International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 5 [May. 2023] PP: 74-81

Innovative Automation Systems Application in Plant Growing in Greenhouses

Asist. Prof. Kamil ÖZCAN
Burdur Mehmet Akif Ersoy University, Gölhisar Vocational School,
Burdur, Turkey

Abstract— *The introduction of technology into the field of agriculture has led to a gradual decrease in manpower. Production has been increased with technology. With the increase in production in greenhouses, the need for control and monitoring has increased. When the automation system in a greenhouse is mentioned, it is understood that it is an application in which technologies from different branches such as agriculture, forest, construction, machinery, electrical-electronics, software and communication engineering come together. By applying all these engineering works to a greenhouse, climate conditions suitable for plants are created and the productivity of the product to be obtained is ensured. Peripherals inside and outside the greenhouse; It consists of systems such as heating, ventilation, cooling, shading, fogging, irrigation-fertilization. In the study carried out, environmental units inside and outside the greenhouse; heating, ventilation, cooling, shading, fogging, irrigation-fertilization were made. Thanks to this, a 15% increase in productivity has been achieved.*
Keywords: *greenhouse automation, productivity increase, remote control, remote monitoring*

Date of Submission: 28-04-2023 Date of acceptance: 07-05-2023

I. INTRODUCTİON

During its establishment, regardless of the ambient conditions, in case of necessity, by keeping the temperature, soil-moisture ratio, lighting amount and air movements under control, to provide the most ideal environment for plants to continue their vital functions by making photosynthesis, to produce the seeds, seedlings and saplings of various cultivars and their seeds, seedlings and saplings, plastic etc. Structures that are covered with a light-permeable cover material and that can be moved easily inside are called "greenhouses" [1-5]. Another definition of greenhouse is as follows. They are the structures in which an optimal environment is created for the plants grown in the periods when the outdoor conditions are not suitable for the growth of the plants grown inside [6]. The greenhouse is shown in Figure 1.1.

Figure 1.1. Greenhouse.

Plants placed in various parts of the greenhouse in order to create the environment required by the plants with factors such as the temperature (°C), the amount of light, the soil-moisture ratio, the amount of moisture in the greenhouse and the amount of fertilizer for the stages such as growing the plants planned to be produced in the greenhouse and growing and maturing the plants. The whole of the systems used with sensors and electronic materials depending on a certain computer programming language is called greenhouse automation [7,8]. In Figure 1.2, some systems of greenhouse automation are given by visualizing. Greenhouse automation is shown in Figure 1.2.

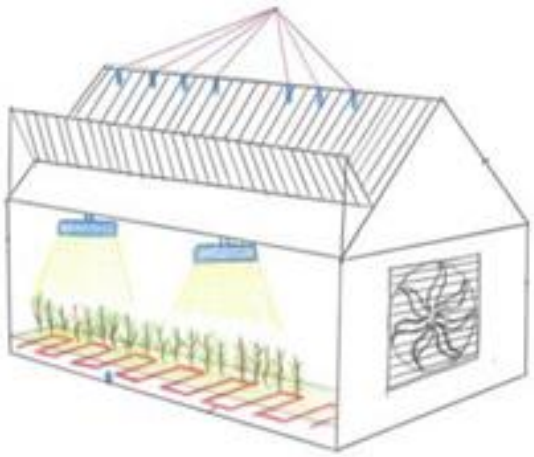

Figure 1.2. Greenhouse automation

The main goal in the establishment of greenhouses is to provide the most ideal environmental conditions for the products planned to be grown in the greenhouse and to create a growing environment free from negative factors by controlling the growth of these products at the maximum level. Since it is very difficult to control the climate outside the greenhouse, it is necessary to control the indoor climate. In order to control the climate inside the greenhouse, it is necessary to make the plants feel as if they are outside by keeping the internal volume of the greenhouse large enough. In addition, climate control in the greenhouse is provided by many methods such as automatic ventilation according to the temperature level in the greenhouse, CO2 release to the environment where the plant is located, and shading curtain controls to reduce the radiation level that causes the increase in the greenhouse temperature, and thus, the product efficiency from the plants is ensured. increased [9].

With the ventilation system, the plants in the greenhouse feel as if they are outside, and the CO2 gas that the plants need for photosynthesis enters into the greenhouse. Another importance of aeration is to make the plants transpiration [10]. With good ventilation, it is possible to reduce the temperature inside the greenhouse by 2-3°C compared to the temperature outside the greenhouse. Adjusting the relative humidity in the greenhouse can also be done by ventilation [11]. One of the most important values needed for healthy ventilation in the greenhouse established in a suitable place in terms of physical and geographical location is the number of changes in the air per hour. The number of air changes should be 50-60 in a greenhouse covered with plastic sheeting, and approximately 40-50 in glass-covered greenhouses. Under normal conditions, the number of air changes is between 15 and 30 [12]. Figure 1.3 shows the ventilation system in greenhouses.

Figure 1.3. Ventilation in greenhouses.

The main task of the heating process in greenhouses is to distribute the heat evenly inside the established greenhouse. The heating process is also of great importance in terms of the quality of the product to be grown in the greenhouse, the development time of the product and the amount of product to be obtained [13]. In order for the plants in the greenhouse to complete their development, the temperature inside the greenhouse must be kept at certain levels.

In addition, greenhouses should be heated in the winter and cooled in the summer [14]. It is of great importance that the heating project determined before the heating process is applied to the greenhouses is fully adjusted and that the investment costs in greenhouse construction are reduced and the energy savings to be made are well calculated.

Subsequently, the type of greenhouse to be built and the maximum heat power requirement (Watt (W), Kilowatt (kW) or Megawatt (MW)) should be determined, depending on the type of greenhouse to be built and the equipment to be used while the greenhouse will be built, considering the external environmental conditions of the place where the greenhouse will be established.

While making the calculation, the required outdoor temperature value is determined based on the average of the lowest temperature (°C) obtained 2 times in a row within the minimum 10-year climate values. This temperature value obtained is the highest heat power value that occurred during the year. Thus, it is possible to meet the heat energy required by the greenhouse throughout the year. However, the highest heat power value is needed at a very short time during the year. For this reason, knowing at what time of the year the heat power repetitions occur will enable projecting according to more realistic values [15]. While the heating process is carried out in the greenhouses, the distribution of the heat into the greenhouse is by conduction (contact), convection (air flow) radiation and electromagnetic waves (radiation). As the temperature difference, the inside of the greenhouse should change by a maximum of 5-8°C during the day, and the temperature should not be less than 15°C on cold days when the weather is bad, and not more than 30°C on hot days when the weather conditions are good. In addition, it is necessary to heat the greenhouse in winter [16].

In cases where the temperature inside the greenhouse is more than 27 ºC, the artificial cooling process is done by the fan etc. in the system. If the temperature inside the greenhouse is below the specified temperature (27ºC), natural ventilation will prevent the greenhouse from getting too cold. When the average outdoor temperature is below 27ºC, natural ventilation will prevent excessive increase in indoor temperature. The temperature inside the greenhouse should not exceed 30-35ºC in the long term. Temperatures above 35ºC cause damage to the vital functions of the plants. Likewise, excessive decrease in soil temperature in the greenhouse stops plant development. Since the temperature demands of the plants planned to be grown in the greenhouse are at different degrees, it is very important to pay attention to these situations in terms of aquaculture [17].

Plants should be in environments where there is plenty of light and temperature is not too high during the stage when they emerge from seeds and become seedlings. The temperature values required for optimum growth from plants show between 12-30ºC. Temperatures below 12ºC reduce the germination power of plants. In addition, if it is below 0ºC, the plants freeze [18,19]. Figure 1.4 shows the heating system in greenhouses.

Figure 1.4. Heating in greenhouses

Water, which is vital for plants, can be supplied in different ways for plants grown outdoors, but for plants grown in greenhouses, it is provided only by irrigation. Irrigation is provided by many methods in greenhouses. With the development of technology, surface irrigation method has been abandoned and surface irrigation has been replaced by new technological irrigation methods. The most widely used of these methods are drip irrigation methods, as they have superior aspects to other methods.

The convenient supply of the materials used for the drip irrigation method in our country and the importation of them when necessary has increased the spread of the drip irrigation method. In order to prevent water stress, which will affect the quality of the plants grown in the greenhouses and the yield obtained from them, an applicable irrigation plan is required to apply the water needed by the plants grown in the greenhouse during the growth phase, in the required quantities and times. However, although there are monitoring techniques developed depending on the external environment (soil, climate) for irrigation planning, these monitoring techniques are not at the desired level for greenhouse cultivation in our country.

In general, producers plan the irrigation process by making visual estimations. In this case, the substances needed by the plants (water and fertilizer) are not used enough and some problems (increase in ground water,

drainage problem, etc.) occur. In addition to these, the quality of irrigation water should be determined scientifically so that there is no decrease in the yield to be obtained from plants [20,21].
There are many irrigation methods in greenhouses from past to present. These irrigation methods are generally made as Drip Irrigation, Sprinkler Irrigation, Furrow Irrigation and Capillary Irrigation. Figure 1.5 shows the irrigation system used in greenhouses.

Figure 1.5. Irrigation in greenhouses

Light is a must for both plants grown outside and plants grown in greenhouses. In the photosynthesis event, which plants do for the continuation of their vital functions, they need light in order to take CO2 (carbon dioxide) and water in the environment and combine them to produce a product. As it is known, plants generally provide their light needs from the sun, which is a natural source of heat and light, but this is achieved with an artificial lighting system in greenhouses on days when the weather conditions are unfavorable and at night when the sun is not present. [22-24]. A sample picture of greenhouse lighting is given in Figure 1.16. Figure 1.6 shows the lighting system used in greenhouses.

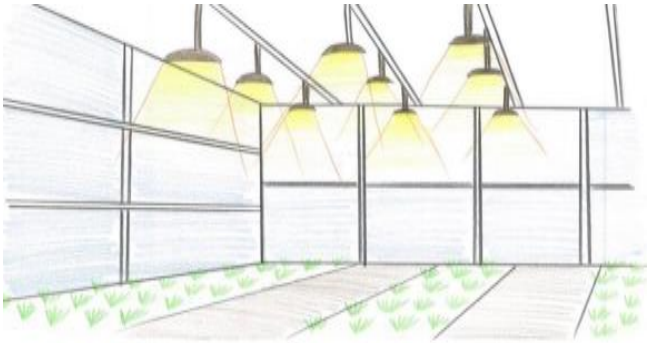

Figure 1.6. Lighting in greenhouses.

II. MATERIAL AND METHOD

In the study, it was aimed to increase the productivity by irrigation and fertilization according to the needs of the plant grown in the greenhouse. While doing this, the possibility of remote monitoring and control is provided. Greenhouses are outside the residential areas. For this reason, it is very costly to go and irrigate. With the automation system developed in this study, remote irrigation and fertilization were performed and the costs were minimized. The general study of the study is shown in Figure 2.1.

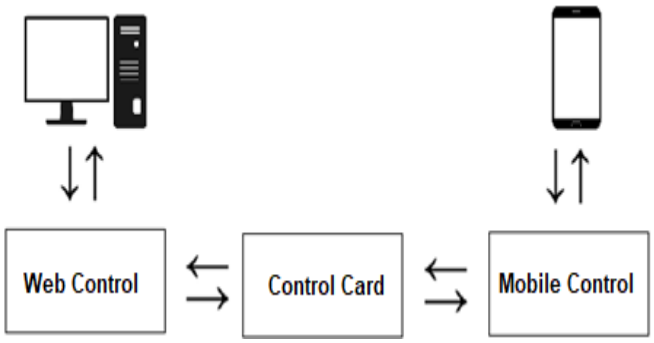

Figure 2.1. General operation.

As a result of the study, irrigation and fertilization were carried out in the greenhouse. For this, 3 fertilization tanks and one acid tank were used. Fertilization and irrigation necessary for the plant were carried out from here. Figure 2.2 shows the implemented system.

Figure 2.2. Implemented system.

Microcontroller was used in the study. With the microcontroller, indoor and outdoor temperature and humidity values are displayed instantly. At the same time, irrigation valves are controlled. Figure 2.3 shows the control card used in the system.

Figure 2.3. Control card.

The biggest feature of the study is that it can work with a mobile application. Today, there is no one left without a mobile phone. Mobile application is designed because mobile phones are always with us. With the mobile application, the system can be monitored and controlled at any time. The mobile application interface is shown in Figure 2.4.

Figure 2.4. Mobile interface.

The implemented system can also be controlled by the internet. This increases the accessibility of the system at all times. The internet interface of the system is shown in Figure 2.5.

Figure 2.5. Device interface.

III. DISCUSSION

With the work done, remote control and monitoring of the greenhouse was provided. In this way, productivity has increased. At the same time, crop costs were cut. Greenhouses, as is known, are located outside the settlements. This causes travel expenses every time. The greenhouse is used for irrigation. This causes in path and time. These costs have been minimized by the study.

With the study, productivity increase was achieved in the water used in the crops. An average of 2 liters of water was saved per day. Figure 3.1 shows the average daily water efficiency.

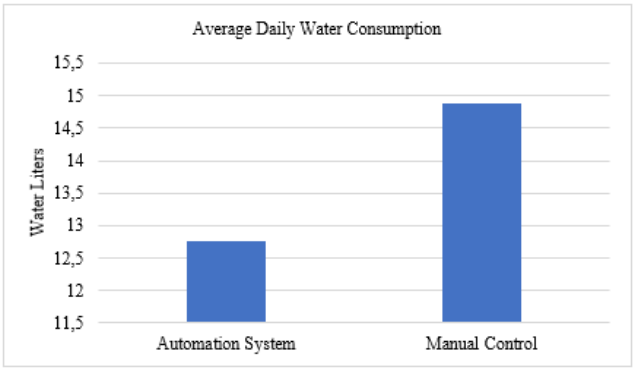

Figure 3.1. Average daily water efficiency.

With the implemented system, savings were achieved in the amount of crops. A productivity increase of approximately 7 kilograms has been achieved in the amount of crops. Figure 3.2 shows the productivity increase in crop quantities.

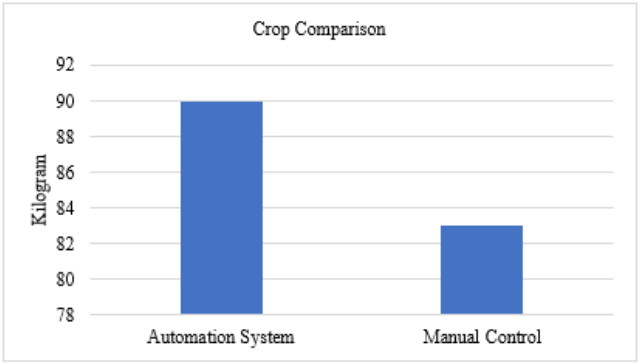

Figure 3.2. Productivity increase in crop quantities.

IV. RESULT

As a result of the work carried out, remote monitoring and control of the greenhouse was provided. Thanks to this, productivity gains were achieved in the greenhouse. Both the greenhouse water consumption decreased and the number of crops increased at the same time. Savings were achieved in the expenses used for greenhouse control and monitoring. A great deal of savings has been achieved in costs, especially for irrigation and control.

REFERENCES

[1]. Sase S, Kaçıra M, Okushima L, Ishii M, Moriyama H, Kowata H, 2004. Cooling Greenhouses under Natural Ventilation. International Workshop on Agricultural Structures and Environmental Control, Korea.
[2]. Tsai CH, Bai YW, Chu CA, .Chung CY, Lin MB, 2011. PIR sensorbased Lighting Device with Ultra-low Standby Power Consumption, IEEE Transactions on Consumer Electronics, 57 (3): 1157-1164.
[3]. Campen JB, Bot G, & De Zwart HF, 2003. Dehumidification of Greenhouses at Northern Latitudes. Biosystems Engineering, 86 (4): 487-493.
[4]. Sung HJ, Park KJ, 1997. Development of Heat Pump- PCM Latent Heat Storage System for the Greenhouse Heating (I) Journal of Korean Society for Agriculture Machinery 19 (3).
[5]. Teitel M, Tanny J, 1999. Natural Ventilation of Greenhouses: Experiments and Model. Agricultural and Forest Meteorology, 96: 59-70.
[6]. Günerhan GG, Kocar G, Hepbaşlı A, 2001. Geothermal Energy Utilization İn Turkey, Internatıonal Journal Of Energy Research, 25, 769-784.
[7]. Hasan KMM, Rahman MS, Rafiq MA, 2017. Experimental Analysis of Harmonic and Power Factor for Various Lighting Loads, 2017 3rd International Conference on Electrical Information and Communication Technology (EICT), 7-9 Aralık 2017, Khulna.
[8]. Usmani JA, Tiwari GN, Chandra A, 1996. Performance characteristic of a greenhouse integrated biogas system, Energy Convers. Mgmt, 37(9): 1423-1433.
[9]. Kendirli B, Çakmak B, 2010. Use of Renewable Energy Resources in Greenhouse Heating. Ankara University Journal of Environmental Sciences, 2(1): 95-103.
[10]. Çolak A, 2002. A Study on Indoor Temperature, Dew Temperature and Relative Humidity Pattern in an Unheated Glass Greenhouse, Journal of Ege University Faculty of Agriculture, 39(3): 105-112.
[11]. Ma X, Li Y, Yang L, 2018. Design of Environment Parameter Adjustment System for Greenhouse Based on STM32. 13th IEEE Conference on Industrial Electronics and Applications (ICIEA). Wuhan, 719 - 723.
[12]. Latha MNS, Girish S, Ganesh AB, 2016. Cooperative Communication Enabled Wireless Sensor Network For Monitoring Green House. International Conference on Advanced Communication Control and Computing Technologies (ICACCCT). Ramanathapuram, 86-91.
[13]. Kürklü A, Çağlayan N, 2005. A Study on the Development of Greenhouse Automation Systems. Journal of Akdeniz University Faculty of Agriculture, 18(1):25.
[14]. Vassılıou NN, 2000. Determination of Natural Ventilation Rate in a Double Span Arch Type Greenhouse. Acta Horticulture, Haifa, 534:171-180.
[15]. Cartoğlu B, 1991. Heating and Cooling Control in Greenhouses. Garden and Greenhouse International Journal of Fruit, Vegetable, and Floristry, 2: 51-53.
[16]. Gorjian S, Hashjin TT, Ghobadian B, 2011. Solar Powered Greenhouses. SET2011, 10th International Conference on Sustainable Energy Technologies, Istanbul, 4-7 Sep. 2011.
[17]. Fuller RJ, Cooper PI, Sale PJM, Speed REW, 1983. Crop Yield Use in a Solar Greenhouse. Solar World Congress, 1222-1226.
[18]. Özgener Ö, Koçer G, 2004. Geothermal heating applications. Energy Sources, s: 353-360.
[19]. Arinze EA, Schoenau GJ, Besant RW, 1986. Experimental and Computer Performance Evaluation of A Movable Thermal İnsulation For Energy Conservation in Greenhouses. Journal of Agricultural Engineering Research 34: 97–113.
[20]. Lin KH, Huang MY, Huang WD, Hsu MH, Yang ZW, Yang CM, 2013. The effects of red, blue, and white light-emitting diodes on the growth, development, and edible quality of hidroponically grown lettuce (Lactuca sativa L. var. capitata). SciHortic-Amsterdam. 150: 86–91.
[21]. Opdam JG, Schoonderbeek GG, Heller EB, Gelder A, 2005. Closed greenhouse: a starting point for sustainable entrepreneurship in horticulture. Acta Hort, 691:517-524.

[22]. Koç C, Citizen M, Koç AB, 2009. LED Lighting Technology and Its Use in Agriculture. 25. Agricultural Mechanization National Congress, Isparta, pp: 153-158.
[23]. Çağlayan N, Ertekin C, 2011. Use of LED Grow Lamps for Crop Production. I. Ali Numan Kıraç Agriculture Congress and Fair with International Participation, 27-30 April 2011, Proceedings Book, Eskişehir, p:1227-1232.
[24]. Anderson JM, Chow WS, Park YI, 1995. The Grand Design Of Photosynthesis: Acclimation Of The Photosynthetic Apparatus To Environmental Cues. Photosynth Res 46: 129–139.