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Cultivation of Basil under Hydroponics with Nutrient Film Technique in Controlled Environment

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ABSTRACT

A research work was carried out on cultivation of basil crop under hydroponics by controlling the environmental parameters at Dr. NTR College of Agricultural Engineering, Bapatla. The results of research work conducted for two seasons i.e., season_1(April and May) and season_2(August and September) on environmental parameters is presented in this paper. Nutrient Film Technique (NFT) was used in the hydroponics to increase the growth of basil crop. The environment was maintained using foggers to bring the temperature and humidity to optimum level. Using proper instrumentation, the foggers were operated to maintain these two environmental parameters. CO_2, temperature and humidity were measured with 'Rotronic CP11' make instrument. Polynomial equations were fitted for the humidity and temperatures maintained inside the hydroponic polyhouse which are discussed in this paper.

Key words: *Hydroponics, NFT, Nutrients solution.*

Introduction

By 2050, the global population is projected to attain 9.7 billion by demographers. Additionally, it is predicted that half of the fertile land worldwide will be unusable for farming (Pardev *et al.*, 2014). In 1960, with 3 billion population over the World, per capita land was 0.5 ha but presently, with 6 billion people it is only 0.25 ha and by 2050, it will reach to 0.16 ha. Urbanization, natural disasters, climate change, and the indiscriminate application of herbicides and pesticides, all of which are reducing land fertility currently affecting soil-based agriculture. Soil-based agriculture is facing some major challenges; most importantly decrease in per capita land availability. To overcome these problems, now-a-days, soilless culture technique was developed and commercially introduced for intensive production of horticultural crops, particularly vegetables under polyhouse condition. However, in almost all the systems, soil as growing media are replaced with other media mostly due to plant protection concerns regarding soil borne pathogens as well as environmental regulations against ground water pollution with nitrate and pesticides. Removing soil from production system can provide number of advantages in the management of both plant nutrition and protection compared to conventional soil-based production systems. Hydroponic farming is currently gaining popularity around the world due to its effective resource management and high-quality food production.

Hydroponics is a technique of growing plants without using the soil, grow in nutrient rich solution. The term Hydroponics was derived from the Greek words hydro' means water and ponos' means labour and literally means water work. The word hydroponics was coined by Professor William

Gericke in the early 1930s; describe growing of plants with their roots suspended in water containing mineral nutrients. Researchers at Purdue University developed the nutriculture system in 1940. During 1960s and 70s, commercial hydroponics farms were developed in Arizona, Abu Dhabi, Belgium, California, Denmark, German, Holland, Iran, Italy, Japan, Russian Federation and other countries. Most hydroponic systems operate automatically to control the amount of water, nutrients and photoperiod based on the requirements of different plants (Resh, 2013).

The main factors affecting on basil crop for growing in polyhouse are temperature, humidity and CO_2. Among all of these environmental parameters, temperature is considered as the main factor. It is necessary to identify germination cardinal temperatures including base (Tb), optimum (To) and maximum (Tm) temperatures for determine the best planting date of each crop (Parmoon *et al.*, 2015). The amount of germination below base temperature and above maximum temperature is 0%, while optimum temperature is the temperature where germination is maximal (Eberle *et al.*, 2014). Cardinal temperatures for germination in many plants are greatly similar to those of normal vegetative growth (Adam *et al.*, 2007).

Basil is a warm season herb usually propagated by seed, but germination and consequently plant establishment becomes difficult under unfavourable temperature conditions (Zhou, 2012). There is some information in the scientific literatures about the base, optimum and maximum temperatures for basil seed germination. However, less attention has been paid on the use of regression models for calculating of basil thermal needs. In research on green and purple types of basil, germination and seedling emergence in saline condition were higher at 25 °C than 15 and 35 °C treatments (Ramin, 2006). In another study it has been reported that the highest germination percentage of sweet basil occurred at 25-30 °C. Moreover, optimal temperature for germination of this species was approximately 30 °C, so warmer temperatures are much more proper for basil (Mijani *et al.*, 2013). In similar experiment on Indian basil it was reported that the temperature of 25 °C is optimal for seed germination (Kumar, 2012).

Materials and Methods

Study area description and details of polyhouse

The Naturally ventilated polyhouse constructed at the Dr. NTR College of Agricultural Engineering, Bapatla with the dimensions of 20 m x 12 m was used in the current study. Naturally Ventilated Polyhouse is best suited at places where it is neither too hot nor too cold. Here there are opening in the sides which can be closed or opened to let in cold air and the warm air goes out.

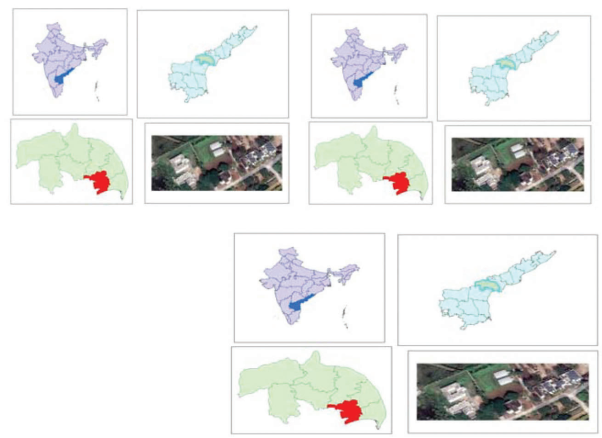

Fig. 1. Location of study area

Control the environmental parameters

In order to manage and control the internal temperature and relative humidity of hydroponic structure, the foggers are to be operated to get a range of 25-30 °C temperature and 65-70% relative humidity throughout the experiments. Less temperature and high humidity are required for proper growth of the Basil crop and so it is required to control the environment inside the structure, suitable equipment such as foggers and dehumidifier were provided inside the polyhouse.

4-Way foggers

In hydroponic structure foggers were used to maintain the temperature and relative humidity in hydroponics structure. The operating pressure range of 3.12 to 4.21 kg/cm^2, these foggers produce an average droplet size of 65 microns each and every time. This creates a favourable saturated humidity ideal for rooting. Each nozzle of the 4-way foggers has a flow rate of 4l/h. Fogger was connected inside the structure which gives fine fog and works with 1HP motor.

Dehumidifier

Dehumidifier were fitted at front side of polyhouse on the table to remove hot air from structure as shown in Fig. 2, so that comfort environment was created as per requirement of the crop.

Measurement of environmental parameters in polyhouse

The Rotronic Instruments CP11 was used to measured the environmental parameters, like temperature, relative humidity and corbondixide (CO_2) in polyhouse daily as shown in Fig. 3. These environmental parameters were recorded daily at 1 hours interval. These data, which were used for observing daily variation in microclimate during the experiment.

Fig. 2. Dehumidifier

Fig. 3. Rotronic Instruments CP11

Preparation of nursery

For growing of nursery required, proper proportion of 60% cocopeat, 20 % perlite and 20% vermiculite shown in Fig.4 (a, b, c) was mixed. The plug trays used to grow nursery were filled with the premixed cocopeat up to 1½ inches. The seeds were placed carefully in trays and covered with cocopeat as a layer. The plastic sheet is covered on the trays up to 3 days, after 3 days the plastic cover is removed and water is sprayed with spray cans in the morning and evening daily without disturbing the seed. After 15 days the basil seedlings were transplanted into hydroponic frame with net caps.

Fig. 4(a) Cocopeat (60%) b) Perlite (20%) c) Vermiculite (20%)

Transplantation

The basil plant are transplanted in net pots with growing media into holes provided in the top of the tube (growing channels). The roots of the plants are suspended down to the channel where they make contact with the shallow film of the nutrient solution. The shallow film of the nutrient solution allows the plants to absorb nutrients and have access to oxygen in the air without being water logged. The shallow nutrient solution flows all the way through each of the channel having plants in it to the other side, passing by each plant and wetting the roots on the bottom of the channel.

Working principle of NFT

The reservoir (tank) is placed at the bottom of the A-frame, connected to the top of the plastic channels by a pump. The nutrient solution is pumped up from the reservoir to the top channel of the frame with 0.1 HP electric pump. The channels were sloped slightly in zig-zag manner and all channels were connected at the ends so that the nutrient water flows from top channel to the bottom channel. The nutrient solution flows from one side to another side of channel, the surplus nutrient solution will stream/flow out of this pipe and move into bottom channel or tube, and finally to the solution tank/reservoir where it is recirculated through the system again (Fig. 5).

Nutrients used in Hydroponics

In hydroponics system, Plants need seventeen elements which are essential nutrients for proper growth. Essential nutrients can be broadly categorized as macronutrients and micronutrients. Macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, calcium and magnesium. Micronutrients include iron, manganese, zinc, boron, molybdenum, chlorine, copper

Fig. 5. Nutrient Film Technique

and nickel.

To prepare nutrient solution, 500 g of nutrient solution A and 500 g of nutrient solution B of nutrient powder was mixed with 5L of water. The solution was thoroughly stirred and stored at room temperature in a air tight container. The nutrient solution diluted with water equal quantity of nutrient solution A and B in the reservoir**,** four nutrient solution concentrations 900, 1000, 1100 and 1200 ppm were chosen for the present research work.

Reults and Discussion

As discussed above, the environmental parameters were controlled and polynomial equations were fitted to find the trend of variation within the polyhouse and were discussed in the following subsections. The experiment was conducted during the year 2021.

Humidity

The daily average variation of humidity maintained in the polyhouse during April and May; August and September is shown Fig 6. The highest humidity value is 71.08% and lowest value 43.47% was observed in the month of the May and April respectively. Relative humidity (RH) is an inverse function of temperature. The value of R^2=0.601 is obtained for the polynomial equation of order 6. Humidity is important to make photosynthesis possible. In the case of basil, good humidity around the plant is even more important than for most other crops, because the plant can only absorb a reduced amount of humidity and hence has less water evaporation than most plants. If the plant loses too much water, the stomata will close with the result photosynthesis stops. If this happens, no further CO_2 can be absorbed, and CO_2 is required to keep the photosynthesis going.

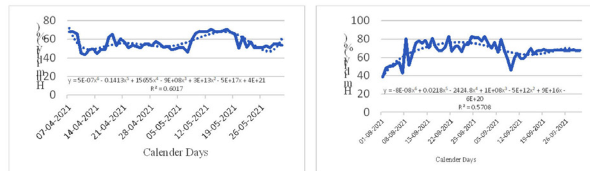

Fig. 6. Variation of Humidity in polyhouse in the month of April and May; August and September

The humidity is increased in the season_2 (august and September). The daily average variation of humidity in August and September was observed in the month of the September is 83.27% and lowest value was observed in the month of the August is 38.41%. The value of R^2=0.571is obtained for the second season for the fitted polynomial equation.

Basil plants will operate without damage with relative humidity ranging from 65-70 percent. Lower relative humidity can stress the plants by allowing them to spend excessive energy pumping water through their tissue into the air. Rapid changes in the relative humidity can severely stress a plant. A relative humidity increases or decrease of as little as 20 percent in a few minutes can cause tissue damage because the plant cannot adapt quickly enough. Rapid decreases in relative humidity can be brought about by suddenly bringing in large volumes of dry outside air for polyhouse cooling purposes. A drop in polyhouse temperature due to nightfall or sudden cloud cover can quickly bring about an increase in relative humidity. If the plant has been rapidly taking up water, it will continue doing so because any adjustment in plant water uptake occurs slowly. The water taken up after the rise in relative humidity cannot be given off as freely into the air through the leaves and instead may be stuffed into foliage to an extent that it does cell damage. Basil plant can also experience rapid increases and decreases in relative humidity because of temperature changes and cooling system air exchanges in the polyhouse. Either the rapid increase or the rapid decrease in relative humidity can cause leaf tissue damage in basil plant.

Temperature

The daily average variation of temperature in April and May; August and September are shown in Fig.7. The temperature increases in month of April and May. The highest temperature value is in 40.04 °C and lowest temperature value is 32.8 °C was observed in the month of the May and April respectively. Temperature is an inverse function of relative humidity (RH). A value of R^2 =0.528 was observed for the fitted polynomial equation of order 6.

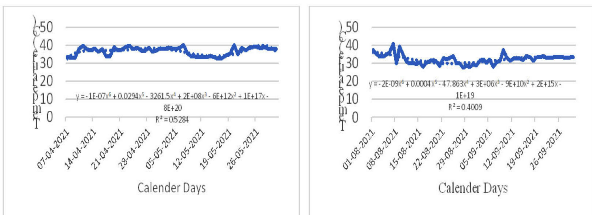

Fig. 7. Variation of temperature in polyhouse in the month of April and May; August and September

The temperature is decrease in the month of the august, because of the occurrence of more rains in the august month. The highest temperature value was observed in the month of August is 41.0 °C and lowest temperature value of 27.68 °C was observed in the month of the August. The value of R^2 =0.400 was observed for the fitted polynomial equation of order 6.

Basil thrives in warm temperature 80 to 90 degrees Fahrenheit (about 27 to 32 degrees Celsius) which is the ideal temperature range, with six to eight hours of direct sunlight per day. The temperature can affect plants in several different ways. Temperature influences the rate of development and as a result of lower average daily air temperature, flowering is often delayed when plants are grown at cooler temperatures. Extremely low or high temperature can cause damage, reducing yields and/ or making shoots unmarketable. Increasing or decreasing the difference between day and night air temperature can increase or decrease stem and internode elongation.

CO_2 concentration

The daily average variation of CO_2 concentration observed in the months of April and May; August and September were shown Fig 8. The CO_2 concentration was highest value is 579.1 ppm and the lowest value is 444.08 ppm (Fig. 8) in season 1. The values recorded higher in the month of April and lowest in May. The CO_2 increases if the temperature also increases. The highest CO_2 concentration occurred on April 2021. The value of R^2 =0.507 was observed for the fitted polynomial equation of order 6.

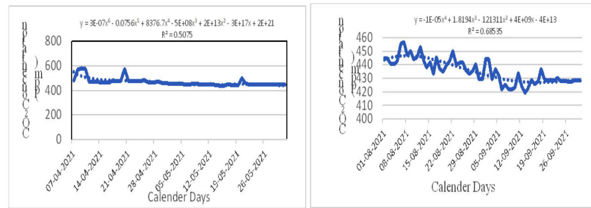

Fig. 8. Variation of CO_2 concentration in polyhouse in the month of April and May; August and September

The CO_2 concentration was 457 ppm observed in the month of the august and the lowest was 419.0 ppm in the month of the September (Fig. 8). The CO_2 decreases if the temperature also decreases. The value of R^2 =0.585 was observed for the fitted polynomial equation of order 6.

Polyhouse need to be properly sealed to maintain a desirable level of CO_2. Excess CO_2 level can be toxic to plants. On warmer days, it is difficult to maintain desirable higher CO_2 levels because of venting to cool the polyhouses. The most common way to increase the CO_2 concentration in the polyhouse is by making use of the exhaust gases from the cogeneration. These exhaust gases contain a significant concentration of CO_2. However, they also contain the harmful gases NOx and Ethylene.

The observations on regular biometric parameters like crop height, no. of leaves, no. of branches, diameter and root length were recorded in 10 days interval. Similarly, two cuttings were made for each

Fig. 9. Basil crop grown under hydroponics

season once in a month and were recorded. The results were promising. The cost economics, and the above details are yet to be published.

Conclusion

The environmental parameters were recorded and were so adjusted to maintain proper temperature, humidity and CO_2. Proper relative humidity range i.e., 60-75%, temperature below 30^0 C, CO_2 levels of 600 to 1500 ppm were tried to control. Throughout the growing period, the above range was tried to maintain by operating the foggers, dehumidifiers through natural ventilation. To find out the variation trend of the above parameters, polynomial equations were fitted with order between 5 and 6. R^2 values between 0.5 and 0.6 were obtained for all the fitted equations. The yield results and biometric observations recorded were promising and yet to be published.

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