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EFFECT OF AUTOMATED CONTROLLING SYSTEM USING RASPBERRY-PI MICROPROCESSOR ON GROWTH PARAMETERS OF EGGPLANT IN GREENHOUSE

Bilal Ahmad[1], Raees Ahmed[2]*, Muhammad Tahir Younas[2], Muhammad Saeed[3], Irfan Jamshed[4], Sohaib Masroor[5], Arshad Wahab[1], Umed Ali[7], Bilal Hayder[1], Muzaffar Subhani[1], Muhammad Abbas[2], Sohail Tariq[6], Basharat Mahmood[2],

[1]Department of Electrical Engineering, University of Poonch Rawalakot, Rawalakot, AJK, Pakistan. [2]Department of Plant Pathology, Faculty of Agriculture, University of Poonch Rawalakot, AJK, Pakistan. [3]Wheat Research Sub-station Murree, Pakistan. [4]Department of Computer Systems Engineering, Mirpur University of Science and Technology, AJK, Pakistan. [5]Department of Biomedical Engineering, Sir Syed University of Engineering and Technology, Karachi, Pakistan. [6]Department of Mechanical Engineering, Mirpur University of Science and Technology, AJK, Pakistan.
[7]Department of Botany, Mir Chakar Khan Rind University Sibi. Balochistan
E-mails: raees@upr.edu.pk

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ABSTRACT

To bridge up the quality gaps and excel in the production of eggplant there is a need to switch the conventional production system to smart greenhouse house monitoring system. The study was designed to evaluate the growth parameters using smart greenhouse monitoring system designed with Raspberry-Pi microprocessor and sensors to control the microclimate (temperature and humidity) of a prototype greenhouse. A set of experiment was designed, one in a smart greenhouse system and the 2nd in the conventional greenhouse system to evaluate the growth parameters of eggplant. In a microclimate of smart greenhouse the temperature and humidity was set controlled using two sensors and automation system to control the mist spray and heating/cooling system inside the prototype greenhouse. Standard production technology was adopted in both the experiments and the experiment was replicated thrice. It was observed that the smart greenhouse monitoring system maintained the microclimate inside the prototype greenhouse ultimately effect the growth and yield parameters. The results predicted a progressive increase in growth parameter up to 10-20% in plant height, flowers per plant, fruits per plant and weight of fruit in automated greenhouse using microcontroller. Similarly quality of fruit was significantly affected as maximum fruit diameter 35 mm and fruit firmness 6.9 libre was recorded that was significantly higher than the fruit in the conventional greenhouse. The over average yield of eggplant per plant was recorded 5.6 kg/plant in automated greenhouse while 4 kg/plant fruit yield was recorded in conventional greenhouse that was significantly higher. The findings of current study predicted that the overall yield of eggplant was significantly higher and the growth and quality parameters were also higher in automated greenhouse using microcontroller and can be used for the potential eggplant production in urban agriculture.

KEY WORDS: Automated greenhouse; Automation; Microprocessor; Raspberry-Pi

INTRODUCTION

Eggplant (*Solanum melongena*) considered an important vegetable crop cultivated worldwide, with the production of 56.618 million tons. In Pakistan total production of egg was 99416 tonns from the total harvested area of 7327 hectares with an average yield of 13.5684 metric tons/ha (FAO, 2021). One of the key limitation in the production of eggplants is non-availability of irrigation water, especially in the hot and dry summer and is considered susceptible to the drought stress especially on the maturity of the crop in reproductive phase (Karam *et al.*, 2011)and ultimately affects the yield of eggplant.

Today, the agriculture is adversely affected by the climate change thus generating resource issue especially water stress and temperature fluctuations. Thus using smart technologies and sensor based artificial intelligence; the production of agricultural commodities should be progressively good without compromising the food quality and yield of the crop (Baylon *et al.*, 2021). Sensors and artificial intelligence is the way forward to play a key role in reducing the labour and efforts in Smart agriculture. In the era of modern agriculture smart greenhouses equipped with the sensors and microprocessors not only accelerate the agriculture production technology but also played a role in quality produce production that ultimately effect the economic growth of the country (Singh and Saikia, 2016).

According to the results revealed by Taşan *et al.* (2022) that the yield estimation of eggplant on the basis of vegetative indices was done and found that the performance of ANN model was better that the machine learning models due to the efficiency of computational procedures used in the ANN model followed by SVR model that only use the kernel function that only support the vector than other models (kNN, AB and RF) (Modaresi and Araghinejad, 2014). The same results were reported by Huang *et al.* (2019) the performance of kNN was higher than the other models (AB and Rf). Also the tree-based models (AB, RF) use greedy algorithms that may cause noise in the dataset collected.

In the growing populations, urbanization growth, industrialization in the cities and rural areas, global warming as well as environmental pollution, the agriculture sector is adversely effected all over the world by decreasing or spoilage of agriculture lands that may lead to a big challenge for food security in future (Folnovic, 2011). This issue may demand the use of new techniques especially internet based and sensor based smart technologies to ensure food security all over the world. According to Rayhana *et al.* (2020) greenhouse agriculture should be an alternative to cope the food security issues by controlling microclimatic conditions for cropping all over the year. While the greenhouses have limitations for successful cropping and its supervision due to rise in the temperature inside the greenhouses. For that reason the use of smart technologies like Internet of Things (IoT), sensors, artificial intelligence, smart monitoring systems can way out the challenges in conventional greenhouse systems by controlling the microclimate inside the greenhouse (Rayhana *et al.*, 2020).

To monitor the microclimatic parameters including temperature, humidity day and night duration and electric connectivity, a precision agriculture monitoring system (PAMS) was developed using smart wireless sensor network (WSN) and Raspberry-Pi microprocessor as server but still the system is not tested on a large area (Flores *et al.*, 2016).

Keeping in view the current scenario the study was designed to evaluate the growth parameters of eggplant in an automated smart greenhouse equipped with a microcontroller to control the humidity and temperature for eggplant production.

MATERIALS AND METHODS

Raspberry-Pi microprocessor: The installation of Raspberry-Pi microprocessor to control temperature and humidity using sensors was done in a prototype greenhouse. The set of data set in the microcontroller was temperature about 24-28 ℃ and humidity above 75% for its vegetative growth during first 40 days then the temperature was changed to 25 ℃ and humidity within the greenhouse below 60% for reproductive phase. Then in third phase again temperature was raised to 28 ℃ for setting the fruit color. The given data set was accessed using a digital receiver after a specific time interval.

Sensors used: Two sensors were used in smart greenhouse to recorded data continuously set with an android application to display the readings (Figure 1) these sensors includes;

1. DHT11 Humidity sensor to monetize humidity level in the prototype greenhouse (Figure 2a);
2. LM35 Temperature sensors to monitor the temperature inside greenhouse (Figure 2b);
3. Set timer to calculate the time to change the temperature and humidity sensor settings as automated greenhouse controller (Figure 3).

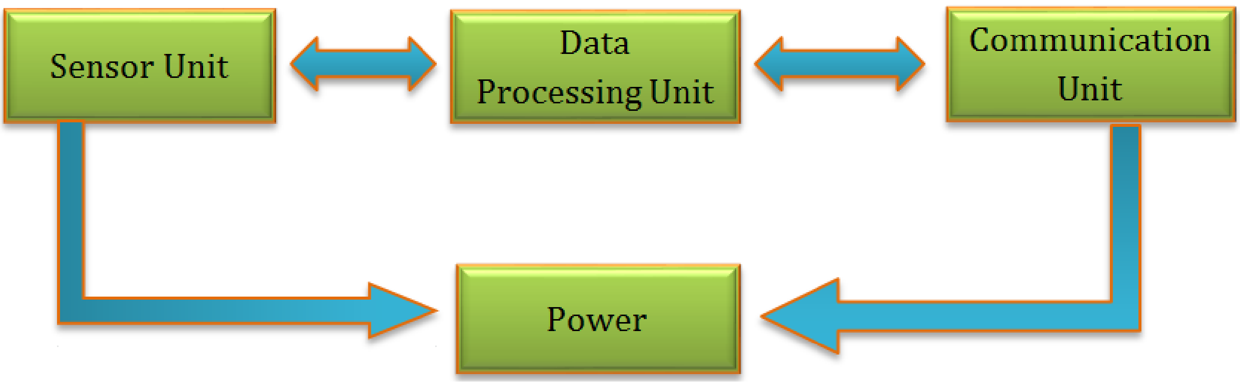

Figure 1: A block diagram of a sensor node used.

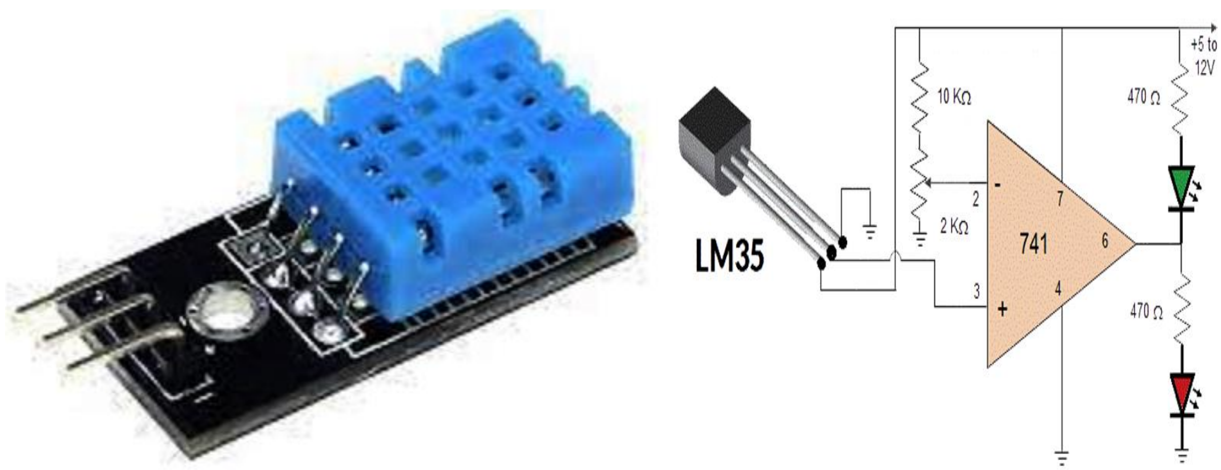

Figure 2. a) DHT11 Humidity sensor; b) LM35 Temperature sensor used in the study add reference of this circuit if available.

Experimental Design: The sterilized soil filled in the pots was sandy-loam also the average bulk density of dry soil was approximately 1.35 gcm-3 throughout the depth. The pots of about 35 x 60 cm were filled with sterilized sandy loam soils. Already cultivated seeds of Fair Tale variety of eggplant were transplanted in the pots and were kept in the smart greenhouse prototype and a set of control experiment was maintained in a conventional green house to compare the results. Single seedling was kept transplanted into an individual pot. Before transplantation of seedlings burnt farm manure was added in the pots and a standard proportion of MOP, phosphoric acid, potassium nitrate and ammonium nitrate was applied with irrigation water using drip irrigation system after transplantation of eggplant seedlings. Moreover pest control was also done in the both set of experiments during the whole growing period of eggplant. Ten pots were transplanted for each set of experiment in the conventional as well as in the smart greenhouse to get the average data of growth and quality parameters.

Data Analysis: Data was recorded for growth and quality parameters. Plant height, Number of flowers per plant, number of fruits harvested per plant and some quality parameters like average fruit weight, fruit diameter, shape of fruit and fruit firmness was recorded. Eggplants were several times hand-harvested from the study pots and were weighed. One way ANOVA analysis method was used for statistical analyses. For the determination of difference between the average Tukey test was applied.

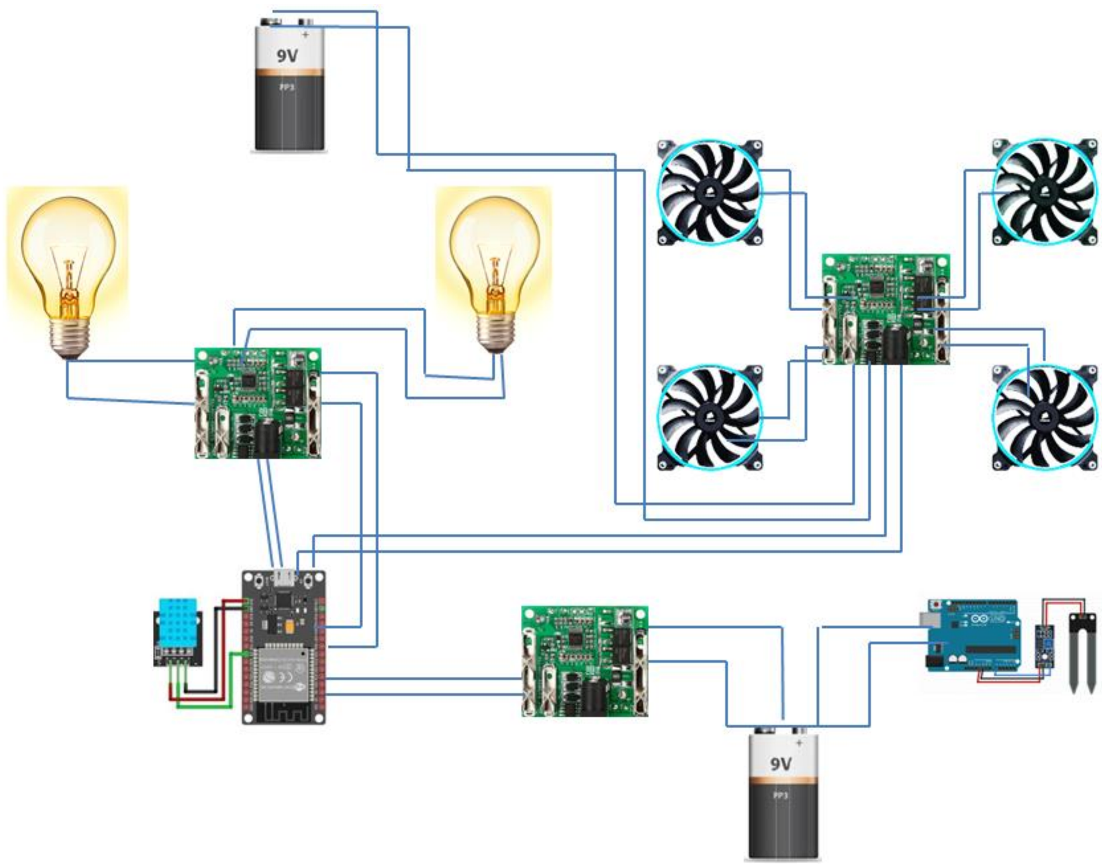

Figure 3: Flow diagram of automated greenhouse microcontroller.

RESULTS

In relation with the current study period, mean temperature and humidity was recorded that was ranged between 24 and 30 °C and 48 and 65.5% respectively in the automated smart greenhouse, (Figure 4) while in the conventional greenhouse the temperature and humidity was relatively higher with a difference of 5-7 ℃ temperature and 10-15% humidity.

The comparison of temperature was done based on data recorded in the automated greenhouse and conventional greenhouse. The impact of temperature found proportional with the growth and quality parameters in the automated greenhouse as the temperature was set and found uniform throughout the growing period of eggplant crop while in conventional greenhouse the temperature was raised and not found uniform throughout the growing period of eggplant growth and reproductive phases (Figure 4).

After 20 -30 days of transplantation the growth parameters were recorded with an interval of 5 days both in conventional and automated greenhouse. It was found relatively 10-20% better results in automated greenhouse than conventional greenhouse. The average plant height 140 cm was recorded in the controlled automated greenhouse while 121 cm in conventional greenhouse (Figure 5). Similarly, after 30 days 21 number of flowers were counted in smart greenhouse that was higher in number than conventional. Moreover the number of fruits and fruit weight was recorded 20 and 135gm respectively in automated greenhouse that was significantly better than conventional greenhouse (Figure 5).

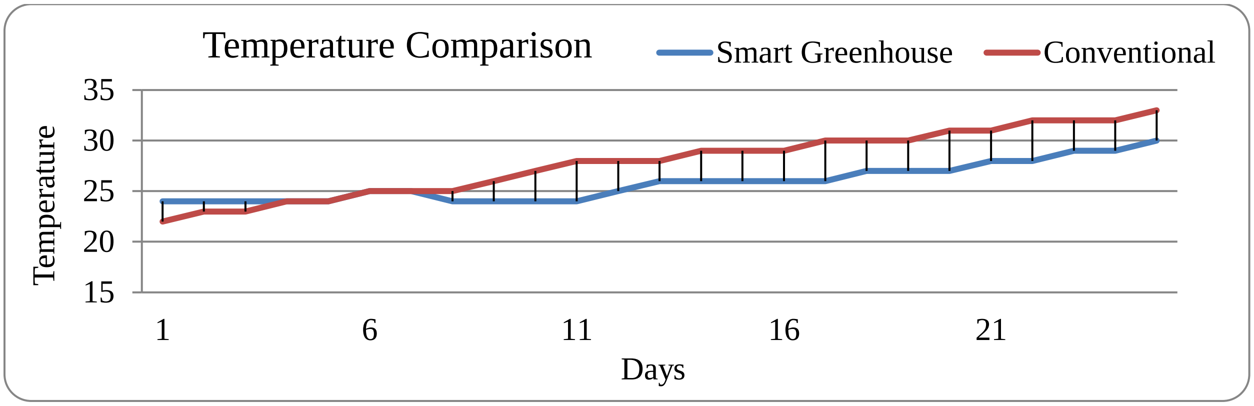

Figure 4: Comparison between smart greenhouse and conventional greenhouse temperature during crop growth.

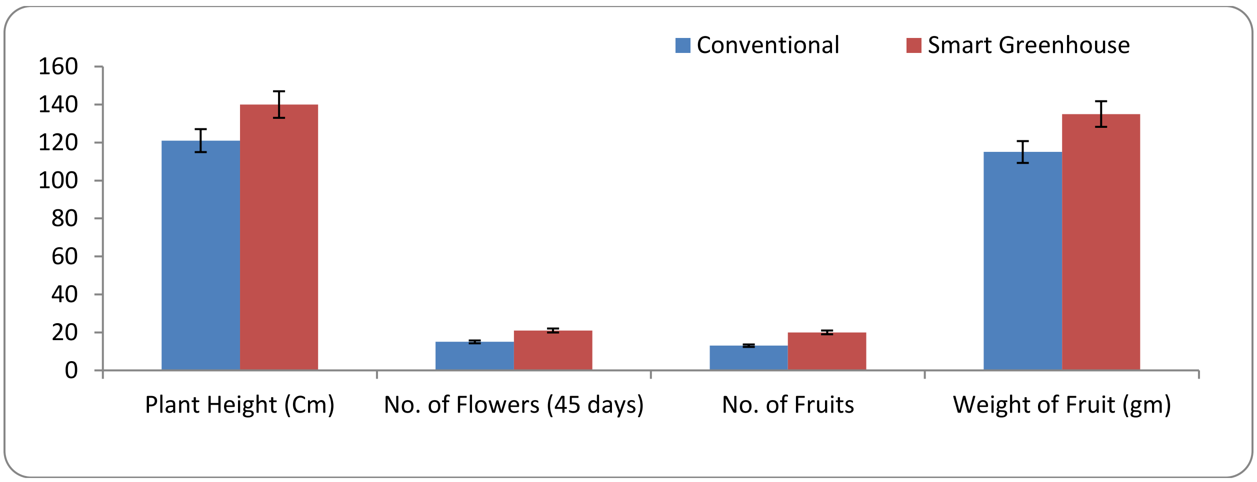

Figure 5: Comparison of different growth parameters of eggplant in smart and conventional greenhouse.

Results regarding the quality parameters i.e. fruit color, fruit diameter, shape of fruit and fruit firmness are presented in table 1. It was observed that the quality parameters in the automated greenhouse were significantly better than in the conventional greenhouse (Table 1). It was recorded that the fruit diameter was 45mm and fruit firmness was 6.9 libre in case of smart greenhouse while the same was 38 mm and 6.1 libre respectively in conventional greenhouse. Moreover the fruit color was uniform purple and the shape of fruit was round for all the fruits on the same plant in automated greenhouse while it was light purple to dark and irregularly round respectively in conventional greenhouse (Table 1).

Similarly the yield of eggplant was recorded and found that the average maximum yield of eggplant per plant was 5.6 kg/plant in automated greenhouse (Figure 6) while on average 4 kg/plant yield was measured in conventional greenhouse.

Table 1: Comparison of quality parameters of eggplant in smart and conventional greenhouse.

Growth Parameters	Conventional	Smart Greenhouse
Fruit Color	Light Purple-dark	Purple
Fruit diameter (mm)	38	45
Shape of Fruit	round irregular	Round size uniform
Fruit firmness (libre)	6.1	6.9

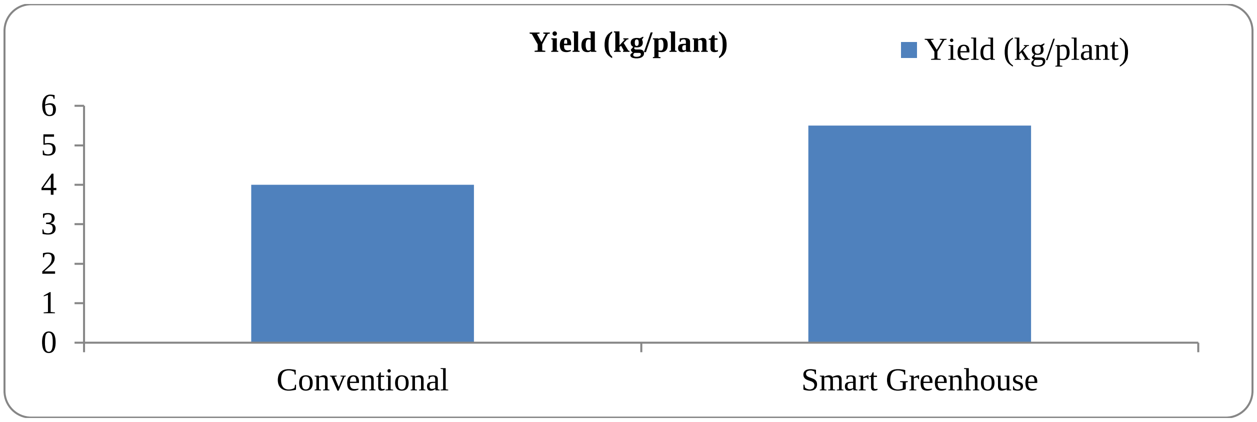

Figure 6: Comparison of yield/plant of eggplant in smart and conventional greenhouse.

DISCUSSION

In greenhouse production of eggplant, different traits were focused including the color of eggplant considered the most important as a market factor for the demand of customers. But the color of eggplant varies in the field and in conventional greenhouses due the temperature effects during harvesting and storage (Wasson *et al.*, 2017), it is a big challenge to achieve an even and attractive fruit color after harvesting and shipping (Wasson *et al.*, 2017). Therefore, the temperature control during fruit setting and maturity is an important factor for tomato production as from the same botanical family in automated greenhouse technologies (Kirci *et al.*, 2022; Bannister *et al.*, 2008).

Several similar studies have reported that the number of fruits per truss in tomato crop, belonging to the same botanical family as eggplant, and few other vegetables, rises with temperature raise to an optimum range and then declines at higher temperatures (De Koning, 1994; Uzun, 2007). The results found in the current study are similar with the previous findings of Lovelli *et al.* (2007) in the eggplant, and Dalla Costa and Gianquinto (2002) in bell pepper.

A similar findings were reported by Saha *et al.* (2017) that Atmega328 microcontroller was used with Arduino, sensors to evaluate the efficiency and reliability of the an automated greenhouse and were efficient and reliable than conventional greenhouses for growth parameters of vegetable crops. The results were parallel to the current findings that human errors should be minimized and automated regulation of temperature and humidity monitoring may influence on the growth and yield parameters of eggplant. Similar study was conducted by Singh and Saikia (2016) that a prototype of remote-controlled greenhouse was developed using microcontrollers with specific parameters and found efficient results as compared with conventional greenhouse farming.

Results of the study reported by Azaza *et al.* (2016), showed efficient results by using water efficient microcontroller model as same to be used in this study on a large scale and found 33% less water used in the cropping pattern similarly designed in a conventional greenhouse. The results of this study was also parallel to the results of Sari *et al.* (2018) that used an Arduino uno microcontroller using sensors, fans, LED bulbs and water pump and found the DHT11 temperature sensor had average 2.64% error value that was close to the error margin specified in the specifications of the used sensor. Internet based machine learning or artificial intelligence is an approach to gather and process the computational data to make calculations and relationship between the variables in an automated greenhouse monitoring systems to provide automated solutions. These technologies were already used in agriculture sector to develop automation systems for irrigation, fertilization drones and also used to identify and envisage models of plant diseases management (Liu *et al.*, 2017; Dubey and Jalal, 2013; Channe *et al.*, 2015).

Similar study was designed to develop an automated greenhouse monitoring system using microcontrollers with an Android application to automate two variables (Temperature and humidity) with specific time periods in an automated greenhouse to evaluate the growth, yield and quality parameters of eggplant and were found significant results of growth and yield of eggplant.

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