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OPTIMIZING GROWING CONDITIONS FOR SUCCESSFUL PLANT PROPAGATION

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ABSTRACT

Controlling the microclimate in greenhouses is essential for improved plant growth and increased crop yields. To create ideal environmental conditions for all greenhouse crops, it is possible to control key microclimate parameters like solar radiation, temperature, relative humidity, light and CO_2 using a variety of control measures like heating, natural or forced ventilation, CO_2 dosing, humidification and dehumidification. However, the production procedure for these improvements calls for more energy and fuel use. Extreme weather conditions can also have a negative impact on the greenhouse microclimate, thus it is important to maintain appropriate ambient control when carrying out sophisticated energy balancing procedures, such as reducing emissions and producing costs. This essay provides information on various greenhouse climate control factors, their management strategies and how they affect the crops that are grown.

Key words : Gas exchange, Greenhouse, Light, Microclimate, Relative Humidity, Solar radiation, Temperature.

Introduction

Plant propagation is the process of increasing the number of plants of a particular species or cultivar. Asexual and sexual reproduction are the two main methods used to propagate plants. Plant sexual reproduction, or the generation of fertile seeds, is the most common method of plant multiplication in nature. These seeds germinate and develop into fully developed, reproducing plants when exposed to the right environmental conditions. The use of vegetative plant components in asexual propagation techniques has also been pioneered by horticulturists over time. This makes it possible to develop plants in ways that are not possible in nature.

Global interest in managed environmental agriculture has increased during the past 20 years. People have realised that we need to enhance intensive agriculture systems to suit our demands while preserving non-renewable resources throughout global population expansion. In contrast to normal farming, greenhouse agriculture enables the cultivation of food crops outside of the growing season *e.g.*; Kalbande *et al*. (2013). It is possible to cultivate crops more productively while maintaining a favourable environment for the plants. Flowers are now more frequently grown in greenhouses than in the past as a result. The cultivation of good varieties and the provision of ideal environmental conditions will increase the quality and quantity of agricultural harvest. Depending on the type of plant and stage of growth, a different optimum microclimate is needed. Environmental stress that slows development but boosts quality is sometimes seen as the ideal situation. e.g. Hashimoto (1989). High-tech buildings called greenhouses are made to offer the ideal environment for year-round plant growth and production. Provided and maintained at appropriate levels for growth include light, temperature, humidity, carbon dioxide concentration and air composition e.g.; Bailey (2002), Shamshir and Ismail (2013), Santosh *et al*. (2017).

Plant reactions to environmental factors, such as temperature, which has a substantial influence on crop timing and output *e.g.*; Pearson *et al.* (1995) and light, which is the primary predictor of crop growth, are what ultimately determine crop yield *e.g.*; Ellis *et al*. (1990). Temperature, humidity and leaf temperature in greenhouses are all impacted by the light transmission of the cover material. Despite the strong genetic qualities of crops, inappropriate temperature control, greenhouse humidity and inadequate carbon dioxide dosage can significantly reduce output, even causing crop failure. This makes microclimate control in greenhouses one of the top objectives. There are several internal and external elements that influence the variance in the greenhouse microclimate *e.g.*; Santosh *et al*. (2017). External elements include things like the outside temperature, relative humidity, solar radiation intensity, wind speed and direction, etc. While internal considerations include the greenhouse's geometry, the placement of the heating and ventilation system's components, the kinds of soil, genetic traits and crop varieties.

Increased production may be achieved by maintaining an ideal greenhouse environment during the growing season. Additionally, greenhouses allow for the effective use of various inputs, including water, fertiliser, seeds and pesticides, as well as the growing of four to five crops year in a controlled microclimate. For increased crop output, many types of shielded buildings can be constructed. Low polyhouse tunnels, however, can be a low-cost method of establishing a favourable microclimate around the crops grown by rural farmers by raising temperature and capturing carbon dioxide, which in turn increases plant photosynthetic activity and, consequently, crop productivity *e.g.*; Kumar *et al*. (2017). It is also feasible to automate environmental controls for the acclimatisation of tissue culture plants in advanced research programmes and the production of high-value crops in greenhouses utilising computers and artificial intelligence.

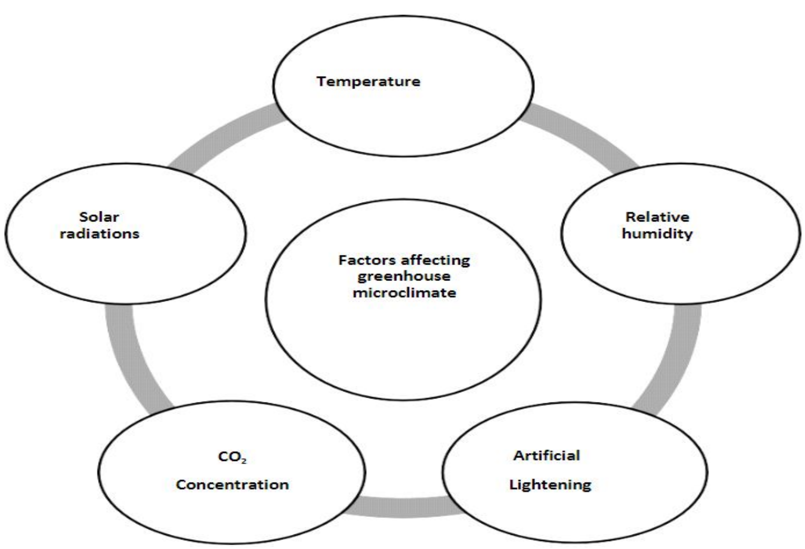

Fig. 1 : Factors affecting greenhouse microclimate.

Microclimate parameters in greenhouses

To stimulate development through photosynthesis, plants need specific climatic conditions. In order to maximise plant development and productivity, microclimate control in greenhouses serves as its major objective *e.g.*; Radojevic *et al*. (2014). In the parts that follow, it is covered in more detail how some of the important microclimate characteristics, such carbon dioxide, light, relative humidity and solar radiation, affect our daily lives.

Solar Radiations

As solar radiation levels fall, the output of plant dry matter declines linearly. In higher latitudes during the winter, it is often impossible to expect efficient dry matter production without artificial lighting. Irradiation must be kept to a bare minimum to promote proper development and blooming. Artificial lighting is mostly required for long-term crops.

Effect of Temperature and Regulation

The following groups of plants can be made based on how temperature influences the germination of their seeds:

- Plants that can only germinate in cold temperatures.
- Plants that can only germinate in hot environments.
- Plants that can sprout at a range of temperatures that is not too extreme.

Usually, the mature plant's preferred temperature determines which classification its seeds belong to. Cole crops, for instance, favour cool weather and produce seeds that grow at relatively low soil temperatures. On the other hand, corn thrives in warm climates and requires rather warm soil for germination. The ideal soil temperature for the majority of plant seeds to germinate is between 75- and 80-degrees F.

Temperature has been found to be the primary factor influencing germination *e.g.*; Milbau *et al*. (2009) and Roberts (1988). The ideal temperature for germination for many species is between 10 and 20 °C. The fastest germination rate occurs in this temperature range *e.g.*; Baskin and Baskin (2001). There are base and ceiling temperatures for each species that represent the ranges at which germination can take place. No germination may take place below these extremes or above them. Temperatures that are too high for a species will prevent it from germination, decreasing its chance of survival as a result of climate change *e.g.*; Finch-Savage and Leubner-Metzger (2006).

The temperature is the most important component that has to be managed in the greenhouse. The majority of plant functions, such as photosynthesis, transpiration, respiration, germination and blooming, are affected by temperature. It also controls transpiration rate via stomatal regulation. The sort of crop that will be cultivated largely dictates the temperature needs in a greenhouse. Temperature characteristics including the maximum temperature, lowest temperature, daytime temperature, night-time temperature and the differential between daytime and night-time temperatures must be addressed seriously *e.g.*; Jain *et al*. (2017).

The majority of plants cultivated in greenhouses are warm-season species that can withstand temperatures between 20 and 30 ^{0}C on average, with estimated lower and maximum limits of 10 and 35^{0}C, respectively. The greenhouse will need to be heated if the ideal outside temperature is below 10 ^{0}C and ventilation will prevent internal temperatures from rising too high during the day if the ideal outside temperature is below 27 ^{0}C. However, if the average maximum temperature rises above 27-28 ^{0}C, artificial cooling will be needed e.g. Santosh *et al*. (2017). When the highest greenhouse temperature is higher than 35 ^{0}C, most crops suffer damage.

Relative humidity

Plant growth is impacted by humidity, which is a direct result of transpiration e.g.; Jain *et al*. (2017). Typically, relative humidity values between 60 and 90 percent are ideal for plant growth. Extreme humidity (over 95%) slows plant growth, lowers transpiration and encourages the fast emergence of fungal diseases like Botrytis cinerea. On the other side, reduced humidity (below 60%) may result in dehydration, water stress and a detrimental effect on plant development *e.g.*; Kittas *et al*. (2012); Santosh *et al*. (2017). During the day, humidity is reduced with the use of ventilation. As long as illnesses do not manifest, humidity seldom has a direct and immediate detrimental influence on plant development and is frequently disregarded *e.g.*; He and Ma (2010). Controlling humidity is essential for avoiding negative impacts and obtaining a high-quality plant yield since it has an impact on how all key greenhouse crops are grown *e.g.*; Bakker (1991). High RH have higher transpiration both during growth and during desiccation stress and that there is no stomatal response to darkness.

Light intensity

Photosynthesis, photo morphogenesis and photoperiodism are the three light-dependent processes that control plant growth. Every variation in lighting has an instantaneous effect on these processes. When light is present, photosynthesis transforms carbon dioxide into organic material before releasing oxygen. The main energy source that enables it to happen is light, making it the most important process. Plants respond to various forms of light by going through a process called photomorphogenesis. Contrarily, photoperiodism refers to a plant's response to varying day durations and whether it will blossom *e.g.*; Santosh *et al.* (2017). Artificial lighting is only necessary for crops that demand longer day lengths because light levels are often enough in many regions of India for efficient plant cultivation.

Artificially reducing light intensity during roots can reduce photosynthetic activity but help prevent cutting desiccation *e.g.*; Tombesi *et al.* (2015). High light intensity is thought to be harmful for cutting roots because it raises transpiration and temperature of the leaves and promotes drying of the leaves and cuttings. In reality, many woody and herbaceous plants have less cutting roots under high light regimes *e.g.*; Aminah *et al*. (1997); Zaczek *et al*. (1997); Zobolo (2010). On the other hand, in some other species especially herbaceous daily light irradiation is positively correlated with cutting rooting and development *e.g.*; Lopez and Runkle (2008), Park *et al*. (2011), Currey *et al*. (2012).

By increasing fruit weight and dimensions, more LED inter lighting increased plant morphology and productivity *e.g.*; Paucek *et al*. (2020). Furthermore, Light quality controls different plant development pathways and the responses were plant-dependent, indicating that the impact of Light quality on the plant needs more research *e.g.*; Zhang *et al*. (2018).

Most plants require light to grow and stay healthy, however not all plants require light to germinate and as we will see, some seeds dislike light. Let's just state that the main cause is the impact of light on phytochrome, a plant pigment found in the seed. The kind of light the seed receives is relevant here. Blue light hinders germination while red light generally encourages it *e.g.*; Keun H. Cho *et al.* (2019).

Some, but not all, popular seeds which prefer light for germination are:

- Achillea
- Alyssum

- Antirrhinum
- Begonia
- Calceolaria
- Coleus
- Ficus
- Gaillardia
- Gerbera
- Gloxinia
- Helichrysum
- Kalanchoe
- Nicotiana
- Petunia

Seeds that need darkness to germinate should be placed at the proper depth and covered with black plastic or something similar to block out all light until germination occurs.

Some other popular types which **prefer darkness** for germination are:

- Calendula
- Centaurea
- Delphinium
- Gazania
- Nemesia
- Primula sinensis
- Schizanthus

Late winter sowings of tuberous begonias require additional lighting in order for them to grow properly. Due to their sensitivity to day length, when it is less than 12 hours, they develop tubers rather than growing vegetatively *e.g.* Fjeld T. (1985).

Carbon dioxide (CO_2)

Even if a greenhouse is effectively ventilated, when a thick crop is developing, the CO_2 concentration might fall dramatically below the outside level. The early morning is when the greenhouse's CO_2 concentration peaks and as the ventilation rate increases, it starts to decline to its lowest level by afternoon e.g.; Akilli *et al.* (2000). As CO_2 concentrations in most Flower species restrict photosynthesis, productivity decreases. The ideal CO_2 concentration for growth and production seems to be between 700 and 900 mol mol^{-1} e.g.; De Pascale and Maggio (2008), Santosh *et al.* (2017). A steady or irregular rise in CO_2 within the greenhouse may boost fruit output by more than 20% for both dry and fresh matter. CO_2 enrichment is essential for improving produce quality e.g.; Shanchez-Guerrero *et al.* (2005). Since the plant's stomata are how CO_2 is absorbed, other climatic elements that affect the plant's stomata openings have a significant impact on how well CO_2 is absorbed in a greenhouse.

Hormones

Controlling and coordinating cell division, development and differentiation is among the most crucial roles that plant hormones play *e.g.*; Hooley (1994). The germination and dormancy of seeds are two plant functions that can be impacted by plant hormones *e.g.*; Graeber *et al.* (2012). Gibberellins and abscisic acid are two distinct hormones that control germination. Gibberellins advance germination while Abscisic Acid encourages dormancy and inhibits it *e.g.*; Finch-Savage and Leubner-Metzger (2006).

Conclusion

According to the information provided above, light, humidity, temperature and gas exchange are some of the main environmental factors that contribute to a favourable microclimate that results in higher quality and more plant propagules being produced (seedling and sapling). Red light generally aids in rooting; Low to medium temperature (65 to 75 degrees F), high RH (55 to 90 %) at 20 degrees Celsius and enhanced morphological and physiological characteristics of C_3 plants were achieved by increasing CO_2 concentration from 350 ppm to 700 ppm.

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