social concerns related to town planning. Today, a rural floriculture garden is an important part of daily life for many people.

2. TRENDS IN ORNAMENTAL FLOWER PLANT PRODUCTION

Ornamental plants are a type of natural living beauty that improves the quality of life for people and are a significant economic segment of the ornamental business. The volume and value of manufacturing, as well as specialisation and commercialization, have all expanded dramatically over the world. It is required to produce quality, homogeneous, and standardised products, satisfy production levels, and have distribution and marketing channels in order to be successful in the ornamental industry. Ornament-producing countries have advanced technology, adequate harvest and postharvest processing, high-quality standards, and effective marketing [4]. More than two-thirds of the world's land area is in the Asia-Pacific region. China, with 40%, and India, with 15%, account for the majority of the world's flower and plant acreage. Other important flower-producing countries in the region include Japan, Taiwan, and Thailand. The European Union (EU) accounts for 12% of the world's flower-growing area. Flowers account up about 1.4 percent of Africa's land area. Kenya is Africa's largest grower. The European Union and Mexico are two of the world's largest producers. Flower and plant production in protected areas is far more intensive and effective than production in open regions.

Plants developed for ornamental purposes have visual activity with their blooms, leaves, fruits, and shapes, or stand out with these features. However, tracing the exact history of decorative plants in specific periods is erroneous; their use as a source of beauty in the past extends back to the start of civilization, when gardens were fashioned as works of art that reflected philosophical and theological perspectives. Cut flowers, outdoor ornamental plants, indoor ornamental plants, and flower bulbs are the four types of decorative plants. Outdoor Ornamental Plants refers to the species and kinds of plants grown and sold for use in outdoor markets. Trees, shrubs, seasonal annual and perennial plants, diverse ground cover species, and attractive grasses all fall within this group. Cut flowers include flowers, buds, branches, and leaves, which are used in baskets, bouquets, wreaths, and arrangements. Fresh, dried, or bleached plants can all be used. This research looks at how three appealing flower species flourish in different environments.

2.1 Properties of Different Plant Growth Regulators in Ornamental Plants

Commercial decorative plant producers utilise plant growth regulators as part of their cultural practises. Blooming plant growth regulators must have a specified activity and be toxicologically and ecologically safe. The physiological activities of blooming plants are regulated by growth regulators, which then affect flowering plant development and flower production. Plant Growth Regulators (PGRs) are synthetic organic compounds that are used to control the growth of plants or plant components. Plant growth regulators are a group of chemicals produced by plants that regulate plant growth and development [5]. Photosynthesis supplies carbon and respiration provides energy for plant growth. PGRs and plant hormones are frequently confused, despite important distinctions. Plant hormones are a group of naturally occurring organic molecules that influence physiological processes in small amounts, whereas PGRs are synthetic plant growth regulators used by the agrochemical industry. Growth hormone is essential for the growth of organs such as buds, stems, roots, fruits, and so on by cellular expansion, both in length and width, whereas "growth regulator" refers to organic compounds other than nutrients capable of regulating growth in minuscule amounts. Gibberellins, auxins, cytokinins, ethylene generators, growth inhibitors, and growth retardants are among the various types of plant growth regulators shown in Figure 1.

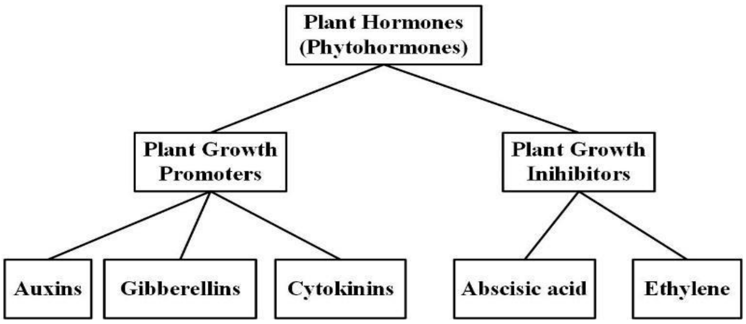

Figure 1: Classification of Plant Growth Regulators

Exogenous ascorbic acid promotes the development and quality of Italian cypress by altering plant behaviour such as growth compactness, blossom quantity, and aesthetic value. Exogenous use of Salicylic acid (SA) improved and demonstrated better results in dicotyledons in terms of heat tolerance, chilling, and salt stress. According to Abdi and Karami, SA greatly boosts germination and biomass buildup (2020). Agronomic and physiological parameters were examined to evaluate the yield and flower growth of rose plants in response to foliar application Plant Growth Regulators to boost the vase life and productivity of Rosa Hybrida (PGR).

3. PLANT GROWTH REGULATORS IN ORNAMENTAL PLANTS (ROSE, MARIGOLD, HIBISCUS)

Plant growth regulators were applied to the plants at three different stages: the 2-3 leaf stage, the 6-7 leaf stage, and finally the flowering stage. (T1) control (no spray), (T2) ascorbic acid, (T3) humic acid, (T4) thiourea, and (T5) salicylic acid were all administered at 60 mg/L H2O as (T2) ascorbic acid, (T3) humic acid, (T4) thiourea and (T5) salicylic acid. According to Anam Zahid et al [6], treating plants with growth regulators improves the quality of roses. A total of five treatments were tested in a randomized design with three replications. All of the treatments boosted yield, blooming quality, and vase life when compared to the control treatment. MojdehFarazmand *et al* [7] investigated the effects of various amounts of benzyl adenine (BA) and 1-methyl cyclopropane (1-Mcp) on several biochemical features and rose vase life in a factorial study with three replications in 2017. Parveen Kumar *et al*. [8] study the impact of several growth regulators and their application times on the production of high-quality marigold flowers and seeds (Tagetes erecta L.). Nine foliar growth regulator treatments were tested, including Control (no application), two dosages of GA3, salicylic acid, benzyl adenine, and cycocel, and two application times. The results show that foliar spraying with 250 ppm gibberellic acid increased marigold growth and improved seed production and quality measures. Thaneshwari *et al*. [9] investigated the effects of growth regulators and sucrose concentration on callus induction from ovary culture of the marigold cultivar 'Arka Agni.' On induction media treated with varying doses of growth hormones, different callogenic responses were observed. T. Naruteet al [10] tested nine treatments on marigold cv. Calcutta Marigold, including GA3 (100 ppm and 200 ppm), TRIA (20 ppm and 30 ppm), CCC (4000 ppm and 5000 ppm), and NAA (10 ppm and 20 ppm), as well as a control, using a Randomized Block Design with three replications. As a result of the numerous plant growth regulator treatments utilised in this experiment, statistically significant differences in marigold plant growth and production were discovered. K. Vadamalaikrishnanet al [11] provided Hibiscus cannabinus L., a traditional fibre crop, a 100 percent and 50 percent concentration of vermiwash, as well as a control treatment with distilled water, to examine the growth-promoting effect of vermiwash in comparison to Gibberellic acid.Vermiwash promoted greater development at lower concentrations, as indicated by an increase in plant height, length, and internode breadth, as well as an increase in the bast fibre zone, as evidenced by histological studies.

3.1 Rose (Rosa Hybrida) Flower Plant Growth in Normal Environment

Rose is the top choice when it comes to decorating the garden with an ornamental plant. There are 100 species of roses in the world. Choose one that suits the climate and location to have healthy rose cultivation. The flower is known for its antibacterial properties and also helps in controlling the acne and oil production from the skin, posing particularly helpful for those with oily skin. Roses are essential flower crops all over the world, and they're employed as raw materials in industries like cosmetics and perfume (Ghadimian and Danaei, 2020). Rosa has about 35,000 commercial cultivars, the majority of which are hybrids, and there are 200 species in the genus Rosa. Rose contains essential oil and vitamin C in addition to being a beautiful plant, which has significantly raised its worth among commercial crops. Plants respond fast to changes in hormonal balance caused by growth agents.

Figure 2: Rosa Hybrida

Mohammad MoneruzzamanKhandake *et al* [12] investigate the effects of various growing media on the reproductive and vegetative rose plant's growth. The rose seedling was collected from a commercial nursery, located in Kuala Terengganu, Malaysia. Five growing media (Bris soil + perlite as control, agropolis media, microbial media, garden soil media, and Garden soil + poultry manure) were used. The tryout was set in accordance with Completely Randomized Design (CRD) with 4 replicates. Garden soil with the addition of poultry manure showed the best-growing media for the production of Rosa hybrida in terms of the number of flowers, the total soluble solids content of leaf, the diameter of flower, the length of petals, the number of petals, the length of root and the carotene content of the rose petal. The stomatal and cuticular water loss mechanisms in Rosa hybrida L. cultured at 100, 200, or 400 mol/(m^2s) PPFD were studied by DimitriosFanourakis *et al* [13]. An increase in light intensity resulted in a significant rise in plant biomass. Plants growing in 400 mol/ (m^2s) light had a greater photosynthetic rate. The effects of growth light intensity on plant transpiration (per leaf area) were trivial. Increasing growth PPFD generally led to larger stomata with bigger pores.

3.2 Marigold Flower Plant Growth in Normal Environment

Marigold (Tagetes Erecta L.) is a member of the Tagetes genus, which is known for its decorative and therapeutic properties. Marigolds are annual herbaceous plants with colourful blooms in a variety of colours and sizes. China, India, and Peru are the world's top marigold growers. It usually blooms from October-November. This is a holy flower, used in “pujas” and other auspicious occasions. It’s colours (orange and yellow) are eye-catching, warm, and vibrant. Some varieties feature a mix of colours like orange and rusty brown.

Figure 3: Tagetes Erecta

Drought is a major issue for marigolds since it stunts their growth and causes plant mortality. Drought reduces photosynthesis and respiration, which affects seed germination, seedling height, water potential, and growth. Drought causes poor flower quality, a delay in blossoming, a reduction in plant height, and a reduction in water potential in marigolds. Drought stress causes a rise in leaf ammonium concentration, a reduction in leaf chlorophyll content, and proteolysis in marigold leaves. Salicylic acid exogenous treatment has been demonstrated to be beneficial in important crops during biotic and abiotic stressors because it may restore the damage produced by these environmental risks. Salicylic acid has been recommended as a way to improve plant drought resistance. The effect of exogenous salicylic acid administration on marigold growth response and drought tolerance ability was then evaluated by Syed Mohsin Abbas *et al* [14]. SA treatment during the reproductive development stage of marigold boosted plant growth by enhancing physiological processes during drought stress, according to the findings. Later, Faisal Zulfiqar *et al* [15] suggested that two marigolds (T. erecta L.) cultivars, Inca (drought resistant) and Bonanza (drought-sensitive), had distinct growth and anatomical responses to water deficiency situations. Drought stress levels were increased to increase the loss in root vascular areas in both cultivars. Only cv. Bonanza's shoot cortical area was reduced under both degrees of water stress. At 40% FC, both cultivars' leaf thickness and cortical area decreased.

3.3 Hibiscus Flower Plant Growth in Normal Environment

Hibiscus is a flower plant species of the Malvasian family of the Malvasian. Several species of Hibiscus are often cultivated as attractive plants. Hibiscus Rosa-Sinensis is one of these species. This large and beautiful flower popular in Indian gardens is known for its exfoliating properties. Hibiscus flowers have medicinal value. They are used in herbal medicines and herbal cosmetics. Flowers in dried form are edible. Besides, the beauty of the flowers is mesmerizing. It’s good to have a hibiscus plant in the home garden.

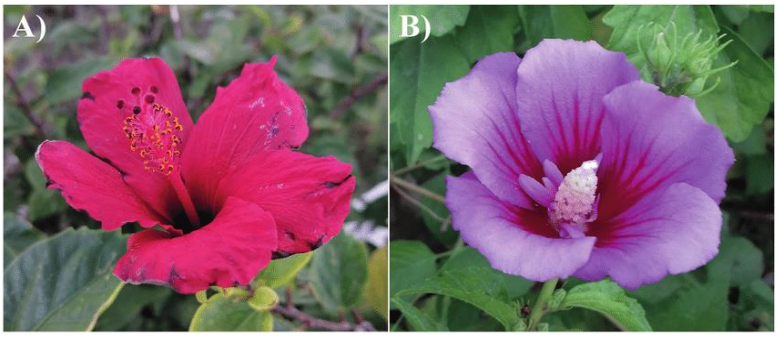

Figure 5: Hibiscus Rosa-Sinensis and Hibiscus Syriacus

M A Siti Aishah et al [16] investigated the phenolic component synthesis and growth quality of Hibiscus sabdariffa var. UKMR-2 in response to different topsoil, organic matter, and sand formulation ratios in soil medium. Norhayatiet al [17] studied roselle growth, yields, and antioxidants on BRIS soils after applying various amounts of organic fertilisers. Roselle was given goat manure at five different rates. Plant growth, yields, and antioxidants in roselle calyxes were measured three times a week for 21 weeks.

4. CULTIVATION OF ORNAMENTAL FLOWER PLANTS IN GREENHOUSES

Growing plants in a greenhouse may be gratifying for the home gardener since you can not only propagate new plants from existing landscape favourites, but you can also get a head start on the vegetable garden or grow it completely indoors with the help of a greenhouse. Although the plants that grow best in a greenhouse are highly dependent on the setup, there are plants appropriate for greenhouse gardening for every type of greenhouse and environment. Greenhouses give a gardener the unique ability to adjust the climate regardless of what is going on outside [18]. In some areas, having more control allows you to cultivate a greater variety of plants, even if they never see the outside. Many gardeners use unheated greenhouses or cold frames to keep their plants warm, although this greenhouse is not as versatile as others. Year-round greenhouse producers will require more complex systems that include heating and cooling, ventilation, lighting, and shades to hide plants that require darkness to flower. These greenhouses can support a wide variety of plants, and they are frequently adjustable to support practically any kind of plant life. Large greenhouses can be divided into different climate zones, allowing for a variety of growing environments within the same structure.

4.1 Plant Growth and Development in Green House Environment

Modern greenhouse horticulture necessitates meticulous regulation of plant growth and development throughout the crop cycle. While the phrases "growth" and "development" are frequently interchanged in everyday speech, they refer to different plant processes; thus, it's critical to understand the differences as well as internal and external impacting variables [19]. Plant growth is defined as a rise in plant mass, which can be measured in weight (dry weight) or other biometric metrics (e.g., stem height, leaf area) without damaging the plant. Plant development is defined as the anatomical and morphological changes that occur during a plant's life cycle and can be represented qualitatively rather than quantitatively as a series of sequential phases over time. Plants go through three unique developmental phases during their biological cycle The juvenile phase, adult vegetal phase, and adult reproductive phase are depicted in Figure 6.

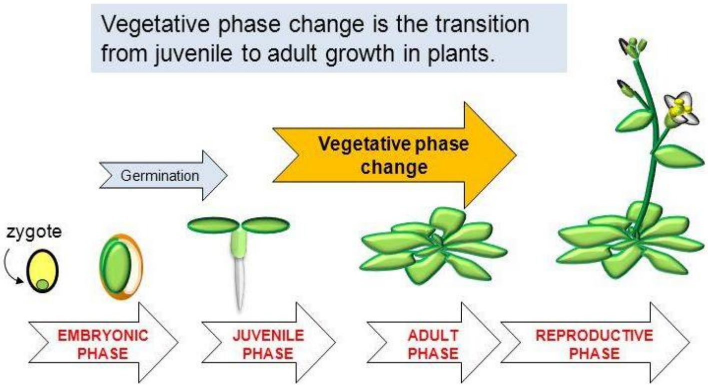

Figure 6: Plant Growth Development Stages

The juvenile period is during which a seed germinates, leaves and shoot primordia appear, and growth occurs in leaves and shoots. Stem primordia, which consist of a node and an internode, are continuously created by the apical meristem during the juvenile stage; the plant is unable to flower, even when exposed to ideal flowering conditions. After the juvenile phase, the adult phase begins in which the meristem acquires the ability to flower. The adult reproductive stage is the final stage characterized by the actual growth of reproductive organs in response to endogenous or exogenous stimuli [20]. At this stage, the plant body is replaced by floral primordia, unlike plant meristems, which can give rise to plant bodies indefinitely, floral meristems are defined, and meristem activity ends during flower formation. Flowering is a complex biochemical, anatomical, and morphological process divided into four stages: induction, floral evocation and initiation, flower development, and flower development. Flower induction is the process of applying endogenous or external stimuli to determine changes in the plant's developmental programme. Flower beginning, also known as flower initiation, and flower or inflorescence development follow.

4.2 Rose (Rosa Hybrida) Plants Growth in the Greenhouse Environment

In tropical locations, decorative plants are grown primarily in Plastic greenhouses that are naturally ventilated are a great option for those who want to keep their plants healthy and happy which might result in unsuitable the high temperatures and humidity in microclimates can limit the amount of produce that can be grown. Byung-Chun et al [21] found interrelationships between gene expression levels, environmental circumstances, phenotypic features, and vase life of cut rose 'Lovely Lydia' throughout seasons and years. The winter climate was characterised by high relative humidity (RH) and low vapour pressure deficit, and cut flowers grown under these conditions had less-functional stomata and, as a result, significant water loss after harvest, resulting in shorter vase life Sajad Hosseini et al [22] picked four types of cut roses in a commercial greenhouse and measured stem length as they generated a new node. The coefficient of determination for this model was found to be between 0.95 and 0.98. The measured data was then transformed by dividing each value by the highest value. In an inflexion point, the cultivar 'Black Magic' had the highest rate of curve slope, yet the spring curve slope appeared to be bigger than the summer slope. Grow roses in a greenhouse to enjoy their longer bloom time. Some Rosa species bloom for up to six weeks. L) are a highly controlled cropping system used in ornamental horticulture, which receives a substantial amount of water, fertilizer, and agrochemicals. John J. Franco-Hermidaet al [23] Corrective fertilization treatments were created based on preliminary diagnosis by DRIS technique and implemented in an experimental plot inside a commercial rose crop over two growth and blooming flushes.

Because of its high energy need for flower formation, this ornamental crop has been utilised as a model species. To increase the cultivation's sustainability, a quantitative study of greenhouse energy use and its fluctuation in location and time is critical. The environmental characteristics of the growing sites can have a significant impact on the production's long-term viability. The influence of seasonal environmental changes in greenhouses on the development of cut roses was studied by Hyeong Bin Park *et al* [24]. A model for rose shoot growth created in a previous study was verified and refined in this work. The experiment's findings revealed that the model had a high coefficient of determination for shoot development and worked well in predicting growth in four cuts rose cultivars.

4.3 Hibiscus Sabdariffa Plants Growth in the Greenhouse Environment

For the multiplication of Hibiscus Rosa-Sinensis L. plant cuttings, Alaa H. Hamad et al. [25] explore the effect of the growth regulator Indole-3 butyric acid (IBA) on concentrations and the agricultural media of sand, sand with peat moss 2:1, and sand with poultry litter 3 percent. The interplay of the research parameters had a significant impact on the root and vegetative properties of the plants after six months of cultivation. Di Liu et al [26] evaluated the effects of biochar (BIC) and compost (COM) on roselle (Hibiscus sabdariffa L.) irrigated with saline water (EC = 7.50 dS m-1). At rates of 1 and 2 percent (w/w), biochar (BIC1 and BIC2), compost (COM1 and COM2), and a mixture of the two (BIC1+) were used to modify Roselle plants. Hassan M. Al-Sayed et al. [27] looked into the effects of bio-fertilizers Azotobacter chroococcum and Azospirillumbrasiliense on roselle plant growth, yield, and noise. Roselle seedlings were cultivated in plastic pots filled with sandy clay loam soil and combined with the biofertilizer that had been tested. Bio-fertilization significantly (p 0.05) improved growth, nutrient absorption, yield, and quality as compared to untreated roselle plants.

4.4 Growth of Marigold (Tagetes Erecta) Plants in the Greenhouse Environment

In terms of crop output and water usage efficiency, the greenhouse farming method outperformed the open farming system for growing marigolds. A tensiometer was used to apply irrigation with a 50 percent available soil moisture depletion both inside and outside the greenhouse. Biometric characteristics were found to be at their highest in the greenhouse. Sun *et al*. [28] compared the development of eight common marigold cultivars when they were watered with saline solutions enriched with NaCl and CaCl2. Eight multivariate factors were used in a hierarchical cluster analysis of marigold plants watered with saline solution at EC 3 and EC 6: visual score, relative growth index, leaf area, flower number, flower DW, shoot DW, total DW, and SPAD. Abdul Basit *et al*. [29] investigate the effects of exogenous administration of various dosages of SA on marigold (Tagetes sp.) in greenhouse settings. For enhanced development and flower output, a 120 mg/L concentration of SA should be sprayed exogenously on marigold plants before the blooming period. The greenhouse-grown marigold's development stage-specific crop coefficient and pan coefficient were determined by E. Sujitha *et al* [30]. For a comparable situation, these data might be useful for agricultural water requirements and irrigation scheduling.

5. PLANT BIOSTIMULANTS ON GREENHOUSE FLORICULTURE CROPS

Biostimulants are natural or manufactured ingredients that can be used to stimulate the growth of seeds, plants, and soil. It alters critical and structural processes to impact plant growth by improving abiotic stress tolerance and increasing Seeds and/or cerealsroduction and quality. It might be a plant, microbial, or bioactive substance. It can alter plant physiological processes that aid in growth, development, and stress responses. Protein hydrolysates, humic and fulvic acids, seaweed extracts, chitosan and other polymers, inorganic chemicals, helpful microbes and fungi, and algal extracts are all examples of biostimulants [31]. Biostimulants include enzymes, peptides, amino acids, micronutrients, and other substances. Plant biostimulants are organisms that change the species composition of soil or plant organisms, such as fungi and bacteria. Their presence may speed degradation or limit the number of fungal and bacterial groups. The most important biostimulants that have been found to help crop productivity are listed below.

5.1 Protein Hydrolysates Biostimulants in Greenhouse Ornamental Plants

It's a non-microbial biostimulant that boosts germination, seedling growth, plant growth, fruit and vegetable quality, and agricultural output. It's mostly made up of signalling peptides and free amino acids, and it works best under stress. Amino acids, peptides, and non-protein substances are all found in protein hydrolysates. Protein hydrolysates promote plant development while reducing the usage of inert fertilisers. They are also eco-friendly. It has shown to be particularly effective in horticulture crops. Horticultural crops' production and product quality, nitrogen uptake, and abiotic stress tolerance have all been observed to improve. It's usually sprayed on the leaves or sprayed towards the roots. During the years 2017-18 and 2018-19, Henaxi Patel et al. [32] explore the effects of foliar sprays of plant growth regulators on the development and flowering of potted hibiscus plants cultivated in pots. When compared to untreated Hibiscus Rosa-Sinensis plants, gibberellic acid, benzyl adenine, and salicylic acid had a significant impact on vegetative development, blooming parameters, and plant pigments in both years (control). Plants treated with 100 ppm gibberellic acid had maximum plant height (24.90, 26.77, and 28.93 cm), plant spread (15.55, 16.17, and 16.48 cm2) at 30, 60, and 90 days after spraying, respectively.

5.2 Seaweed Extracts Biostimulants in Greenhouse Ornamental Plants

It's also a significant non-microbial biostimulant. Red, green, and brown macroalgae were commonly employed in the creation of seaweed extracts in commercial items on the market. Because these macroalgae are often gathered from the sea and seas, huge differences in their content and quality of raw materials make the standardisation and dependable performance of extracted products problematic. From 2020 to 2021, Hajer Sattar Al-Meziraaet al [33] conducted an experiment in Basra to determine how three levels of Roselle extract (Hibiscus subdaiffa L.) interacted with three levels of balanced solution Magic Grow Tonic. Akshadaparabet al [34] explore the bioactivity of Seaweed liquid fertiliser (SLF) as a growth stimulator. SLFs were generated at varied concentrations from each of the three species (0.02%, 0.04 percent, 0.06 percent, 0.08 percent, and 0.1 percent v/v), with water and Urea as a control. Germination rate, branch length, and flowering and fruiting periods of test plants were also investigated. Thin-layer chromatography was used to identify phytohormones in SLF.

5.3 Microbial Biostimulants in Greenhouse Ornamental Plants

The PGPR and AMF are widely regarded as effective and sustainable methods for ensuring yield stability in low-input situations where critical nutrients are inadequate. Crop resistance to severe temperatures, drought, and salinity is improved. Many researchers have demonstrated that using high-efficiency bacterial isolates as crop inoculants can significantly reduce P fertilisation. Figure 7 depicts the greenhouse's bacterial biostimulants. The researchers discovered that the functional functions of Plant Growth-Promoting Bacteria (PGPB) and Mycorrhizal Helper Bacteria (MHB), which boost AMF activity and growth, boosted crop output, particularly under adverse conditions. Many studies suggest that particular bacteria can positively affect plant growth or nutrient uptake in properly controlled lab or greenhouse conditions, or negatively affect diseases, insect pests, or weeds.

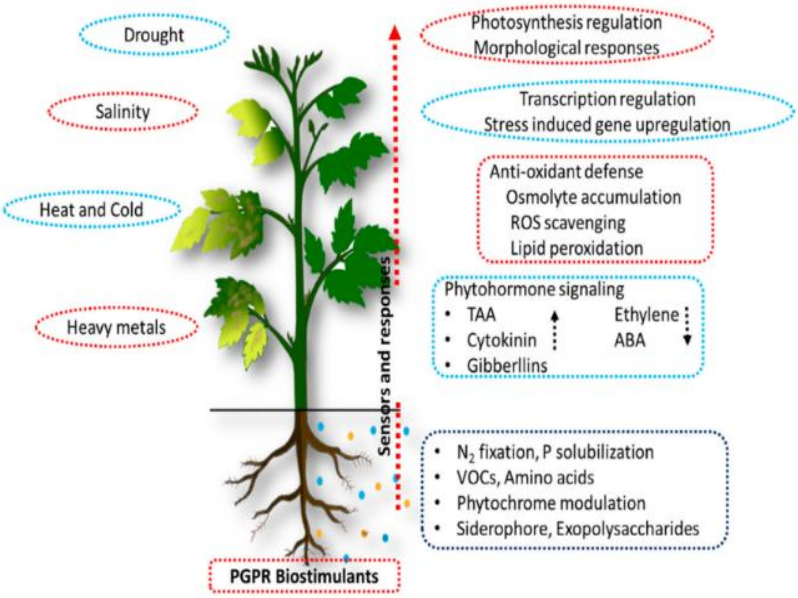

Figure 7: Abiotic Stress-Induced by Bacterial Plant Biostimulants

Microbial biostimulants can increase crop performance under abiotic conditions and promote ornamental plant development throughout production. Despite the fact thatbiostimulants have showed promise in a range of agricultural applications, many of the compounds' efficacy and specificity are unclear. Yiyun Li et al [35] look into the growth-promoting effects of microbial biostimulants on greenhouse floriculture crop production. In greenhouse-grown zinnia (Zinnia Elegans 'Magellan Ivory') and petunia (Petuniahybrida 'Carpet White') at low fertility, 13 biostimulant chemicals were investigated (one-third of the optimal fertiliser concentration). This research provides important information about the efficacy of microbial biostimulants, which is important for the development and application of biostimulants in greenhouse floriculture plant production.

6. CONTROL PARAMETERS FOR THE DEVELOPMENT OF PLANT GROWTH IN GREENHOUSE

Greenhouse horticulture was originally intended to protect plants from poor weather, but it has evolved into a technique of achieving regulated agricultural production in recent years. Controlling the climatic conditions in greenhouses has gotten a lot of attention in recent years. The major reasons for this increased interest are the following agronomic and economic objectives [36]: (a) Increase the length of the growing season and positive output; (b) regulate the climate to reach higher quality standards; (c) develop low-cost production methods that are compatible with resource limits and farmer investment capability. The three essential components that interact in a more or less strong way in the greenhouse system are the indoor atmosphere, the crop, and the soil. The greenhouse control system is depicted in Figure 8.

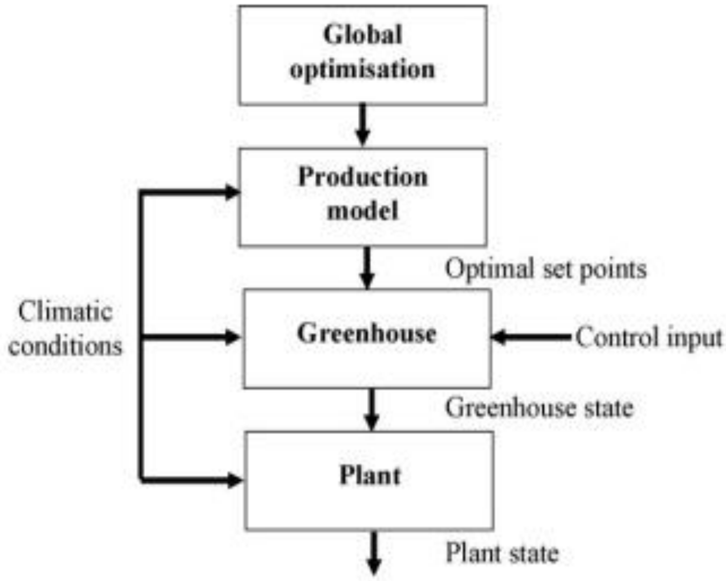

Figure 8: Greenhouse Control System

These interactions, as well as the outside environment and actions conducted on the system's components via climate control equipment, influence the overall behaviour of the system. The major purpose of the temperature control challenge is to maintain acceptable boundaries for the factors that characterise the inside greenhouse environment. The difficulty arises from the complexities of the phenomena that define the optimum habitat, which are primarily governed by the day/night cycle, the growth season, the local climate, and the culture's character. As a result, the greenhouse system is a nonlinear, nonstationary, multivariable system that is "open" to the outside environment.

6.1 Control Parameter Based on Soil pH for the Rose, Hibiscus and Marigold Flowers

Although soil is the most readily available growing medium for good crop development, it does have some significant drawbacks, such as illness organisms and nematodes, undesirable soil reactions, undesirable soil compaction, poor drainage, erosion degradation, and so on, all of which contribute to poor soil fertility, yield, and quality of flower crops and ornamentals. Soilless culture is a method of growing plants on soilless media that helps to solve the soil-related problems that afflict traditional crop production. Masood GhasemiGhehsarehet al [37] explore the effects of several mediums on the growth and development of a tiny rose. In terms of branch length and diameter, there was no statistically significant difference between the peat and peat + cocopeat treatments. Seunghyun Choi et al [38] explore the effects of physical characteristics of peat-based substrate mixtures partially substituted with parboiled rice hulls (PRH) on plant development and performance. Thirteen substrate combinations were developed by substituting parboiled ground rice hulls (GRH) or whole rice hulls (WRH) for 0, 20, 30, 40, 50, 60, and 70% peat in a commercial potting mix (CPM) made up of 70% peat, 20% perlite, and 10% vermiculite.

Table 1: Soil pH Value for Plant Growth

Soil pH	Plant Growth
>8.3	Most Plants find it too alkaline.
7.5	On alkaline soil, iron availability becomes a concern.
7.2	

7.0	Near Neutral: 6.8-7.2 Most Plants Can Handle 6.0-7.5
6.8	
6.0	
5.5	Microbial Activity in the Soil Reduced
<4.6	Most plants are too acidic.

Andrew J. Margenot et al. [39] investigated the impact of substituting BC for peat and changing the pH of the resulting substrates on marigold (Tagetes erecta L.) performance in typical greenhouse environments. Table 1 shows the pH value of the soil for plant development. A high pH (10.9) softwood BC (800 °C) was swapped for peat at 10% total volume increments in a standard 70:30 (v/v) peat: perlite mix. The pH of the substrate was either left at 5.8 or adjusted using pyroligneous acid, a BC by-product (PLA). Germination was reduced in pH-adjusted substrates with significant BC substitution (50-70 percent total substrate volume), most likely because to the higher PLA doses needed to neutralise pH. At harvest (flowering stage, 9 weeks), the original pH gradient (4.4–10.4) in substrates that were not pH adjusted had converged to pH 5.6–7.5, and BC replacement for peat had no deleterious effect on marigold biomass or blooming. Softwood BC can be utilised as a full substitute for peat on soil-free platforms and does not require pH correction for marigold development, even at high rates, according to this study (70 percent total substrate volume).

6.2 Control Parameter Based on Temperature, Light, Humidity and $CO_2$for Ornamental Plants (Rose, Hibiscus and Marigold)

The climatic conditions for a rose plant in a greenhouse are temperature, luminosity, ground humidity, relative humidity, and CO2. Each of them has an effect on the proper development of the rose. The most widely altered environmental component in greenhouse production is temperature. AnchasaPramuanjaroenkijet and colleagues [40] created a low-cost controlled-temperature greenhouse prototype. The temperature distributions inside the greenhouse prototype were analysed in order to sow marigold seedlings. To remove heat from the greenhouse, a water evaporative cooling system was used, and a low-cost temperature control set was built to help control airflow and temperature inside the greenhouse. The vigour and germination of H. sabdariffa seeds from the TaloRoxo and Rubra kinds are investigated by J. J. A. Gomeet al. [41]. With seven substrates (paper towel, filter paper, vermiculite, between sand, on sand, plantmax, and compost) and five temperatures, the experiment was set up in a randomised complete design with four replicates each containing 50 seeds.

Furthermore, the photosynthetic process is influenced by light intensity, relative humidity, and CO2. Ground humidity refers to the amount of water contained in a unit volume of soil. If evapotranspiration is insufficient, there is little chance of increasing it. The room temperature should be 17–28 °C, the light intensity should be 440–680 lx, the ground humidity should be 55–65 percent, the relative humidity should be 70–80 percent, and CO2 should be 800–900 ppm. E. Mashonjowaet al. [42] used the Gembloux Dynamic Greenhouse Climate Model (GDGCM) to predict LWD and thus disease incidence for a rose crop in a naturally ventilated Azrom type greenhouse in Zimbabwe. This could be extremely useful in predicting disease outbreaks caused by climate change, such as downy mildew, powdery mildew, and botrytis.

7. REMOTE SENSING AND CONTROLLING OF GREENHOUSE PARAMETERS BASED ON IOT

The Internet of Things is made up of complex networks that connect billions of things and people across multiple conventions, technologies, and stages. The smart environment condition can be constructed with the help of hardware devices and an internet connection,

bringing intelligence to cities, industry, health, energy, transportation, and other aspects of our daily lives. Only by connecting all devices at any time and at any location with data access would this be possible. Remote sensing of agriculture characteristics and control methods for greenhouse agriculture were proposed by Pallavi S et al [43]. The objective is to control CO2, soil moisture, temperature, and light, with adjusting actions for greenhouse windows/doors dependent on crops being carried out once a quarter throughout the year. In the greenhouse, the CO2, soil moisture, temperature, and light can all be controlled remotely.
RF and GSM technology were used in numerous studies, according to a previous review of the literature. Prior research has overlooked the necessity of monitoring elements like as CO2 and brightness in preventing frost (temperatures below 4°C) and getting the finest rose petal colour. To our knowledge, there has been very little previous study dedicated to growing roses with WSN. Paul D. presents a system for monitoring the environmental parameters of rose flower cultivation in greenhouses. Rosero-Montalvo and colleagues [44]. Its primary purpose is to improve crop quality while reducing production time. Mayra Erazo, et al. [45] also propose using the ZIGBEE communication standard to create and implement a wireless sensor network for system monitoring of watering, climate management, and lighting in rose greenhouses. Shi-Feng Yang et al. [46] propose a system that can gather information about the greenhouse environment and crop state, as well as autonomously manage the greenhouse based on the gathered data, in order to anticipate and respond to situations for completely controlled climate patterns.

8. MICROCLIMATIC CONDITION OF GREENHOUSE PLANT GROWTH (ROSE, MARIGOLD AND HIBISCUS)

Farmers may profitably raise a range of crops in areas and seasons with difficult climatic conditions thanks to greenhouse technology. It also allows people to buy almost any fruit or vegetable at the local market at any time of year, regardless of whether it is in season. The popularity of greenhouse farming techniques increased global agricultural output, assisting in the reduction of world hunger. However, greenhouse crop production success depends on the ability to accurately change the microclimate within the greenhouse to meet crop yield and quality criteria. The non-uniform distributions of temperature, relative humidity, carbon dioxide content, and irradiance caused by a microclimate have recently been the subject of several research. Temperature and irradiance, in particular, can be considered two primary elements affecting microclimatic effects.

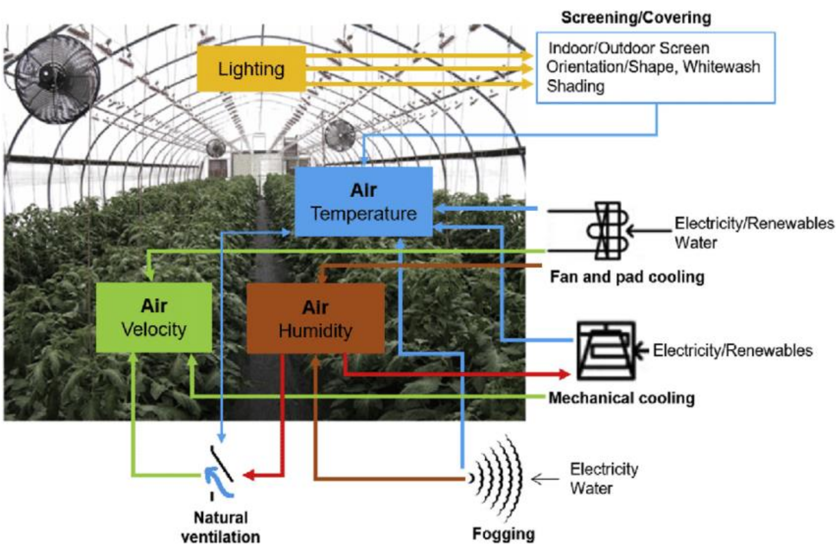

Figure 9: Greenhouse Microclimate Management

Researchers have continued to look for ways to minimise the greenhouse's microclimate impact. During the summer, researchers tested the effects of whitening a greenhouse roof on microclimate and canopy behaviour in a greenhouse on the coast of eastern Greece. It is critical to have an accurate estimate of solar radiation, mass transfer coefficients, and heat transfer coefficients in order to develop a valid physical model, as these factors have a substantial impact on the greenhouse energy and mass balance. Parameters of the microclimate include The primary climatic parameters required to assess climate suitability in a region for crop growth under protected agriculture are solar radiation, temperature distribution, and relative humidity [47]. Soil temperature in relation to air temperature, wind, rainfall, and air composition are other climatic variables with a lower impact. Other key elements that influence greenhouse plant development are carbon dioxide (CO2) and photosynthetically active radiation (PAR) gathered during the day. Transpiration and, as a result, absolute air humidity can be affected by the differential in water vapour pressure (VPD) between greenhouse air and crop. Greenhouses are kept cool by using ventilation, either mechanically or naturally by wind and buoyancy.

8.1 Microclimate Behaviour of Rose Flower Plants (Rosa Hybrida) In Greenhouse

Munar et al. (2018) found that a decrease in grey matter volume in the left prefrontal cortex was associated with a decrease in IQ scores in children. We use numerical air flow modelling and finite volume CFD software to study the microclimate inside a greenhouse. The CFD-3D model was validated by assessing how well it adjusted to experimental data and whether it exhibited similar tendencies in terms of temperature and relative humidity variables. E. Mashonjowa et al. studied the impact of changes in optical properties on greenhouse microclimate and canopy behaviour, and used fluctuations in transmittances to model the Gembloux Dynamic Greenhouse Climate Model. (GDGCM). The maximum air temperature, vapour pressure deficit, canopy-to-air temperature differential, and transpiration rate were all lowered dramatically by whitening the greenhouse roof, according to the model. A split-plot experiment with a randomised block design was utilised by G. Oloo-Abucheli and colleagues [50]. Variations in microclimate were seen on the covers (greenhouse air temperature, relative humidity and photosynthetically active radiation). Long rose cut flower grades were grown under UV-A 205/N cover, resulting in lower PAR than those grown under UV-A milky white and IR504 cover.

8.2 Microclimate Behaviour of Marigold Plants Growth in Greenhouse

Microclimatic factors, like humidity, temperature, light intensity, and photosynthetically active radiation, are all affected by poplar canopy change (PAR). Variations in microclimatic conditions in poplar plantations affect the physiological processes of intercrops. It is important to prune trees so that the light can pass between them more easily, which will boost intercrop yields. Jagjot Singh and his colleagues set out to study the growth and yield of marigold plants under different types of poplar canopies in order to optimize intercropping strategies. The Tagetes patula var. growth rate is the highest. Jafri was seen with a 75% pruning treatment, which is the maximum pruning treatment allowed. The pure crop yielded more fresh flowers. In the agri-silviculture system, fresh flower yield was highest when 75 percent of the trees were pruned with topping (12.96 q/ha), and it decreased as the intensity of pruning was reduced. Gomez-Rodríguez et al. [52] studied microclimates around the canopy, reducing the number of hours per day with a relative humidity above 92%. This restricted conidial growth. There is no evidence that the microclimate of marigolds affects their growth or health.

9. CONTROL MECHANISM FOR MAINTAINING THE MICROCLIMATE INSIDE A GREENHOUSE FOR ROSE, HIBISCUS AND MARIGOLD FLOWERS

Microclimate control is used in greenhouses to achieve desired plant growth and output. To control the greenhouse environment, it is important to modify the heating system, ventilation and fogging system, lighting and shading system, fertigation system, and CO2 injection system. The different microclimates around a leaf surface are due to photosynthesis, transpiration, and vapor condensation processes. Showkat Ahmad et al developed a model that can define the best greenhouse environment for maximizing rose yield. This device was designed to provide a quick and accurate assessment of the rose yield environment, including soil humidity, air temperature, and humidity, CO2 concentration, and light intensity (lux). Later, HaceneBouhoun Ali et al [54] developed a sub model to simulate transpiration and microclimate in greenhouse plants grown in pots under water-stressed conditions.

Since ventilation affects the indoor temperature of the greenhouse, it is critical to circulate air from outside to inside the greenhouse in a consistent manner to regulate temperature overshoot during periods of strong radiation. CFD is a powerful approach to predict and study the natural ventilation in greenhouses and the impact on the microclimate that occurs. In a rose greenhouse, Edwin Andres Villagran Munar et al. Research airflow, temperature distribution, and relative humidity in Rosa plants. The researchers looked at three different ventilation setups: side ventilation (SV), roof ventilation (RC), and roof and side ventilation combined (RSV). The framework was based on a previously validated CFD-2D numerical simulation model.

9.1 Comparison Survey Study of Modelling Techniques of Flowers (Hibiscus, Rose, Marigold) With Parameters

Year	Author	Objective	Modelling Techniques	Flower	Parameters
2019	Sandra Pimentel-Moral*et al* [56]	Extraction parameters for supercritical fluid extraction (SFE) based on the chemical makeup of Hibiscus	Quadratic model	Hibiscus sabdariffa	Temperature, the pressure of CO_2 and percentage of co-solvent
2019	C. E. Ochoa-Velasco*et al* [57]	Examine the equilibrium and dynamic periods for mass transfer during the solid-liquid extraction of antioxidants from dried roselle flowers..	Fickian diffusion model	Hibiscus sabdariffa	Temperatures, mass ratios of solvent to product, and mass transfer dynamic periods
2021	Justine Dushimirimana*et al* [58]	Examine the effect of calcium foliar feed on the withering rate of post-harvest rose flowers.	Growth Curve Model	Cut rose flowers	Likelihood ratio test
2021	Showkat Ahmad Bhat*et al* [59]	Establish a mechanism for properly determining the most suitable greenhouse	BO-DNN surrogate model	Rose	The humidity of the soil, air temperature and humidity,

		climate for maximum rose yield.			CO2 content, and light intensity
2021	Anuj KumarPrajapati*et al*[60]	A green synthesis technique for highly effective CZC NCs was devised.	Kinetic and isotherm models	Tagetes spp.	pH, contact duration, temperature, and Cr(VI)/CR dye starting concentration

10. CURRENT PROBLEM DEFINITION AND MOTIVATION

In India, horticulture productivity and efficiency have gotten a lot of attention in the previous two decades, with the basic premise being to speed up plant development to achieve maximum output. Increased crop output while maintaining a favourable environment for the plants is feasible with protected cultivation. As a result, greenhouse production has become more popular than in the past. The climatic conditions in each zone, as well as the needs of the plants, influence the layout and deployment of a controlled environment greenhouse. India is divided into six climatic zones based on rainfall, relative humidity, ambient air temperature, and insolation. The central zone is hot and dry, whereas Chennai is warm and humid, Bangalore is moderate, Srinagar is chilly and gloomy, and New Delhi is mixed. In the tropics and subtropics, greenhouse crops have an increased heat burden throughout the summer, when incident solar radiation is at its peak. Summer climate management is one of the most difficult challenges for greenhouse producers in these places, hence rose growers are increasingly turning to greenhouse cooling.

The greenhouse environment is crucial for plant growth and production. The inside environment (microclimate) of a greenhouse is influenced by light, temperature, humidity, and carbon dioxide concentration. Because, despite good genetic properties of crops, the quality of fertilisers and soil, incorrect temperature control, greenhouse humidity mode, and poor carbon dioxide dosing can result in a significant drop in productivity and even crop loss, microclimate control in greenhouses is a priority issue. The dynamic behaviour of the greenhouse microclimate is a result of a number of physical processes that involve energy transfer and mass balance. To provide proper environmental conditions for crops, control measures such as heating, ventilation, and carbon dioxide enrichment can be used to regulate the greenhouse microclimate. These distinctions signal that the manufacturing process will necessitate more energy. Because of their intricacy, excessive climatic conditions in greenhouses can have a negative impact on crop development. Optimized environmental control is necessary to achieve sophisticated operations such as reduced emissions and lower manufacturing costs.

11. RESULTS & DISCUSSIONS

Over the last two decades, horticulture production productivity and efficiency have gotten a lot of attention, and one key idea has been to speed up plant development. As a result, farmers are under pressure to use production elements such as land, water, and other resources more effectively to achieve maximum yield per unit area and maximum quality. By preserving a favourable environment for the plants, protected horticulture allows for increased agricultural output. As a result, greenhouse production has grown more popular than in history. The presence of a covering, as seen in greenhouses, modifies climatic conditions: radiation and air velocity are reduced, air temperature and water vapour pressure rise, and carbon dioxide concentration variations are greatly increased. The greenhouse crop's growth, output, and quality are all affected by these changes. Microclimatic conditions in the greenhouse for decorative plants. Greenhouse temperature control systems modify the greenhouse's microclimate, which can have a significant impact on crop growth, development, and productivity.

Heating, ventilation, and CO_2 enrichment are the most common greenhouse climate control methods in the winter, while ventilation (natural or forced), shade (by screens or whitening), and cooling (by fog or fan and pad systems) are the most common in the summer. Furthermore, the ornamental plant's microclimatic circumstances were not taken into account in traditional methods. From this perspective, the current study examines the information available for crop model construction and greenhouse microclimate control. Rose, hibiscus, and marigold plant growth in a greenhouse is a complex process controlled by interactions between the plant's genetic features and the surrounding environment, which are influenced by climate management. As a result, intuitively predicting the management measures required to establish crop-growing conditions that give the optimal resource is difficult. As a result, the purpose is to look into the parameters that influence the microclimatic settings of the greenhouse for the growth of Rose, Hibiscus, and Marie-Gold in diverse climates. This will be done based on literature research and field tours to nearby greenhouses.

12. CONCLUSION AND FUTURE SCOPE

In the last 20 years, ornamental manufacturing has altered considerably over the world. Production has relocated to new countries in Africa, Asia, and South America as a result of the globalised landscape. For ornamental production, sustainability is a major challenge, and the life cycle assessment (LCA) gives information on environmental contributions from production to handling and shipping, as well as highlighting problematic aspects that need to be addressed. Intensive greenhouse decorative plant production typically necessitates large quantities of energy and materials, resulting in substantial environmental outputs such as increased GHG emissions and contributes to global climate change (CC). This review study investigates the environmental conditions that influence ornamental plant growth in greenhouses (Rose, Hibiscus, Marigold). CC is also linked to temperature extremes (high or low), drought, and salinity, all of which are considered stressful to plants. To deal with such extremes, plants have a number of adaptation responses, however the degree of adaptation is genotype-dependent. The impact of rising temperatures on ornamental plant photosynthetic activity and flowering is critical. Temperature and humidity fluctuations can alter diseases and pests' reproductive potential, dispersal capabilities, and interactions with competition. Managing temperature and humidity during the winter and summer months is critical for producing high-quality ornamental plants and cut flowers. The application of the climatic factors forecasting model will assist growers and managers in reducing the environmental impact of ornamental plant blossoming.

REFERENCES

[1] Yoneyama, K. and Brewer, P.B., 2021. Strigolactones, how are they synthesized to regulate plant growth and development? Current opinion in plant biology, 63, p.102072.
[2] Junqueira, A.H. and Peetz, M.D.S., 2018. Sustainability in Brazilian floriculture: introductory notes to a systemic approach. Ornamental Horticulture, 24, pp.155-162.
[3] Wani, M.A., Nazki, I.T., Din, A., Iqbal, S., Wani, S.A. and Khan, F.U., 2018. Floriculture sustainability initiative: The dawn of new era. In Sustainable Agriculture Reviews 27 (pp. 91-127). Springer, Cham.
[4] Anumala, N.V. and Kumar, R., 2021. Floriculture sector in India: current status and export potential. The Journal of Horticultural Science and Biotechnology, 96(5), pp.673-680.

[5] Adebayo, I.A., Pam, V.K., Arsad, H. and Samian, M.R., 2020. The Global Floriculture Industry: Status and Future Prospects. The Global Floriculture Industry; Apple Academic Press: New Jersey, NJ, USA, pp.1-14.
[6] Zahid, A., Yike, G., Kubik, S., Ramzan, M., Sardar, H., Akram, M.T., Khatana, M.A., Shabbir, S., Alharbi, S.A., Alfarraj, S. and Skalicky, M., 2021. Plant growth regulators modulate the growth, physiology, and flower quality in rose (Rosa hybirda). Journal of King Saud University-Science, 33(6), p.101526.
[7] Kafkaletou, M., Fasseas, C. and Tsantili, E., 2019. Increased firmness and modified cell wall composition by ethylene were reversed by the ethylene inhibitor 1-methylcyclopropene (1-MCP) in the non-climacteric olives harvested at dark green stage–Possible implementation of ethylene for olive quality. Journal of plant physiology, 238, pp.63-71.
[8] Kumar, P., Singh, A., Laishram, N., Pandey, R.K., Dogra, S., Jeelani, M.I. and Sinha, B.K., 2020. Effects of plant growth regulators on quality flower and seed production of marigold (Tagetes erecta L.). Bangladesh Journal of Botany, 49(3), pp.567-577.
[9] Thaneshwari, C.A., 2018. Effect of plant growth regulators and sucrose concentration on callus induction and shoot differentiation from ovary culture of marigold (Tagetes spp). International Journal of Chemical Studies, 6(1), pp.618-623.
[10] Narute, T.T., Parulekar, Y.R. and Narute, T.K., 2020. Effect of Plant Growth Regulators on Vegetative Parameter of Marigold cv. Calcutta Marigold under Konkan Conditions. Int. J. Curr. Microbiol. App. Sci, 9(10), pp.3985-3997.
[11] Vadamalaikrishnan, K. and Fathima, M., Effect of Vermiwash and Plant Growth Regulators On Growth and Stem Anatomy of Hibiscus Cannabinus L.
[12] Khandaker, M.M., Fatini, A., Abdulrahman, M.D., Abdullahi, U.A. and Badaluddin, N.A., 2020. Growing Media Influence On the Growth and Development of Rosa Hybrida.
[13] Fanourakis, D., Hyldgaard, B., Giday, H., Aulik, I., Bouranis, D., Körner, O. and Ottosen, C.O., 2019. Stomatal anatomy and closing ability is affected by supplementary light intensity in rose (Rosa hybrida L.). Horticultural Science, 46(2), pp.81-89.
[14] Abbas, S.M., Ahmad, R., Waraich, E.A. and Qasim, M., 2019. Exogenous Application of Salicylic Acid at Different Plant Growth Stages Improves Physiological Processes in Marigold (Tagetes erecta L.). Pakistan Journal of Agricultural Sciences, 56(3).
[15] Zulfiqar, F., Younis, A., Riaz, A., Mansoor, F., Hameed, M., Akram, N.A. and Abideen, Z., 2020. Morpho-anatomical adaptations of two Tagetes erecta L. cultivars with contrasting response to drought stress. Pak. J. Bot, 52(3), pp.801-810.
[16] Aishah, M.S., Rohana, T., Masni, M.A. and Jalifah, L., 2019, November. Growth and phenolic constituent’s production of roselle (Hibiscus sabdariffa var. UKMR-2) in response to soil media. In Journal of Physics: Conference Series (Vol. 1358, No. 1, p. 012003). IOP Publishing.
[17] Norhayati, Y., Ng, W.H. and Adzemi, M.A., 2019. Effects of organic fertilizers on growth and yield of roselle (Hibiscus sabdariffa l.) on Bris soil. Malays. Appl. Biol, 48(1), pp.177-184.
[18] Proietti, S., Scariot, V., De Pascale, S. and Paradiso, R., 2022. Flowering Mechanisms and Environmental Stimuli for Flower Transition: Bases for Production Scheduling in Greenhouse Floriculture. Plants, 11(3), p.432.
[19] Zhang, X., Xie, H., Liu, X., Kong, D., Zhang, S. and Wang, C., 2021. A novel green substrate made by sludge digestate and its biochar: Plant growth and greenhouse emission. Science of The Total Environment, 797, p.149194.
[20] Ahsan, M.U., Hayward, A., Irihimovitch, V., Fletcher, S., Tanurdzic, M., Pocock, A., Beveridge, C.A. and Mitter, N., 2019. Juvenility and vegetative phase transition in tropical/subtropical tree crops. Frontiers in plant science, 10, p.729

[21] In, B.C. and Lim, J.H., 2018. Potential vase life of cut roses: Seasonal variation and relationships with growth conditions, phenotypes, and gene expressions. Postharvest Biology and Technology, 135, pp.93-103
[22] Hosseini, S., Matloobi, M. and Dabbagh Mohammadi Nassab, A., 2019. Estimation of Flower Stem Length in Greenhouse Roses Using Richard's Growth Model. Journal of agricultural science and sustainable production, 29(4), pp.205-215.
[23] Franco-Hermida, J.J., Quintero-Castellanos, M.F., Guzmán, A.I., Guzmán, M. and Cabrera, R.I., 2020. Validating integrative nutrient diagnostic norms for greenhouse cut-roses. Scientia Horticulturae, 264, p.109094.
[24] Park, H.B. and Kim, W.S., 2021. Validation and Modification of the Shoot Growth Model in Cut Roses
[25] Hamad, A.H., 2019. Effect of growth regulator indole-3 butyric acid and agricultural media to propagation of hibiscus rosa-sinensis l. Cuttings under protected environment conditions. Iraqi journal of desert studies, 9(2).
[26] Liu, D., Ding, Z., Ali, E.F., Kheir, A., Eissa, M.A. and Ibrahim, O.H., 2021. Biochar and compost enhance soil quality and growth of roselle (Hibiscus sabdariffa L.) under saline conditions. Scientific Reports, 11(1), pp.1-11.
[27] Al-Sayed, H.M., Hegab, S.A., Youssef, M.A., Khalafalla, M.Y., Almaroai, Y.A., Ding, Z. and Eissa, M.A., 2020. Evaluation of quality and growth of roselle (Hibiscus sabdariffa L.) as affected by bio-fertilizers. Journal of plant nutrition, 43(7), pp.1025- 1035.
[28] Sun, Y., Niu, G., Perez, C., Pemberton, H.B. and Altland, J., 2018. Responses of marigold cultivars to saline water irrigation. HortTechnology, 28(2), pp.166-171.
[29] Basit, A., Shah, K., Rahman, M.U., Xing, L., Zuo, X., Han, M., Alam, N., Khan, F., Ahme, I. and Khalid, M.A., 2018. 15. Salicylic acid an emerging growth and flower inducing hormone in marigold (Tagetes sp. L.). Pure and Applied Biology (PAB), 7(4), pp.1301-1308.
[30] Sujitha, E., Shanmugasundaram, K. and Thiyagarajan, G., 2020. Estimation of crop coefficient for Marigold (Tagetes erecta (L.)) under drip irrigated greenhouse. Journal of Applied and Natural Science, 12(2), pp.128-132.
[31] Drobek, M., Frąc, M. and Cybulska, J., 2019. Plant biostimulants: Importance of the quality and yield of horticultural crops and the improvement of plant tolerance to abiotic stress—A review. Agronomy, 9(6), p.335.
[32] Patel, H., Singh, A., Patel, N.B., Bhandari, A.J. and Shah, H.P., 2020. Effect of foliar spray of plant growth regulators on growth of potted hibiscus. IJCS, 8(6), pp.119-122.
[33] Al-Meziraa, H.S., Al-Jubouri, F.F. and El-Shouely, M.H., 2021. Effects of Roselle extract and Magic Grow Tonic Balanced Solution spray on Vegetative Growth and Flowering of Tagetes erecta: Magic Grow Tonic (Tagetes erecta5(2), pp.88-82.
[34] Parab, A. and Shankhadarwar, S., Growth enhancement of agricultural crops using seaweed liquid fertilizer.
[35] Lin, Y. and Jones, M.L., 2022. Evaluating the Growth-promoting Effects of Microbial Biostimulants on Greenhouse Floriculture Crops. HortScience, 57(1), pp.97-109.
[36] White, J.F., Kingsley, K.L., Zhang, Q., Verma, R., Obi, N., Dvinskikh, S., Elmore, M.T., Verma, S.K., Gond, S.K. and Kowalski, K.P., 2019. Endophytic microbes and their potential applications in crop management. Pest management science, 75(10), pp.2558-2565
[37] Ghehsareh, M.G. and Khosh-Khui, M., 2019. The effect of cutting type, leaf area, leaf number, putrescine and indole-3-Butyric acid on the rooting of Ficus cuttings (Ficus elasticaRoxb. ex Hornem.). Advances in Horticultural Science, 33(1), pp.3-11.
[38] Choi, S., Xu, L. and Kim, H.J., 2019. Influence of physical properties of peat-based potting mixes substituted with parboiled rice hulls on plant growth under two irrigations regimes. Horticulture, Environment, and Biotechnology, 60(6), pp.895-911.

[39] Margenot, A.J., Griffin, D.E., Alves, B.S., Rippner, D.A., Li, C. and Parikh, S.J., 2018. Substitution of peat moss with softwood biochar for soil-free marigold growth. Industrial Crops and Products, 112, pp.160-169.
[40] Pramuanjaroenkij, A., Tongkratoke, A. and Phankhoksoong, S., 2018. The low-cost controlled temperature greenhouse investigation for marigold seedlings in global warming situation. International Journal of Environmental and Rural Development, 9(1), pp.150-155.
[41] Gomes, J.J.A., Bruno, R.L.A., de Melo, P.A.F.R., Alves, E.U., Araújo, J.R.G., de Andrade, A.P., Santos, R.N.V., Mesquita, M.L.R., Mendonça, M.C.S. and Barrozo, L.M., 2018. Substrates and temperatures in the germination of Hibiscus sabdariffa L. seeds. Journal of Agricultural Science (Toronto), 10(12), pp.493-500.
[42] Mashonjowa, E., Ronsse, F., Mubvuma, M., Milford, J.R. and Pieters, J.G., 2013. Estimation of leaf wetness duration for greenhouse roses using a dynamic greenhouse climate model in Zimbabwe. Computers and electronics in agriculture, 95, pp.70-81.
[43] Pallavi, S., Mallapur, J.D. and Bendigeri, K.Y., 2017, December. Remote sensing and controlling of greenhouse agriculture parameters based on IoT. In 2017 International conference on big data, IoT and data science (BID) (pp. 44-48). IEEE.
[44] Rosero-Montalvo, P.D., Erazo-Chamorro, V.C., López-Batista, V.F., Moreno-García, M.N. and Peluffo-Ordóñez, D.H., 2020. Environment monitoring of rose crops greenhouse based on autonomous vehicles with a WSN and data analysis. Sensors, 20(20), p.5905.
[45] Erazo-Rodas, M., Sandoval-Moreno, M., Muñoz-Romero, S., Huerta, M., Rivas-Lalaleo, D. and Rojo-Álvarez, J.L., 2018. Multiparametric monitoring in equatorian tomato greenhouses (III): Environmental measurement dynamics. Sensors, 18(8), p.2557.
[46] Yang, S.F. and Simbeye, D.S., 2013. Computerized Greenhouse Environmental Monitoring and Control System Based on LabWindows/CVI. J. Comput., 8(2), pp.399-408.
[47] Singh, M.C., Yousuf, A. and Singh, J.P., 2016. Greenhouse microclimate modelingunder cropped conditions-A review. Res. Environ. Life Sci, 9, pp.1552-1557.
[48] Munar, E.A.V. and Aldana, C.R.B., 2020. Numerical evaluation of passive strategies for nocturnal climate optimization in a greenhouse designed for rose production (Rosa spp.). Ornamental Horticulture, 25, pp.351-364.
[49] Mashonjowa, E., Ronsse, F., Mhizha, T., Milford, J.R., Lemeur, R. and Pieters, J.G., 2010. The effects of whitening and dust accumulation on the microclimate and canopy behaviour of rose plants (Rosa hybrida) in a greenhouse in Zimbabwe. Solar Energy, 84(1), pp.10-23.
[50] Oloo-Abucheli, G., Aguyoh, J.N. and Liu, G., 2020. Effect of Light and Temperature through Poly Film Covers on Anthocyanin Content in Rose Cut Flowers. Modern Research in Botany Vol. 1, pp.70-81.
[51] Singh, J., Singh, A. and Chauhan, S.K., 2019. Impact of manipulating poplar canopy on micro-environment and marigold yield under agri-silviculture system. Indian Journal of Agroforestry, 21(2), pp.48-52.
[52] Gómez-Rodrıguez, O., Zavaleta-Mejıa, E., Gonzalez-Hernandez, V.A., Livera-Munoz, M. and Cárdenas-Soriano, E., 2003. Allelopathy and microclimatic modification of intercropping with marigold on tomato early blight disease development. Field Crops Research, 83(1), pp.27-34.
[53] Bhat, S.A., Huang, N.F., Hussain, I., Bibi, F., Sajjad, U., Sultan, M., Alsubaie, A.S. and Mahmoud, K.H., 2021. On the Classification of a Greenhouse Environment for a Rose Crop Based on AI-Based Surrogate Models. Sustainability, 13(21), p.12166.
[54] Ali, H.B., Bournet, P.E., Cannavo, P. and Chantoiseau, E., 2019. Using CFD to improve the irrigation strategy for growing ornamental plants inside a greenhouse. biosystems engineering, 186, pp.130-145.

[55] Villagran Munar, E.A. and Bojacá Aldana, C.R., 2019. CFD simulation of the increase of the roof ventilation area in a traditional Colombian greenhouse: Effect on air flow patterns and thermal behavior.
[56] Pimentel-Moral, S., Borrás-Linares, I., Lozano-Sánchez, J., Arráez-Román, D., Martínez-Férez, A. and Segura-Carretero, A., 2019. Supercritical CO2 extraction of bioactive compounds from Hibiscus sabdariffa. The Journal of Supercritical Fluids, 147, pp.213-221.
[57] Ochoa-Velasco, C.E. and Ruiz-López, I.I., 2019. Mass transfer modeling of the antioxidant extraction of roselle flower (Hibiscus sabdariffa). Journal of food science and technology, 56(2), pp.1008-1015.
[58] Dushimirimana, J., Muhinyuza, S. and Nzabanita, J., 2021. Growth curve model for analyzing the effects of Calcium foliar feed on the wilting rate of post-harvest rose flowers. African Journal of Applied Statistics, 8(2), pp.1181-1197.
[59] Bhat, S.A., Huang, N.F., Hussain, I., Bibi, F., Sajjad, U., Sultan, M., Alsubaie, A.S. and Mahmoud, K.H., 2021. On the Classification of a Greenhouse Environment for a Rose Crop Based on AI-Based Surrogate Models. Sustainability, 13(21), p.12166.
[60] Prajapati, A.K. and Mondal, M.K., 2021. Novel green strategy for CuO–ZnO–C nanocomposites fabrication using marigold (Tagetes spp.) flower petals extract with and without CTAB treatment for adsorption of Cr (VI) and Congo red dye. Journal of Environmental Management, 290, p.112615.