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Plant Response to Greenhouse Environments

(*Lokesh Kumar, Bhardwaj R.L., Somendra Meena, Bharat Meghwal and Lal Chand Meena)
Agriculture University, Jodhpur- 342304, Rajasthan, India
*Corresponding Author's email: lokeshken9497@gmail.com

A crop's productivity is influenced not only by its genetics but also by the microclimate around it. Light, temperature, air compositions and the nature of the root medium are all components of crop microclimate. Only manipulation of the nature of the root medium through tillage, irrigation and fertilizer application is possible in open fields. The closed boundaries of a greenhouse allow for control of one or more components of the microclimate.

Light: Solar radiation's visible light is a source of energy for plants. Light energy, carbon dioxide (Co_2) and water are all involved in the photosynthesis process, which results in the formation of carbohydrates. Plant growth and reproduction are powered by the production of carbohydrates from carbon dioxide and water in the presence of chlorophyll using light energy. The rate of photosynthesis is determined by the amount of available fertilizer, water, carbon dioxide, light, and temperature. The photosynthesis reaction is illustrated below.

$$Co_2 + \text{Water} + \text{Light energy} \xrightarrow[\text{Plant nutrient}]{\text{Chlorophyll}} \text{Carbohydrate} + \text{Oxygen}$$

Significant energy is required to convert the carbon that is combined with oxygen in CO_2 gas to the carbohydrate state. The light energy used in this manner is trapped in the carbohydrate. When the light intensity is reduced, photosynthesis and thus growth are slowed. If more than optimal light intensities are provided, growth slows down again due to chloroplast injury. The international unit of light intensity is known as Lux. It is one meter of direct illumination on the surrounding surface from a uniform point source of one international candle. Light intensities in greenhouse crops range from 129.6klux on clear summer days to 3.2 Klux on cloudy winter days.

The wavelength of light is measured in nanometers (nm). Not all light is useful in photosynthesis. UV light has a shorter wavelength range, i.e. less than 400nm it is toxic to plants in large quantities. Most UV light and light below 325nm is blocked by glass screens. The wavelength of visible and white light ranges from 400 to 700nm.

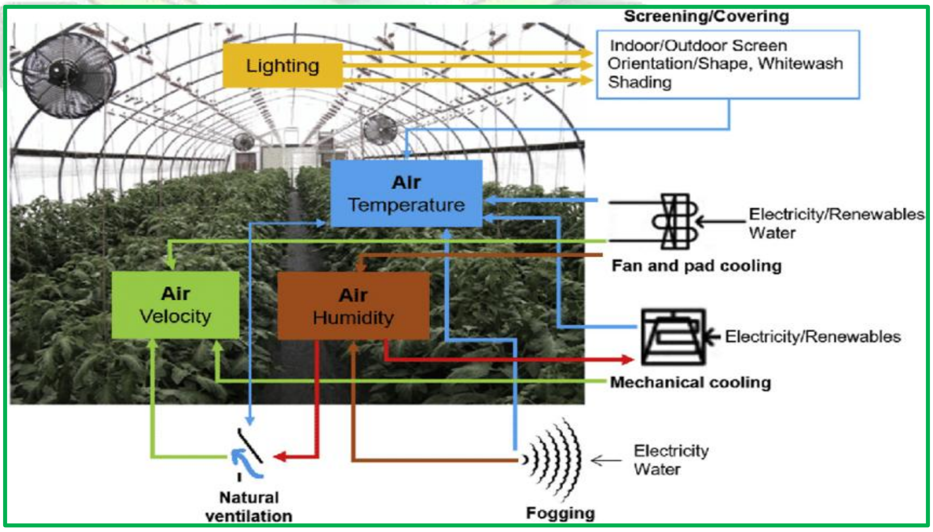

Fig. manage the light, temperature, air and relative humidity inside the green house (Ghoulem *et al.*, 2019)

Aside from causing photosynthesis, far red light (700 to 750nm) has an effect on plants. Longer wavelength infrared rays are not used in the plant process. The visible spectrum of light is primarily used in photosynthesis. Photosynthesis activity is higher in the blue and red bands; however, when only blue light (a shorter wavelength) is supplied to plants, growth is slowed and the plant becomes hard and dark in color. Plants grown in red light (longer wavelength) have soft growth and long internodes, resulting in tall plants. Photosynthesis readily utilizes visible light of all wavelengths.

Temperature: Temperature is a measurement of the amount of heat present. Every crop has a temperature range in which it can thrive. Below this temperature range, the plant life process comes to a halt due to ice formation within the tissue, and cells may be punctured by ice crystals. At the most extreme, enzymes become inactive, and vital life processes cease. Enzymes are heat sensitive biological reaction catalysts. Enzymes regulate all biochemical reactions in the plant. The rate of reactions controlled by the enzyme frequently doubles or triples for every 10^0C increase in temperature until the optimum temperature is reached. As the temperature rises, the reaction becomes suppressed and eventually stops. Green house crops are typically grown at day temperatures that are 3 to 6^0 C higher than the night temperature on cloudy days and 8^0 C higher on clear days.

Relative humidity: Due to the moisture added by the evapo-transpiration process, the relative humidity of the green house air will be higher than that of the ambient air because the green house is a closed space. Some of this moisture is removed by the air that exits the green house due to ventilation. Sensible heat inputs also help to reduce the relative humidity of the air. Processes such as humidification and dehumidification are used in green houses to maintain desirable relative humidity levels. The acceptable range of relative humidity for most crops is 50 to 80%. However, relative humidity of up to 90% may be desirable for plant propagation work. More sensible heat is added in the summer to increase the daytime temperatures of the green house air, and more sensible heat is added in the winter to increase the nighttime temperatures of the green house air, causing a reduction in the relative humidity of the air. Evaporative cooling pads and a humidification fogging system are used for this purpose. When the relative humidity is high, ventilators, chemical dehumidifiers, and cooling coils are used to dehumidify the air.

Carbon dioxide: Carbon is an essential plant nutrient that is found in greater quantities than any other nutrient. Carbon accounts for approximately 40% of the plant's dry matter. Under normal conditions, carbon dioxide (CO_2) exits the atmosphere as a gas at slightly more than 0.03%, or 345ppm. During the day, when photosynthesis occurs under natural light, plants in a greenhouse reduce Co_2 levels to less than 200ppm. In these cases, infiltration or ventilation raises carbon dioxide levels by bringing in outside air to maintain the ambient CO_2 levels. If the CO_2 level is lower than the ambient level, CO_2 may slow plant growth. Maintaining ambient CO_2 levels through ventilation may be uneconomical in cold climates due to the need to heat the incoming air to maintain proper growing temperatures. In such areas, CO_2 enrichment of the atmosphere is practiced. The precise CO_2 level required for a given crop will vary because it must be correlated with other greenhouse production variables such as light, temperature, nutrient levels, cultivar, and degree of maturity. Most crops will respond favorably to Co_2 levels ranging from 1000 to 1200 ppm.

Conclusion

In order to get good crop, we should always know how the plant responds to environment. It is very important to have the proper light energy and carbon dioxide for good growth and development of plants. It’s also important to have the optimum temperature if the temperature is low, ice formation will be take place inside the leave cells and if the temperature is high, it will destroy the chlorophyll. Similarly, its very important to have relative humidity at optimum level because low relative humidity increase high transpiration rate similarly, due to high relative humidity increase the chance of microbial infection in the plants.

Reference

1. Ghoulem, M., Moueddeb, K.E., Nehdi, E., Boukhanouf, R. and Calautit, J.K. 2019. Greenhouse design and cooling technologies for sustainable food cultivation in hot climate. *Biosystems Enginnering*, 183. 121-150.