Arduino based soil moisture analyzer as an effective way for irrigation scheduling

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ABSTRACT

Through the present study we vindicated the crop water requirement for eggplant by using Arduino based soil moisture investigator and compared the total water requirement with the quantity of water being applied by farmers to save such excess quantity of water being wasted by the farmers. Therefore a device was established in the Arduino platform in order to detect the soil moisture, as the moisture sensor shows only the resistance between the two probes. It was calibrated with direct moisture meter to obtain the moisture readings directly. Then selected egg plants were planted in two drip fixed fields in two different times. Such time variation in planting was maintained to facilitate the root study in one field before the irrigation of the test field. Hence, according to the measured root length the soil moisture sensors were inserted into the soil in the test field and plants were irrigated up to the field capacity by using the moisture detection. The measured quantity of water which is actually needed by an eggplant up to 108 days after planting was around 149.26 liter. Simultaneously an investigation was carried out to find the quantity of water being applied by farmers. Finally. The measured quantity of water being applied by the farmers was 604.8 liter and it is 4.05 times higher than actual water requirement. Therefore, by using this soil moisture sensing technique it is possible to save a huge amount of water.

Key words – Process control, Crop water requirement, Eggplant, irrigation interval.

I. INTRODUCTION

All living beings including human are strictly relying on water for survival. Therefore, ensuring the satisfactory supply of water is essential for the wellbeing of this globe [1]. With the world population increment, the available water is getting depleted mainly due to the industrial activities. Agriculture is having a prominent role in such depreciation. In many developing nations irrigation accounts for 90% water withdrawn from available sources of use. In the meantime recent studies convey that around 800 million people in developing world are privation of sufficient nutrition [2], In order to rectify these issues we are in a hurry to increase the food production with the assurance of water sustainability.

Irrigated agriculture has a prominent role in food production but most of the time it is with complete disregard to basic principle of resource sustainability. Most of the famers irrigate their fields with excess amount of water Therefore, irrigation water management in an era of water paucity will have to be carried out most competently, focusing at saving water and at maximizing its productivity.

Precision irrigation is possible only after the measurement of plant water requirement. There are various approaches of crop water measurements deal with soil, plant, atmospheric or microclimatic parameters. However within all parameters soil related measurements; soil moisture sensing is more viable which uses dielectric properties of the soil as it is auto-dynamic as it is not affected by the environmental manipulations and easy accessible [3] Evidence are documented that they were Therefore switching tensiometers were in the usage to find out the soil moisture state and to automate the irrigation in between two different predetermined matrix potentials in tomatoes, citrus, and Bermuda grass [4,5]. But there are some drawback in using these tensitometers, were demonstrated by Smajstrla and Koo (1986) such as entrapped air in the tensiometers, organic growth on the ceramic cups, and the need for recalibration [4]. Hence with the introduction of solid soil moisture sensing probes the above mentioned constrains were asphyxiated and these types of sensors have been used for the crops such as onion and potato [6] and for urban landscapes [7]. Generally, these sensors have been found to involve less maintenance than traditional tensiometers.

Over the last decades the soil moisture sensing field has advanced immensely, the reasons for the advancement can be seen in two distinct ways. The first one is the improvement of computer technology along with powerful, handy integrated circuits developments and the second one is the significant advances in the application of electromagnetic methods for the measurement of soil water availability [8]

Even though there are more researches regarding the soil moister sensing and automation in irrigation, still there is a gap in the concept of precision irrigation with the concern of plant water requirement.

Therefore our objectives of the study were to measure the crop water requirement of eggplant by using the prepared

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soil moisture sensing analyzer, To achieve this objective it was proposed to measure the root length in different time then to insert the soil moister sensors up to the measured root depth and irrigate up to field capacity level which will ensure the application of water at actual plant water requirement. And to compare the required amount of water with the quantity of water that has been applied by the farmer for eggplant, which can be fulfilled through direct investigation from farmers' field.

II. MATERIALS AND METHODOLOGY

A. Development of soil moister analyzer

In order to monitor the soil moisture content an Arduino based soil moister analyzer was prepared. For the soil moister analyzer Arduino UNO board, 16*2 LCD, SD card module, Yl-69 soil moisture sensors, were connected.

Figure 1 shows the final diagram that was made to analysis the soil moisture and for data logging.

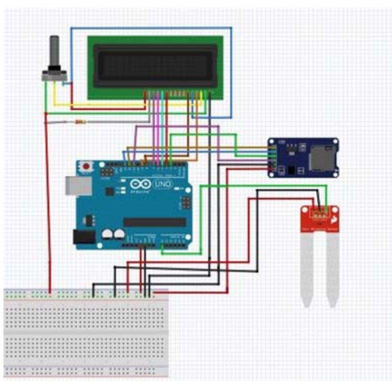

Figure 1 Prepared Gadget

B. Calibration of soil moister sensor

As the soil moister sensor is only will only measure resistance between the two probes, it has to be calibrated with soil moister meter in order to make the sensor to show the direct soil moister measurements. So, for that the soil moister meter readings were noted in different levels of soil moister along with the corresponding resistance readings of moister analyzer and by plotting a graph, a linear equation was obtained.

Then the developed soil moister analyzer was utilized at different measured root depth to maintain the field capacity of root zone to find out the crop water requirement and to store the obtained data.

C. Plant selection

For this research purpose, eggplant (Plastic variety) was selected as it is medium rooted and drought tolerant, so that water saving will be more efficient without crop damage.

D. Field preparation and Preliminary investigation

A field was selected in Department of Agriculture farm, Thirunelvely. According to the Agriculture department spacing recommendation, drip system was developed in the field and some preliminary investigations such as infiltration rate, field capacity level of the soil, emitter discharge, emission uniformity coefficient and finally the measurement of quantity of water being irrigated by the farmers in different stages of eggplant were carried out.

E. Field planting

Eggplants were planted according to the recommended spacing in two adjacent drip irrigation fields. Each field was allowed to have 6 columns and 13 rows. Planting was carried out in two different times. First field was planted 31 days prior to the planting of second field (test field). First field was used for the root investigation and the second field was used to calculate the crop water requirement.

For field planting 23 days old, disease free plastic variety eggplant seedlings were planted in the field manually in the basis of 1 seedling per planting holes. Then the plants were covered by glyricidia plant branches in order to facilitate temporary shading.

F. Root investigation

The first field was irrigated according to the recommendation of Department of Agriculture training center. From each column of field one, 4 plants were randomly selected and uprooted according to the monolith method and roots were investigated for vertical and horizontal lengths in 18 days after planting, 38 days after planting, 58 days after planting, 78 days after planting and 108 days after planting.

G. Estimation of crop water requirement

According to the investigated length of the root, the soil moisture sensors were inserted as shown in the Figure 2 into the soil and plants were irrigated up to the field capacity of soil in the test field. Finally the time needed to irrigate the eggplant in different stages and the time needed between two consecutive irrigation were calculated.

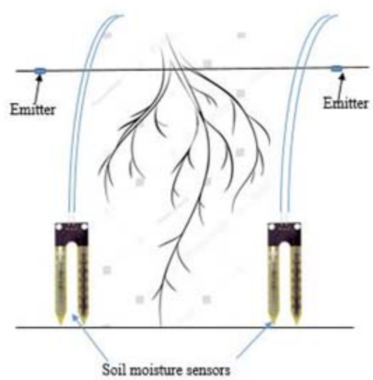

Figure 2 Soil moisture sensor insertion pattern

III. RESULT AND DISCUSSION

Measured infiltration rate of the soil is 350 mm/h, our soil lies under very rapid infiltration soils and chances for flooding during irrigation via drip will be nil [7]. Obtained average discharge rate of the emitters is 3.6 l/h at the pressure of 1.2 kg/ cm^2. Calculated emission uniformity coefficient is 88.88%, this ensures the acceptability of used drip system in the field [6]. Finally the estimated field capacity of the soil was 28% and the permanent wilting point was obtained from literatures and it is 10% [9,10].

The soil moisture sensor was calibrated with direct soil moisture meter. It is essential to calibrate it whenever we use it with different soils, because the soil composition will affect the electrical properties of the probe. Figure 3 shows the calibrated soil moisture curve. Here, the soil moisture content and sensor reading show a positive linear correlation. According to the graph, the equation was

$$Y = -0.0363x + 37.737,$$

where, "Y" implies the soil moisture content and "X" represents the resistance reading given by the probe.

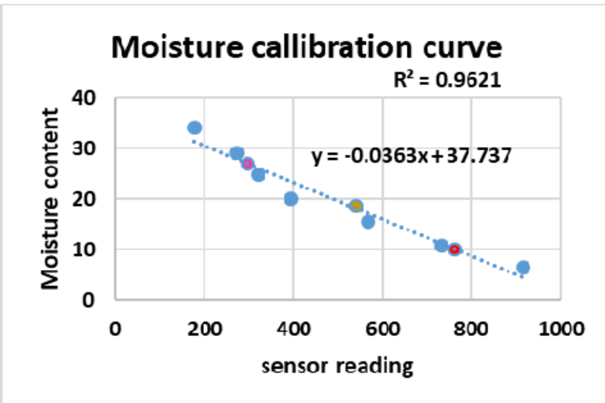

Figure 3 soil moisture calibration curve

Table 1 Measured quantity of water being applied by farmers in different stages

Duration of irrigation (days)	Quantity of water for a plant (liter/day)
3	0.6
15	1
40	4.2
50	8.4

Table 1 shows the quantity of water being applied by the farmers for the eggplant and Table 2 shows the actual crop water requirement. The total water requirement by a single plant up to 108 day is 149.26 liter but the farmers irrigate their fields with the total amount of 604.8 liter per plant up to 108 days. Therefore it is obvious that the farmers irrigate their fields with 4.05 times more water than the actual plant water requirement.

Table 2 Calculated quantity of water needed by a single plant for different stages

Duration of irrigation (days)	Quantity of water for a plant (l/day)
18	0.82
20	1.26
20	1.77
20	1.73
30	1.31

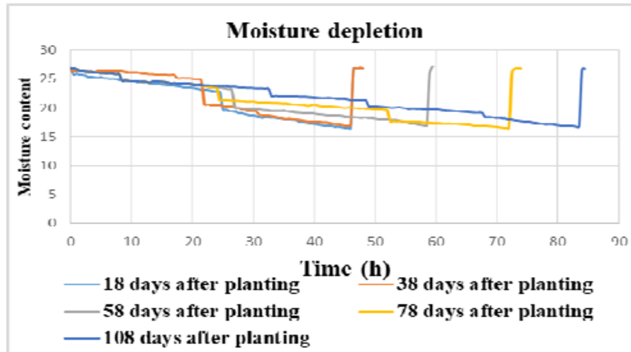

Figure 4 Moisture depletion pattern with time

Figure 4 shows the moisture depletion pattern obtained via the soil moisture investigator. Initially at 18 days after planting soil moisture depleted up to 50% within 46 hours, same pattern was observed in 38 days after planting. Then the moisture retention time increased gradually; during 58 days after planting it was 59 hours, 78 days after planting it was 72 hours and finally at 108 days after planting it was 83 hours. This depletion pattern was influenced by plant absorption and microclimatic manipulations. With the time, plant uptake of water will increase due to its physiological activities but during the earlier days of growth plant canopy will be small and it will facilitate higher rate of evaporation from soil but with the increased canopy the irrigated soil portion will be covered and it will reduce the evaporation quantity of water. Therefor it is obvious that the evaporation effect highly impacts on the soil water depletion pattern than the plant physiological activities.

Obtained values for irrigation interval and crop water requirement will be more useful for the farmers who are not willing to adopt and automated irrigation system. They can simply apply water to their fields with needed at corresponding irrigation intervals

IV. DEVELOPMENT OF AUTOMATED IRRIGATION MODEL

As the water saving obtained in this research work was much promising the farmers need to be convinced to adopt the above method of irrigation. To make it possible a model for automatic irrigation based on the above method was proposed. This model comprised of relay and solenoid valve moreover to the soil moisture analyzer. The automated system automatically controls the irrigation, where we need not to worry about the irrigation scheduling. Whenever the soil moisture is lower than the 50% depletion level from the field capacity and permanent wilting point the relay will act as a switch to automatically switch on the solenoid valve. If the soil moisture exceeds its field capacity level, as it is the maximum limit, solenoid valve will be automatically switched off by the relay.

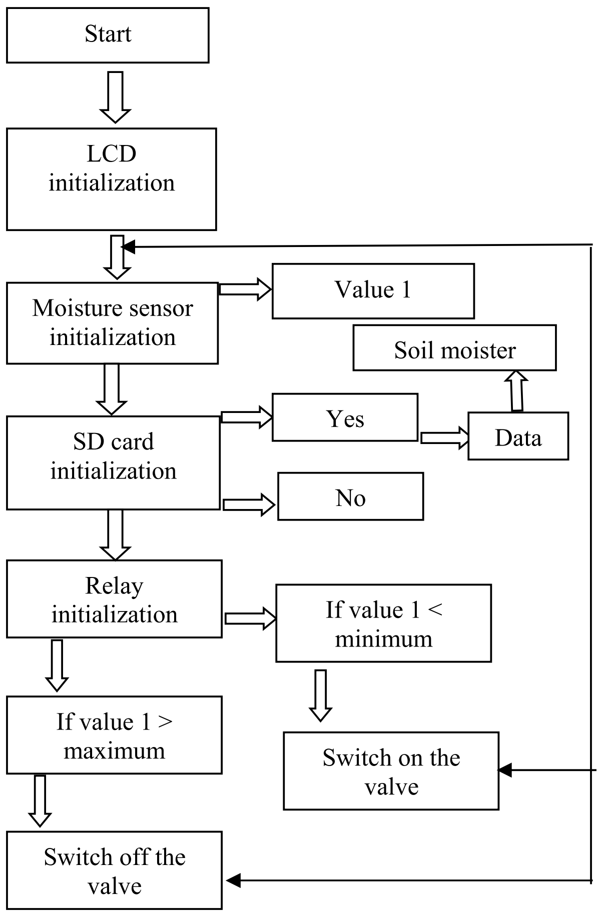

Figure 5 Proposed flow chart for the automation model

Figure 5 shows the flow chart for the automatic irrigation system.

Still now this automated system analyze did not take place in the real field. It will be more effective if we could find the field capacity of different available soils and root growth of different plants in corresponding soil to automate the irrigation system without any investigation.

V. CONCLUSION

With the assistance of an Arduino based device the crop water requirements were calculated for the different stages of eggplant such as 18 days after planting, 38 days after planting, 58 days after planting, 78 days after planting and 108 days after planting respectively the requirements were 0.82 l/day, 1.26 l/Day, 1.77 l/day, 1.73 l/day, 1.31 l/day and the irrigation interval for first 58 days was 46 hours, for next 20 days it was 59 hours, during the next 20 days it was 72 hours and for the final 20 days it was 83 hours. Finally the total water requirement is 149.26 liter for a single plant but farmers irrigate with 604.8 liter of water. This amount is 4.05 times higher than the actual water requirement and 3/4th of total water is vanished unwantedly. Hence we can come to a conclusion that the farmers have been wasting a huge amount of water due to the in accessibilities to available crop water calculation techniques. The proposed low cost soil moister sensing process is more adoptable and more accurate compared to other techniques available to find out the crop water requirement. After the crop water requirement calculation process the irrigation can be automated without any labor intervention

VI. ACKNOWLEDGEMENT

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