Development and evaluation of an automated irrigation system for ordinary agriculture farm

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Abstract. Irrigation is a method of applying water to land or soil to assists the growth of crops. Moisture loss is a common problem in the agricultural situation in developing countries. Therefore, a study was conducted to set up a controlling system for irrigation that is based on the moisture content of soil of the crop field to prevent water and electrical waste using a single-phase water pump and to test the performance of the machine at the field level. The irrigation control machine functions with the help of two electrodes used to measure the soil water content were developed successfully using the low-cost electrical and electronic accessories which functions with DC voltage. This study highlights that the automatic machine was successfully performed in the field. When the machine was used in the field, the vegetative parameters such as average plant height and mean leaf area of the maize plants which was grown under the irrigation of an automatic irrigation system were significantly greater than the normally irrigated plants. Further, the maize plants grown under the automatic irrigation system showed early flowering and 34% average individual plant yield improvement compared to the conventional irrigation system.

1 Introduction

Irrigation is the science of artificial methods of water application to land or soil. The world population reached nearly seven billion people. Water is a basic need for their day-to-day consumption as well as for agricultural purposes. Therefore, water conservation has become a crucial factor in the modern world. Automation technologies are being increasingly applied to agriculture to reduce water wastage, and cost of irrigation and to increase production. Automatically controlled watering systems in the field using moisture sensors are one of the solutions to the water scarcity problem.

This will directly help to reduce the labour cost which is needed for irrigation practices as well as using machines that can supply the exact amount of water to plant according to

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its field requirement which will help the supply of the exact amount of water increase productivity.

The objective of irrigation provides a sufficient amount of water to prevent stress. The stress on the crops may cause a reduction in the crop yield, and poor quality of crop harvest. The amount of applied water to grow will determine the moisture-holding capacity of the soil, and the extent of root development [1].

The scarcity of water resource in the world is acting as a limiting factor in irrigating agriculture Using the machine for irrigation reduce operation and maintenance costs and also due to prevent the extra application of water increasing water availability in the environment. Through regular irrigation, vegetable yields are maintained by minimizing the problem related to environment by application of excessive water and the leaching of agrochemicals [2].

Irrigation is a labour-intensive cultural practice in agriculture. Improving the efficiency of irrigation can reduce the production costs of agriculture and improve sustainability. Through proper management of irrigation, crop yields can be maximized and minimize environmental impacts caused due to the application of water and agrochemical leaching. Irrigation water loss has become a common problem in global agriculture. This system is applied to maintain the level of soil moisture and optimum for the growth of the crops with minimum water wastage [3].

A greenhouse also helps to prevent solar radiation. The structure of the greenhouse with a plastic or glass roof protects plants and provides a controlled environment to raise plants in an indoor environment. The gardener practices manual watering methods to water the plant in the greenhouse or the gardens and this is an inefficient practice to water the plant. When we use manual systems then the possibility of watering which leads to leaching. Some plants can drown when applied with more amount of water. The solution is to form an automatic system of watering. The sensors such as soil moisture detecting sensors are fixed to monitor the watering mechanism inside the greenhouse [4].

Further, most automated irrigation systems are not popular among farmers as they need high initial investment and technically skilled operators. This project aims to manage the time and quantity of irrigation as a solution for the prevailing farm-level problems of irrigation water wastage by developing a simple and low-cost system which can manage the moisture level of a particular soil continuously at its field capacity where the plant can show optimized production [5].

Water absorption is mainly occurring in the roots. An amount of water is absorbed through aerial structures. Young roots make up the majority of the absorptive surface in actively growing plants, while in older perennials and trees, they make up a relatively small portion of the total absorptive surface. The young part of the root consists of a root cap which is a maximum meristematic activity zone. Root hairs, thin-walled outgrowths, have a large surface of absorbents [6].

Tensiometers were the first sensors used to determine the water potential of soil. The irrigation controller was invented using the voltage signal application from the dielectric probe [7-8]

Decision-making on time and the quantity of irrigation water are the most important field challenges faced by farmers. Automated irrigation systems provide solutions for making decisions on the time and quantity of irrigation as they can automatically function when plants need water while monitoring soil moisture content with the help of electronic devices.

2 Methods

This system was tested in the experimental fields for 36 months. Common electronic and electrical equipment was used for this project including Integrated circuits, transistors, LED, Vero boards, solding led, heat zinc, wire, relay switch, hotkey switch, cooling fan, metal box, plug top, water pump, agricultural equipment and planting material for test field preparation, sprinklers, Resistors, Capacitors, Semiconductors, Diodes, Transformers, Cooling fan 12V, Seeds, mamotty, pesticide, 0.75 hp water pump.

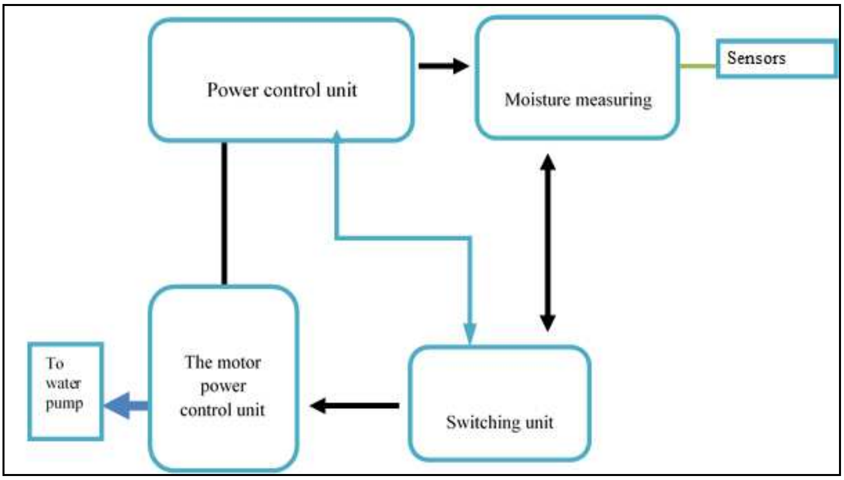

Fig. 1. Flow diagram of the irrigation controlling unit.

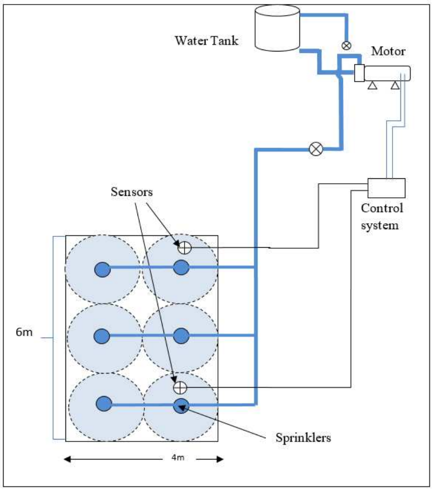

Fig. 2. The layout of the sprinkler irrigation system for a single plot.

Working principle of the controlling unit is explained as follows, the moisture measuring unit will send a low voltage current through the electrodes to the part of the target soil area. Based on the electrical conductivity between both electrodes which are located at a fixed distance in the plant bed, the switching unit delivers the commands for the motor power control unit to regulate the water pump.

When the plant bed dries the available soil moisture level will be reduced therefore the electrical conductivity through the soil will be reduced. Therefore the moisture measuring unit will send the pulse to the Motor power control unit to start the motor. When the motor turns on irrigation commences to the planting bed leading to saturation of water which results from an increase in electrical conductivity between the electrodes again the moisture measuring unit will sense the increase in eclectic conductivity and send commands to the Motor power control unit to switch off the motor.

The automated system was evaluated for its performance on operating sprinkler heads installed with the spacing of 2 x2m on experimental plots of maize intercropped with cowpea and compared with a control. Data collection was carried out on the following parameters at weekly intervals. Plant height, amount of leaves in the plant, average leaf area, number of pods/plant, amount of flowers/plant, average yield/plant and average pod weight were also collected and data analysis was done by using the statistical package Minitab.

For easier comprehension, the experiment's design is displayed below, with the sprinkler head, plants, the flow of electron through the bed and sensor serving as its four key components shown in figure 03.

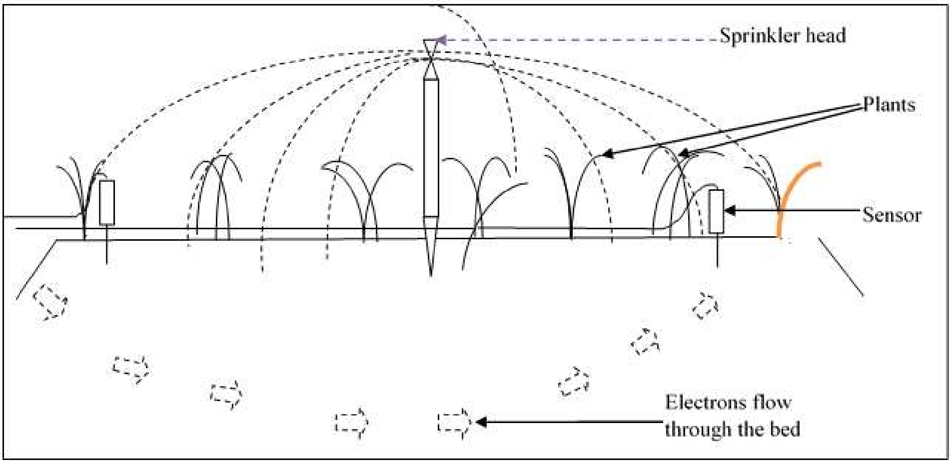

Fig. 3. Explanation of the design of the experiment.

3 Results and Discussions

3.1 Plant height

Plant height showed that the maize plants grown under the irrigation of an automatic irrigation system have performed well in plant height due to continuous maintenance of moisture in the field. Numerous investigations concerning the impact of water stress resulting from lowering the irrigation level from 100% to 75% or from 100% to 80% Evapo transpiration (ET) showed that the yield was unaffected at all irrigation levels [9,10]. Furthermore, the deficit irrigation techniques throughout the agricultural growth phase had a considerable impact on the crop's growth metrics, including plant height [11-12].

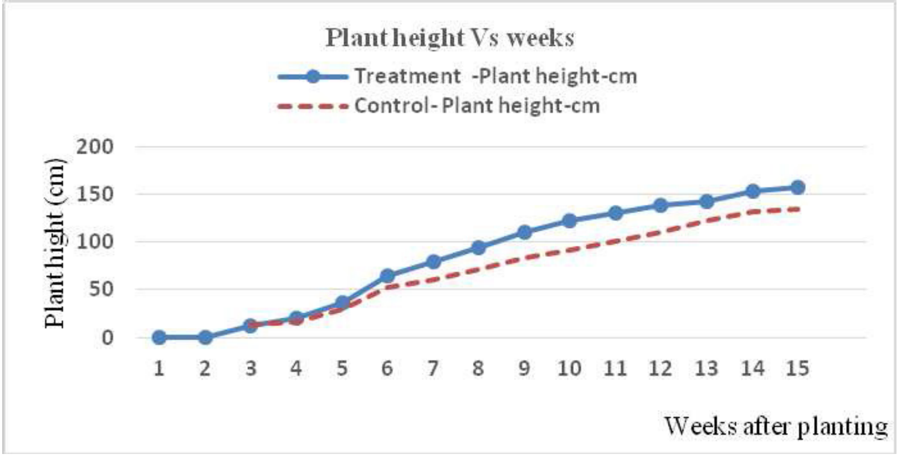

Fig. 4. Average plant height distribution over week.

Figure 4 illustrates the gradual increase up to the fourth week, the abrupt spike from the fourth week to the fourteenth week, and the gradual decline after the fifteenth week. Due to reproductive growth, the plant height was found to be reasonably steady at 155 cm at the 14th week. However, the t-cal value (8.83), which was higher than the table value (2.021), indicated a significant ($P<0.05$) difference from the plant height.

3.2 Average leaf area

Allowing a water deficit has a detrimental impact on the process of leaf creation, and this negative impact was most obvious in the plant. The Water application three weeks resulted in the maximum yields, which obeys our experiment result but it was not substantial in the field crops. Better productions were connected with the larger leaf area during early stage [12-13] .

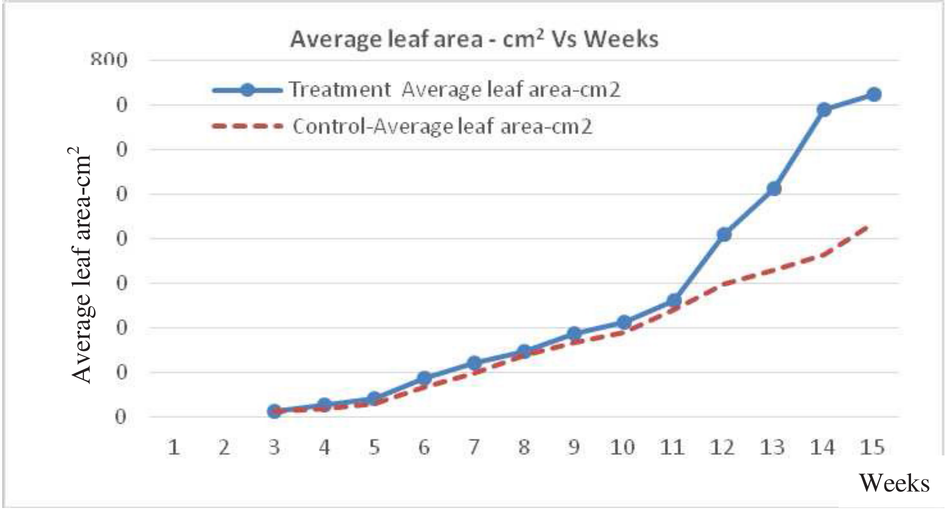

Fig. 5. Average leaf area.

An Independent sample t-test was done to check the average plant leaf area grown under the automatic irrigation system and the control and the t-calculated value was significantly higher (4.369) than the table value (2.021) at ($P<0.05$). Further, even though the leaf area was not prominently differ at early growth stages it has shown a remarkable increase in average leaf area after the 11th week after planting which may lead to a yield improvement in maize plants.

3.3 Number of leaves per plant

Figure 6 shows that the leaf number per plant showed a positive quadratic relationship with irrigation level in crops and it was greatly impacted by the watering schedule [14-15]. The observed growth parameter fluctuations are corroborated by the watering schedules and the growth and yield indices shown in Figure 6.

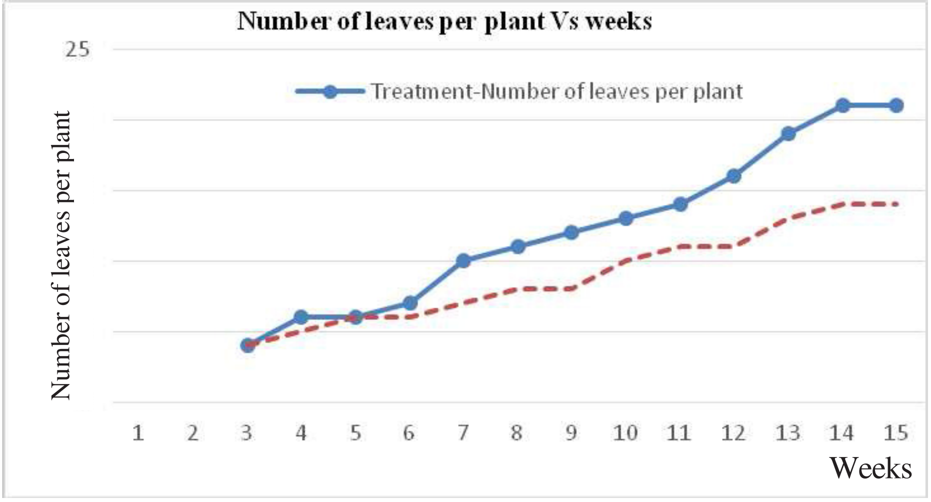

Fig. 6. Number of leaves in a plant.

Figure 6 shows that the maize plants grown under the irrigation of the automatic irrigation system were not much different until the sixth week, after that the average leaves per plant shows a considerable improvement compared to the control treatment. However, that is no significant difference in the mean values of the plant's average number of leaves as the t-cal value (1.806) is not greater than the table value (2.021) at ($P<0.05$). The plant with applied irrigation has the largest number of leaves at intervals of 14 weeks, while the plant without irrigation received the least number of leaves per plant.

3.4 The average amount of flowers per plant

Applying irrigation scheduling requires a dependable control system that can accurately determine the crop's current water status online. It would be very beneficial to create direct, noncontact, nondestructive, and broader sample area techniques for collecting data for irrigation control [16,17]. The reflectance index investigated in this paper appears to be an interesting field for further research in this framework. The elimination of noise (such as interferences from the greenhouse's framework and machinery, shadows cast by the crops, crop background reflectance, and so on) and the establishment of threshold values for irrigation scheduling are likely problems with its application for greenhouse irrigation control [18].

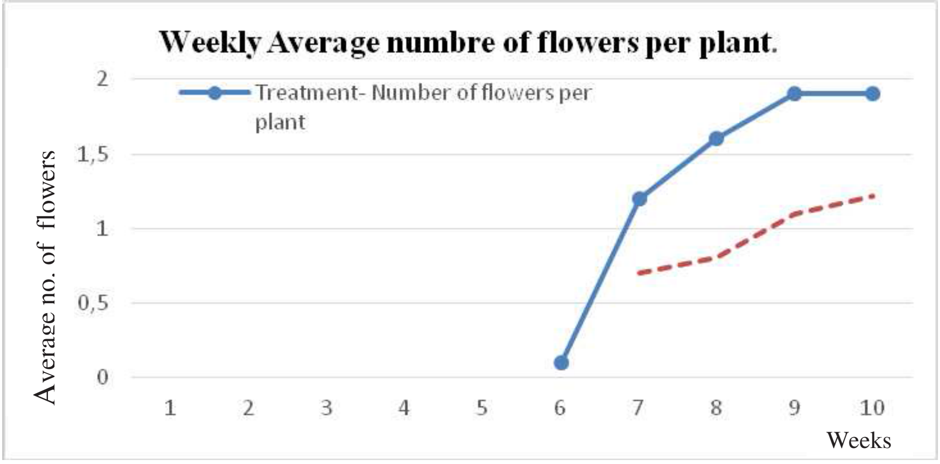

Fig. 7. Average number of flowers per plant 6 weeks after planting.

Figure 7 shows the maize plants grown under the irrigation of the automatic irrigation system was 1.34 while the same was observed to be 0.955. Further, the maize plants grown under the irrigation of the automatic irrigation system were observed to flower about one week (on average) earlier compared to normally irrigated plants. However, it is not significant (P=0.05) in the average number of flowers between automatic irrigation and normal irrigation.

3.5 Yield parameters

The average number of pods in a plant in maize grown under the irrigation of the automatic irrigation system was 1.12 while the same was observed to be 0.76 in the normally irrigated plants (control).

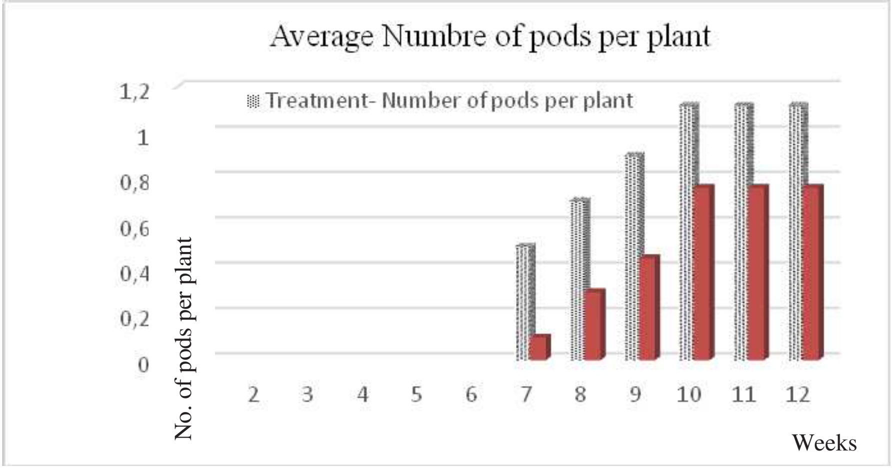

Fig. 8. Average pod weight, number of pods/plant and the pod yield.

The average weight of the pod and the yield of the pod/plant from the maize grown under the irrigation of the automatic irrigation system were 280g and 225 respectively while the same was observed to be 166g and 167 respectively in the normally irrigated plants (control).

4 Conclusions

This study highlights that the vegetative parameters such as average plant height and the average leaf area of the maize plants grown under the irrigation of an automatic irrigation system were significantly greater than the normally irrigated plants. Further, the maize plants grown under the automatic irrigation system showed early flowering and 34 % average individual plant yield improvement compared to normally irrigated plants.

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