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EFFECT TRADITIONAL GREENHOUSE (HIGH TUNNEL) IN THE CHARACTERISTICS OF GROWTH AND YIELD OF THE CUCUMBER

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ABSTRACT

This study was conducted in greenhouses belongs to the College of Agriculture and Forestry at the University of Mosul, for the autumn season 2019. The research included adding a ventilation system that included air circulation inside the greenhouse to eliminate excessive moisture and heat, as well as uniformity of the internal environment of the greenhouse. The greenhouse was divided according to Randomize Complete Block Design in a factorial experiment. The study has been divided into five ridges; the three intermediate ridges were divided into 6 blocks. A sampling of replications was taken according to the vegetative indicator of the studied yield. The two Greenhouses were planted with the yield of the cucumber. Dimensions of the greenhouse were area of 396m 2, length of 44m, a width of 9m, and a height of 3.45m. The first greenhouse was chosen to be without mechanical ventilation. As for the second greenhouse, ventilation and air circulation system (three exhaust fans and other five fans for air circulation) have been added, which works automatically using a low-cost controller (Arduino). The purpose of adopting the Arduino is to ensure the operation and shutting down the ventilation system through sensors reading according to the need of the crop, thus saving electrical energy. The greenhouse was not warm and the time for planting was late. The readings were taken for the vegetative growth indicator obtained during the growth and production period of the cucumber. From the results collected, it was found that the growth and yield indicator of the cucumber crop gave the best results in the greenhouse with mechanical ventilation in comparison with natural ventilation. The results obtained showed that growth indicator for the greenhouse with mechanical ventilation were better in terms of growth. The difference was significant in the height of the plant, whereby the average length of plants for the automated house was 191.93 cm. As for the traditional greenhouse the length recorded 131.70 cm. the percentage of chlorophyll in the leaves of the plant was 1.6 % higher. The leaf surface area of the plant in the automated house reached 14070 cm^2. $Plant^{-1}$, whereas in the traditional house, recorded 11281 $cm^2.plant^{-1}$. The total crop yield achieved was 126% higher in the greenhouse with mechanical ventilation in comparison with the greenhouse of natural ventilation.

Keyword : Greenhouse, air circulation, cucumber, high tunnel, Arduino.

Introduction

The increase in global demand for food is a result of the increase in population moreover the desire to diversify in vegetable crops. The nature of the climate in the Arab countries sometimes is not suitable for production, which leads to a lack in the local need for vegetables and fruits, hence the protected agriculture is of great importance in filling the shortfall in agricultural production and achieving self-sufficiency around the year (Al-Saadoun and Surur, 2005). Protected agriculture is a specialized agricultural system in which exercises supervising and controlling over the soil environment and mini climate, by adjusting conditions such as soil, temperature, radiation, wind, humidity, and air composition). Whereby plants are grown inside the greenhouses which modify their natural environment to obtain products in the off-season, moreover to prolong their production period. Thus increase yields and improve the quality of agricultural products. Eventually meeting the need for agricultural products that cannot be provided by relying on exposed planting only (Castilla, Wittwere, 1995).

Hence the idea of research was adopted, represented in adding a forced ventilation system to the greenhouse environment/mini climate, to get a good condition for the plant growth, provided the lowest rate of energy expenditure. We discussed in our research the cucumber crop that is considered one of the most important crops of vegetables grown in greenhouses. Cucumber also belongs to the *Cucurbitaceae* family. It is important in many countries of the world, including Iraq. It has a demand in the global and Iraqi markets throughout the months of the year. Accordingly, the crop must be supplied throughout the year by increasing the planted areas and following the correct agricultural methods in planting and serving the crop (Al-Bayati *et al*., 2012). The cucumber is greatly planted under the farming system (traditional greenhouses) where the number of classic greenhouses increased to (41776) at 2019 in terms of The Iraqi level moreover in the province of Nineveh that reached to (550), according to the report of the vegetable production of crops and vegetables during the year (2019). The inner environment of greenhouses is a collection of climatic conditions that surround living plants, and in turn, are affected by climatic conditions outside the greenhouse in a large way. This greatly affects plant metabolism activities

and consequently affects production (Bailey, 1985). One of the most prominent problems facing greenhouses is high temperatures and humidity inside greenhouses to levels above the permissible limits, in other words above the level that the plant needs. Damage may be caused by stopping the plant's biological processes however the plants are exposed to insect and fungal infections, which affects the plant and reflects on the crop in terms of quantity and quality. Therefore, ventilation processes are necessary and important process to avoid pathological and insecticide problems, maintain the thermal and moisture balance inside the greenhouse and to compensate for the shortfall in carbon dioxide Necessary in the process of plant photosynthesis that results in an increased fruit growth (El-Sayed, 2006).

The movement of air resulting from ventilation in greenhouses is an important factor affecting the homogeneity of the environment inside the greenhouse, thus on the uniformity of plant growth and quality as a result. Natural ventilation systems were adopted on a large scale by farmers. Simulation tests proved that the movement of air inside the greenhouse depends on the strength of the air movement outside, as well as the external temperature and humidity, therefore it will have a significant impact on the condition of the plants. Moreover, the importance of providing the greenhouse throughout the season with CO_2 from the outside air, furthermore controlling moisture, may not be controlled in natural ventilation (Sase, 2006). Attia (2013) in his study indicated that the comparison greenhouse (without ventilation) gave the lowest values in terms of the studied indicator. The study comprised of dissipation of the excess heat from greenhouses after adding pipes and ventilation vents to improve the greenhouse environment. Attia (2013) recommended studying the ventilation methods added to traditional plastic greenhouses providing the reduction in costs needed to add them. The management of vegetable crops depends on having the correct information in making the necessary decisions; however, we can use the system of real-time monitoring of the greenhouse environment, by using sensors and advanced programs to significantly improve economic performance that results in improving plant growth. That could be done through adopting a system that can collect information related to the environment inside the greenhouse, moreover the state /case of the crops, hence controlling the house environment automatically based on the information collected for prediction and control. Eventually, that leads to completely control the environmental conditions (Yang and Simbeye, 2013).

Materials and Methods

In comparison with the traditional greenhouse that depends on natural ventilation used for growing the cucumber crop. The experiment was conducted in the greenhouses that belonged to the College of Agriculture and Forestry, the University of Mosul, during the autumn season 2019, to study the effect of adding the ventilation and air circulation system inside the greenhouses (exhaust fans placed for ventilation and internal fans for air circulation for the internal climate in addition to a monitoring and controlling device) to get rid of the excess moisture and obtain homogeneity of heat and humidity along with the greenhouse. The first process of preparing the soil for both of the greenhouses with mechanical ventilation and natural ventilation was done then each greenhouse has been divided into five equal ridges. Drip irrigation tubes on the surface of the ridge were placed moreover covering the ridge with black polyethylene mulch, which works to prevent the growth of the weeds and maintain the soil temperature. after the seedlings were planted in equal numbers in both of the greenhouses, the process of serving the crop began with irrigation, fertilization, and controlling of both greenhouses equally, providing the same quantities of fertilizers and water. Finally, operations of climbing the plants then pruning the lower part of the plant were conducted. The following characteristics were studied:

1- Plant Length: The length of the plant was measured when the harvesting of the greenhouses (Al-Sahaf, 1989) was completed, whereby after the eighth reap on 8/1/ 2020. In the automated greenhouse, the height of the plants was measured after the twelfth reap on 28/2/ 2020. According to six replications per Block, three plants were taken from each replication. The height was measured by using the tape measure tool to measure each plant from the soil to the top of the growing top of the plant.

2- Leaf-Chlorophyll content: The chlorophyll leaf content was measured by the aforementioned chlorophyll measuring device on three dates per the two greenhouses. after the third reap that was conducted on November 30/11/ 2019, after the sixth reap that was done on 23/12/ 2019 and after the ninth reap which was on 15/01/2020, nothing that the readings were taken from the treatments separately.

3- The surface area of the leaf (cm^2. $Plant^{-1}$):

It was calculated by taking fifteen fully-grown leaves from each replication of the six replications. Taking thirty disks of the leaves by a cork hole maker of a previously known area (known as the corkborer). Afterward weighing the total paper then the weight of the thirty disks was done using a sensitive and accurate scale inside the laboratory. Extraction of the surface area of the leaves was calculated using the following equation:

$$\text{Foliar area } (cm^2.plant^{-1}) = \text{known foliar area of the disks } (cm^2) * \frac{\text{dry weight of the plant leaves}}{\text{dry weight of the disks taken}}$$

(Lutfi, 1986).

4- Total yield of the fruits (ton/greenhouse): The total yield was calculated for all reaps fruit per each experimental unit. The total yield per square meter of the greenhouse was in tons. It has been calculated using the ratio and proportion method.

Results and Discussion

In order to study the internal environment of the greenhouse, a low-cost monitoring and control unit was adopted, through which temperatures and relative humidity of air were recorded in different locations in the automated greenhouse. Through these values, the operation of fans of both types of Exhaust and air circulation was conducted. The results of the inner environment/mini climate after adding an automated ventilation system had a clear effect on the studied plant- indicator. Significant differences were observed between the greenhouse with mechanical ventilation and natural ventilation. The presence of several sensors in different places inside the greenhouse made the ventilation system work to regulate the temperature of the greenhouse, which resulted in homogeny of the inner environment/mini climate. When the temperature rises above the determined values, the ventilation system would operate, and thus the

greenhouse will get rid of the extra developed heat that leads to thermal retention in the greenhouse mini climate, which is considered one of the main problems in the Greenhouses with natural ventilation. Whereby the ventilation is only done through the movement of air, entering the house from the inlet and exit from the outlet. This is done by the farmer, who opens and closes it manually. This kind of ventilation depends entirely on the condition of the external wind and its speed, if the wind stops, high temperatures will develop inside that lead to negatively affect the plant through affecting its biological processes. This calls for the process of renewing the air and regulating the temperature through forced ventilation, which leads to improving the internal environment of the Greenhouse and providing an appropriate environment for the growth and production of crops inside the greenhouses. That is all done in the automated house, whereby the air vacuums/exhaust fans installed on the top of the greenhouse reduce the internal temperature of the air. The thermostat in the control unit keeps the temperature at (27)°C through the control of the operation of fans installed. They work when the temperature reaches a determined temperature. Nevertheless, the air circulation fans operate around the clock to ensure the homogeny of the inner temperature of the greenhouse. The reason that the air layers are not equal vertically in temperatures in the closed environment. The lower layers are cooler and the upper layers of the air are warmer due to the difference in the density of the hot air from the cold one. Thus, as a result of the effectiveness of air circulation, the homogeny of temperature inside the automated house was better than the traditional greenhouse. (Albright 2002), (Eredics, 2005), (Kolokotsa *et al*., 2010), (Faculty *et al*., 2015), (Revathi and Sivakumaran, 2016) and (Choi *et al*., 2019), who indicated in their studies that Automation and electronic control in a greenhouse environment improve the efficiency of greenhouses, especially when using low-cost systems moreover reduces errors that occur as a result of neglect or inefficient employment.

As for humidity, the effect of automation on relative humidity inside the greenhouse with mechanical ventilation is observed especially in controlling the relative humidity. Whereby the humidity values for the automated greenhouse were lower compared to the traditional one during the study period. This happens through the regulation of the control unit that operates the exhaust fans when Relativity humidity within the house is 90%. Since the relative humidity inside the greenhouse is the main reason for disease conditions in plants that affects the physiological state of the plant. the increase in relative humidity in the air along with a rise in temperature during the day affects the plant by increasing vapor pressure deficiency coefficient (VPD) resulting from the amount of moisture in the air that in turn happens as a result from evaporation and transpiration that occurs in the plant its selves. this happens in the traditional greenhouse whereby the relative humidity recorded (100%) in the evening and early morning periods. afterward, a condensation of moisture occurs on the inner surface of the plastic cover as a result of the difference in temperature between inside and outside the greenhouse. Furthermore, these drops fall on the Plants, leading to pathological cases. This occurs as a result of no good ventilation. The ventilation depends on opening the vents during the day and closing them before the evening. During the autumn season, a problem of temperature decrease appears, whereby opening the vents during the cold month's results in entering the cold air, thus the temperature inside the greenhouse decreases below the permissible limits for the growing plant, which leads to stunted growth and production. The effect of automation was observed on the studied indicator such as plant length (cm). It is noted that the mechanical ventilation and air circulation process affected the length of the plants, whereby a significant difference in plant height and the average length of plants for the automated house recorded 191.93 cm while for the traditional house recorded 131.70 cm.

As for the content of chlorophyll in the leaves, it became clear that the treatment of mechanical ventilation had an obvious and significant effect on this indicator. The automated house showed significant superiority recorded 19.13SPD, whereas in the traditional house was 12.13SPD.

Though it hasn't reached a significant difference between the two greenhouses, but the effect of mechanical ventilation on the - indicator of a plant leaves - surface area of the automated greenhouse was higher than the plant leaves - surface area in the traditional greenhouse. It reached 14070 cm^2. $Plant^{-1}$ in the automated greenhouse. While in the traditional greenhouse, it reached 11281 cm^2. $Plant^{-1}$.

As for the total fruits yield (tons/plastic greenhouse): the effect of mechanical ventilation of the greenhouse had an effective impact during the autumn season, from the first reap to the end of the harvest season process for the crop, where significant differences were observed between the two greenhouses. Whereby the automated house with mechanical ventilation recorded the highest values in comparison with the traditional greenhouse with natural ventilation. The total sum of the fruits of the automated house reached 2126.60 kg, while in the traditional house reached 1256.42 kg.

Table of studied attributes

Factors	Studied traits			
	average length of plants (cm)	**leaf surface area of the plant (cm^2)**	**percentage of chlorophyll**	**The total yield kg / house**
Automated home (mechanical ventilation)	A 191.933	14070	A 19.13	A 2126.62
Traditional House (Natural Ventilation	B 131.700	11281	B 12.31	B 1265.43

Conclusion

Through the automation experiment, the conclusions for the use of mechanical ventilation for the cucumber planting in the fall season were reached.

- The use of automation of a low cost along with the mechanical ventilation system in greenhouses had a positive result in savings in the electrical energy. It included a system of monitoring and controlling of the

inner environment/mini climate, unlike the traditional greenhouses used by the farmer.

- The automated house achieved good results in terms of the vegetative indicator of the plant and the total yield collected in comparison with the traditional greenhouse, in addition to prolonging the life of the plant.

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