Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7433

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2019) *7*(5), 160-165

Research Article

Indian Journal of Pure & Applied Biosciences

Performance Evaluation of Real Time Automatic Irrigation System on the Yield of Cabbage (*Brassica oleracea* L.)

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Received: 21.06.2019 | Revised: 28.06.2019 | Accepted: 6.07.2019

ABSTRACT

The performance evaluation of real time automatic irrigation system designed and developed at the Department of Irrigation and Drainage Engineering, College of Agricultural Engineering and Technology, Dapoli were carried out during January 2017 to April 2018. Cabbage crop was grown on the plot of 14.35 m x 17.10 m size along with micro-sprinklers of 26 lph discharge which were installed at spacing of 1.5 m x 1.5 m. The crop spacing of 0.30 m x 0.45 m was used with raised beds. The designed controller was installed in the field for the entire crop period from 29/01/2017 to 28/04/2017. The four sensors were randomly installed in the field, out of which two sensors were at the depth of 5 cm and the remaining two sensors were at the depth of 10 cm near to the root zone of the crop. The results revealed that the depth of water required on ET_C *basis was 304.37 mm while controller actually applied 283.74 mm water throughout the crop period on real time soil moisture basis. Thus, the real time automatic irrigation system saved 6.78 per cent water of total water requirement over the climatological data. The moisture content study shows that the moisture content in the field was always maintained between the field capacity and 50% depletion of permanent wilting point. The real time automatic irrigation system recorded cabbage yield of 59.54 t/ha which was 18.40% more than manual irrigation system.*

Keywords: *Sensors, Water requirement, Cabbage, Yield, Controller.*

INTRODUCTION

The real time soil moisture based system has capabilities to provide sustainable solution to enhance water use efficiency (WUE) in the agricultural fields. The real time automatic irrigation system uses sensor to automate the irrigation system which improves water use efficiency and applies water up to crop water requirement as and when required by the crop. The sensors should be installed near the root zone in an undisturbed soil.

Cite this article: Bowlekar, A.P., Patil, S.T., Kadam, U.S., Mane, M.S., Nandgude, S.B., & Palte, N.K. (2019). Performance Evaluation of Real Time Automatic Irrigation System on the Yield of Cabbage (*Brassica oleracea* L.), *Ind. J. Pure App. Biosci.* *7*(5), 160-165. doi: http://dx.doi.org/10.18782/2320-7051.7433

When there is condition of deficit available soil moisture content, the sensor send signals to controller to start the irrigation system to deliver water up to the desired depth (Prathyusha & Suman, 2012). Once the soil has reached desired moisture level the sensors send a signal to the micro controller to turn off relays, which control the valves (Shiraz & Yogesha, 2014). It applies the water for plants according to the crop water requirement and operates according to the soil moisture condition of the root zone of plants and minimize or stop manual interventions once calibrated (Abdurrahman et al., 2015). The microcontroller based automated irrigation system consisted of moisture sensors, analog to digital converter, micro controller, electromagnetic relay, solenoid valve, LCD and controller etc. The real time feedback control system has ability for monitoring and controlling all the activities of drip irrigation system more efficiently. This system could save manpower as well as water. It also helps in time saving, removal of human error in adjusting soil moisture levels and to maximize the net profits. Also it can be extended and used for automation of the greenhouses (Nagarajapandian et al., 2015). The growth of the crop is vigorous at field capacity moisture content. The aim real time moisture system is to maintain soil moisture always in between field capacity and fifty percent depletion from permanent wilting point.

MATERIALS AND METHODS

The sensor based automatic irrigation system was designed and developed using different hardware parts such as raspberry pi (controller), soil moisture sensors, temperature sensors, membrane keypad, LCD screen, relay for solenoid valve, relay for pump, PCB and other accessories. Fig. (i) shows the outer view of the developed controller.

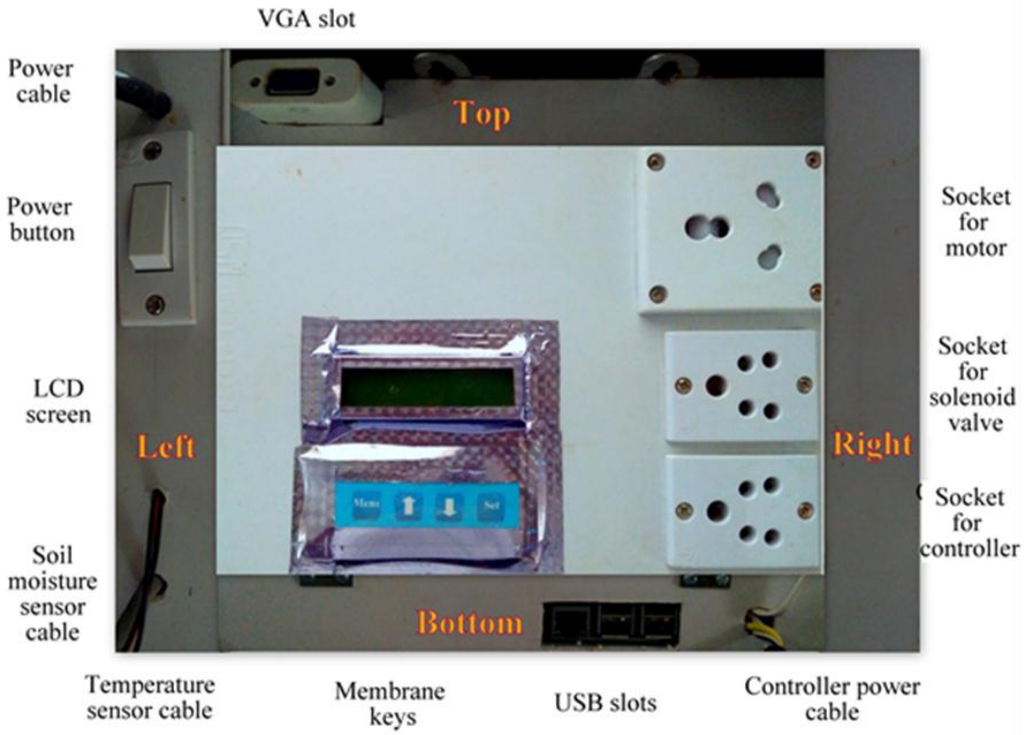

Fig. (i): Outer view of the controller

Experimental site and setup

The Cabbage (*Brassica oleracea* L.) crop was planted at spacing of 0.30 m x 0.45 m over raised beds on the plot of 14.35 m x 17.10 m size at the Instructional Farm of Department of Irrigation and Drainage Engineering. The micro-sprinklers of 26 lph discharge were installed at spacing of 1.5 m x 1.5 m. The land was prepared by primary tillage and secondary tillage with incorporating the Farm Yard

Manure (FYM). The recommended dose of fertilizer for cabbage i.e. 120:60:60 kg/ha and the FYM (Farm Yard Manure) is 20 t/ha were applied in two splits (Nalawade, 2008). The four soil moisture sensors were randomly installed in the field; two sensors at the depth of 5 cm and two sensors at the depth of 10 cm respectively. The soil moisture was monitored for entire crop period. The developed automatic controller was tested for the cabbage (*Brassica oleracea* L.) crop. The irrigation system for experiment consisted of water storage tank (water source), pump, control valves, solenoid valve, filter, micro sprinkler unit, automatic irrigation controller, etc. Fig. ii shows the layout of the experimental plot. The plot was irrigated to its field capacity before transplanting so that seedlings could get favorable moisture conditions for settlement. The transplanting of seedling was done on 29th January 2017.

Installation of the sensors in the cabbage plot:

The sensing of the available soil moisture in the soil at once and in continuity can be achieved by installing the sensor at a particular depth in the experimental plot. Considering the depth of soil, active root availability of crop under study the sensors are placed at the depth of 5 cm and 10 cm. The previous studies of Nallani et al. (2015) also shown the close agreement with this. Total 4 sensors were randomly installed in the field vertically at the depth of 5 cm and 10 cm respectively.

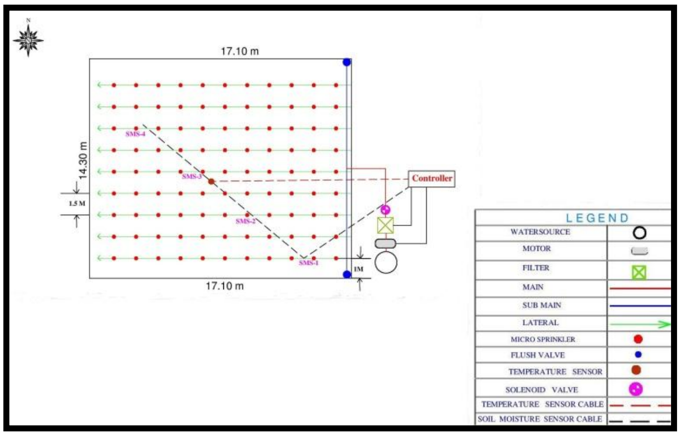

Fig. (ii): Layout of the experimental plot

RESULTS AND DISCUSSION

Water saving:

The developed automatic irrigation system was installed in the experimental cabbage (*Brassica oleracea* L.) plot for entire crop period. The water requirement of cabbage by climatological basis was 304.37 mm while controller actually applied water of 283.74 mm throughout the crop period. It shows 6.77 per cent less depth of water was actually consumed by the crop when irrigated by controller. Fig. (iii) shows the daily moisture content variation in the field for entire crop period.

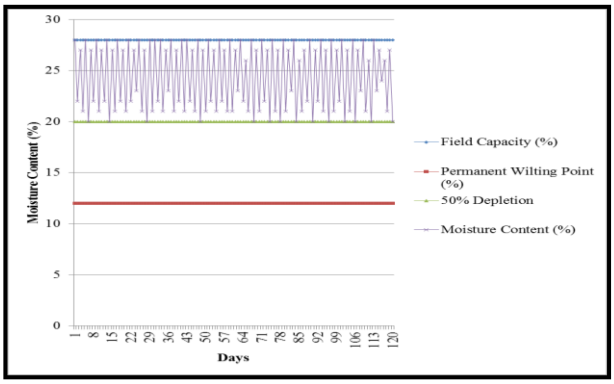

Fig. (iii): Daily moisture content variation for the entire crop period

Soil moisture status:

From Fig. iii it is observed that the moisture content in the field is always maintained between field capacity and 50% depletion. Thus, it can be concluded that the field capacity was always maintained in the field by adopting the automatic irrigation system.

Biometric parameters

The biometric parameters of cabbage such as plant height, number of leaves, plant diameter, and geometric mean diameter of curd, average weight and specific gravity of curd were measured.

Plant Height

From Fig. (iv) it is revealed that the plant height were increased with DAT. The plant height was found 7.4, 13, 17.5, 21.45 cm and 21.68 cm at 15,30,45,60 and 75 days after transplanting respectively.

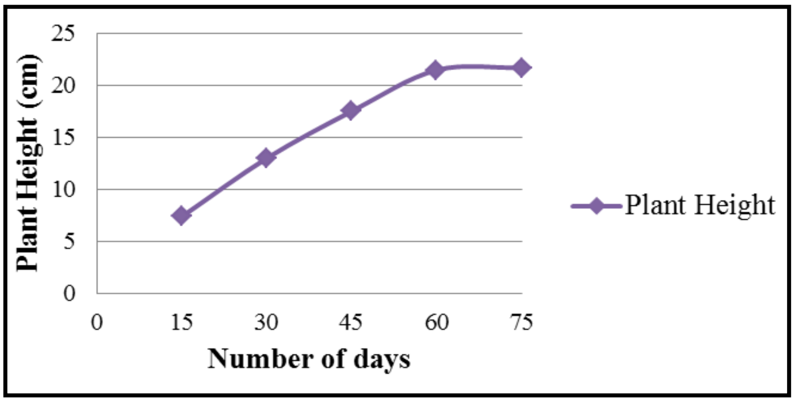

Fig. (iv): Plant height at 15 days interval after transplanting

Number of leaves

Fig.(v) shows that the average number of leaves were around 6 after 15 days of transplanting. These leaves increased rapidly for next 15 days and were 12 after 30 days of transplanting. As the curd formation had started, the number of leaves then increased slowly to only 15 for next 15 days. After 60 days of transplanting, the number of leaves reduced to 11 as some of the leaves were converted into curd. However, after 75 days of transplanting, the average leaves left were only about 10.

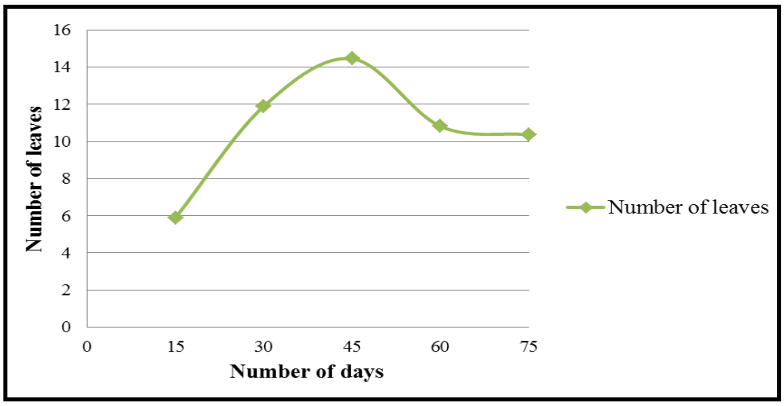

Fig. (v): Number of leaves at 15 days interval after transplanting

Plant Diameter

Fig. (vi) shows that the average diameter of the plants was 6.81 cm after 15 days of transplanting. It was almost doubled after next 15 days and was 12 cm. It was observed that the average diameter of the plants was 21.81 cm after 45 days of transplanting. Further average diameter increased to 29.09 cm after 60 days of transplanting. Finally, the average diameter of the plant increased to 34.63 cm after curd formation at 75 days after transplanting of the seedlings.

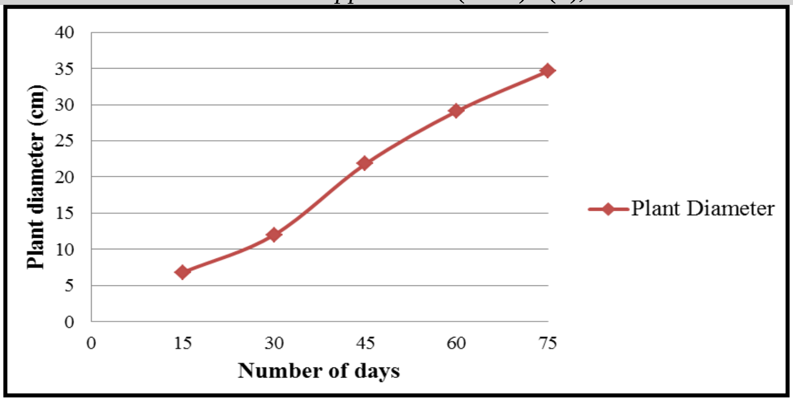

Fig. (vi): Plant diameter at 15 days interval after transplanting

Geometric mean diameter of curd

Geometric mean diameter of curd of the observation plants is given in Table (i).

Table (i): Geometric mean diameter of curd

Sr. No.	Length (cm)	Breadth (cm)	Thickness (cm)	GMD (cm)
1.	110.40	91.24	85.81	95.26
2.	137.76	102.75	101.96	113.01
3.	143.67	104.68	104.60	116.30
4.	139.12	94.26	91.48	106.25
5.	148.85	105.35	96.50	114.81
6.	147.03	102.72	98.70	114.23
7.	135.60	98.00	95.44	108.24
8.	152.92	113.85	104.39	122.04
9.	149.65	110.66	106.90	120.97
10.	147.73	109.64	108.76	120.77
11.	152.84	103.76	103.10	117.81
Average	142.32	103.35	99.78	113.64

It was observed that the average length of the curd was 142.32 cm with the average breadth of 103.35 cm and average thickness of 99.78 cm. The average geometric mean diameter of the curd was found to be 113.64 cm.

Average weight and specific gravity of the curd

Average weight and specific gravity of the curd of the observation plants is given in Table (ii).

Table (ii): Average weight and specific gravity of the curd

Sr. No.	Average weight (kg)	Specific Gravity
1.	0.47	0.55
2.	0.68	0.47
3.	0.99	0.63
4.	0.63	0.53
5.	0.77	0.51
6.	0.89	0.60
7.	0.66	0.52
8.	0.83	0.46
9.	0.99	0.56
10.	0.98	0.56
11.	0.96	0.59
Average	0.80	0.54

Table (ii) shows that the average weight of the curd was 0.80 kg and the average specific gravity was 0.54. Thus, the average yield was 59.54 t/ha for 74074 plants per hectare. Whereas, the manual irrigation recorded the yield of 48.58 t/ha[5]. Thus, automatic irrigation system recorded 10.96 t/ha i.e. 18.40% more yield over manual irrigation.

CONCLUSIONS

The developed automatic irrigation system is real time soil moisture sensing device which records continuously soil moisture from the field and accordingly operates within lower and upper limit conditions of the available soil moisture. It applies water as per requirement of the crop and soil tenacity. The depth of water required on ET_C was 304.37 mm while controller actually applied water of 283.74 mm throughout crop period. It is observed that the use of this system applied 93.22 per cent water of total water requirement by climatological data. The cabbage plants responded the good growth due to automation of the irrigation system. The average yield obtained by automatic irrigation system was 59.54 t/ha which was 10.96 t/ha more than manual irrigation system.

Acknowledgments

The authors are thankful to College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli.

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