Biological Forum – An International Journal 13(4): 848-851(2021)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Impact of Automated Drip Irrigation System on Growth and Yield of Bhendi (*Abelmoschus esculentus* (L) Moench.)

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(Received 08 September 2021, Accepted 13 November, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: A study was carried out to evaluate the performance of different types of automated drip irrigation system on bhendi during *rabi* 2019-20 and *rabi* 2020-21 at the drip automation unit, Tamil Nadu Agricultural University. An approach of irrigation scheduling comprising of 4 different automated drip irrigation systems are time based drip irrigation, volume based drip irrigation, soil moisture sensor based irrigation, switching tensiometer based irrigation which was compared with the surface method of irrigation. The results revealed that tensiometer based drip irrigation recorded higher plant height of 108.29 and 107.58 cm at final harvest stage, dry matter production of 4686 and 4667 kg ha^{-1} at final harvest stage and fruit yield of 23.86 and 24.05 t ha^{-1} during *rabi* 2019-20 and *rabi* 2020-21 resulting in increment over conventional method of irrigation. However, the above treatment was followed by soil moisture sensor based drip both years of study. Automated drip irrigation using sensors found it very handy to turn on and off the pump. Maintaining appropriate moisture content in the root zone throughout the crop cycle in this technology saves a significant quantity of water as well as power and boosts bhendi crop production.

Keywords: Bhendi, automated drip irrigation, surface irrigation, fruit yield.

INTRODUCTION

Water is essential for the development and production of a crop. At the present, the agricultural sector consumes a huge amount of fresh water in India. Due to the scarcity of freshwater resources in India, it is necessary to manage irrigation rationally and emphasize the selection of the most appropriate method of irrigation scheduling for irrigating the crops under drip irrigation, so they can work more efficiently for minimizing the volume of water in irrigated agriculture (Farias *et al*., 2017). Water is grave to assure the availability of vegetable crops throughout the year during the dry season when there is less or lack of rainfall for cultivation. This necessitates the use of an irrigation water management strategy that can help to attain the goal of growing more crops per drop of water through drip irrigation (Panigrahi and Sahu, 2013).

Bhendi (*Abelmoschus esculentus* (L) Moench.) is a renowned and extensively used crop that belongs to Malvaceae family which was originated in Africa (Abid *et al*., 2002). In India, bhendi is grown on an area of 0.53 million hectares with an annual production of 6.51 million tonnes with average productivity of 12.2 t ha^{-1} (Indiastat, 2021). In Tamil Nadu, it occupies 11820 ha with a total production of 1.25 lakh tonnes and productivity of 10.56 t ha^{-1} (NHB, 2018). Bhendi is widely cultivated by the farmers under rain-fed but it also grows well under irrigated condition. In the track of producing a higher yield, bhendi necessitates a persistent supply of water and soil must be relatively moist throughout the growing season. The flowering and fruiting stages of bhendi are said to be the most delicate of the growing season, which in turn reduces the yield due to a lack of water. As a result, a well-managed irrigation system is required to boost the fruit yield. Excessive or sub-optimal irrigation both have negative effects on productivity parameters of bhendi, hence forth irrigation scheduling is considered as a serious component of water management to generate improved irrigation efficiency under any irrigation system (Aiyelaagbe and Ogbonnaya, 1996). Controlled irrigation is needed for higher fruit yields in bhendi cultivation because the crop is susceptible to both over and under-watering. The agricultural sector utilizes roughly 83 percent of water, whereas about 50 to 70 percent of water is wasted due to transport, evaporation, field application and distribution losses under traditional irrigation methods (Al-Harbi *et al*., 2008). Drip irrigation combined with smart water management measures can help to minimize these losses (Dahiya *et al*., 2005). Today the availability of labor for carrying out agricultural activities is less; so, automation in the agricultural process is needed. This difficulty can be completely solved by using the automatic drip irrigation system in which the irrigation will take place only when there will be extreme requirements of water (Nautiyal *et* *al*., 2010). Automation in drip irrigation refers to the operation of a system with no or minimal manual intervention. Irrigation that is automated provides several advantages including greater precision, more efficient water use, and less human labour. It also makes for high-frequency and low-volume of irrigation (Priyan and Panchal, 2017). Sensor based drip irrigation system was found to be performing better than other types of automation setups like time based and volume based drip irrigation systems in terms of fruit yield (Nagarajan *et al*., 2020). The objective of this work was to evaluate a different method of automatic irrigation system compared with common grower practice (furrow irrigation) in the area and scheduling methods of irrigation that may help the farmers to enhance the productivity of bhendi.

MATERIAL AND METHODS

The experiment was carried out during *rabi* 2019-20 at Tamil Nadu Agricultural University, Coimbatore situated at 11° North latitude and 77° East longitude at an altitude of 426.7 m above mean sea level. Weather parameters were obtained from the Agro Climate Research Centre, TNAU. The soil type of the experimental field was sandy clay loam soil. Bhendi (*Abelmoschus esculentus* (L) Moench.) crop of CoBh H4 hybrid with 110 days of duration was sown at 45 × 45 cm spacing in all plots grown under irrigated conditions. The experiment was laid out in randomized block design with four replication and five treatments. The treatments consist of 4 different automated drip irrigation systems, *viz.,* T_1-Time based drip irrigation (Irrigation at fixed interval per stage and refill soil to field capacity), T_2-Volume based drip irrigation (critical depletion along with refill soil to field capacity), T_3-Soil moisture sensor based irrigation (EC H_2O-Capacitance sensor), T_4-Switching tensiometer based irrigation (Irrometer) and T_5-Conventional method of irrigation (furrow irrigation). To evaluate the different methods of automated drip irrigation system over surface irrigation, all agronomic practices such as weeding, disease and pest control were carried out according to the conditions. Data on growth parameters like plant height was measured from the base of the plant to the tip of the lengthiest leaf observed at the different growth stages *viz*., 30, 60, 90 DAS and at the final harvest stage. To estimate the dry matter production, five plants plot^{-1} were collected randomly from the sampling rows of each plot by pulling out the plants. Plants were air-dried and then oven-dried at 65 ± 5°C till a constant weight was obtained. The weight was recorded using an electronic top pan balance and expressed in kg ha^{-1}. Fruit yield of bhendi crop from the treatment was recorded at harvest stage and analyzed using "Analysis of variance test". The critical difference at 5% level of significance of different treatment over each other (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant Height. Plant height has a linear response with irrigation. Taller plants were observed with tensiometer based drip irrigation (T_4) at 30 DAS (24.20 and 24.99 cm) was on par with other drip irrigation treatments (Table 1). This could be due to the initial growth of the plant being slow. Whereas 60 DAS (60.01 and 57.91 cm), 90 DAS (89.22 and 86.14 cm) and at the final harvest stage (108.29 and 107.58 cm) during rabi 2019-20 and *rabi* 2020-21 were recorded higher plant height in tensiometer based drip irrigation (T_4) and it was followed by soil moisture sensor based drip irrigation (T_3). It might be due to upholding the moisture content at field capacity near the effective plant root zone of the plant and reducing the fertilizer leaching through irrigation by using soil moisture sensors under automated drip irrigation than the conventional method of irrigation.

Table 1: Effect of automated drip irrigation on plant height (cm) of bhendi during *rabi* 2019-20 and *rabi* 2020-21.

Treatments	*rabi* 2019-20				*Rabi* 2020-21			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	23.72	52.42	80.60	100.41	19.44	50.27	75.10	99.40
T_2	23.85	54.07	83.04	103.58	20.69	52.01	79.09	102.05
T_3	24.06	57.59	85.87	106.12	22.87	55.22	83.41	104.62
T_4	24.20	60.01	89.22	108.29	24.99	57.91	86.14	107.58
T_5	18.25	50.38	78.52	98.36	17.17	48.21	71.96	96.57
SEd	0.20	0.29	0.27	0.35	0.41	0.23	0.39	0.25
CD (P=0.05)	0.44	0.62	0.58	0.77	0.90	0.50	0.85	0.54

Dry matter production (DMP). Dry matter production of a crop reflects its efficiency in exploiting the available resources such as solar radiation, soil available nutrients, moisture and other niches of the existing environmental circumstances. Dry matter production climbed steadily with advancing growth stages and reached the maximum at harvest. The dry matter production was significantly superior under tensiometer based drip irrigation (T_4) at 30 DAS (1830 and 1930 kg ha^{-1} during *rabi* 2019-20 and *rabi* 2020-21), respectively was on par with soil moisture sensor based drip irrigation (T_3). Whereas, 60 DAS (3125 and 3165 kg ha^{-1}), 90 DAS (3995 and 4025 kg ha^{-1}) and at the final harvest stage (4686 and 4667 kg ha^{-1}) during *rabi* 2019-20 and *rabi* 2020-21 were recorded higher DMP in T_4. This was followed by T_3 (Table 2). This was primarily due to optimal moisture supply and timely nutrient application, which may have improved assimilatory efficiency resulting in more leaves per plant, better branching and LAI contributed to higher dry matter accumulation. These findings are in line with Jeyajothi and Pazhanivelan (2017). The minimum dry matter accumulation was recorded under the conventional method of irrigation (T5).

Table 2: Effect of automated drip irrigation on Dry matter production (kg ha^{-1}) of bhendi during *rabi*2019-20 and *rabi* 2020-21.

Treatments	*rabi* 2019-20				*rabi* 2020-21			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	1639	2592	3262	3768	1674	2711	3481	3973
T_2	1733	2773	3510	4057	1741	2817	3605	4149
T_3	1822	2978	3778	4380	1904	2984	3807	4402
T_4	1830	3125	3995	4686	1930	3165	4025	4667
T_5	1532	2351	2918	3348	1491	2473	3212	3652
SEd	22.68	46.39	30.54	34.70	29.06	58.56	29.57	54.62
CD (P=0.05)	49.41	101.07	66.54	75.61	63.32	127.59	64.42	119.01

Fruit yield (t ha^{-1}). The maximum fruit yield of bhendi was recorded under the treatment where adequate water was given to the crop (Fig. 1). The fruit yield was found to be increased with tensiometer based drip irrigation (T4) and gave the yield of 23.86 t ha^{-1} during *rabi* 2019-20 and 24.05 t ha^{-1} during *rabi* 2020-21. It was followed by soil moisture sensor based drip irrigation (T3). This might be due to watering the crop based on their requirement at the required time. The crop yield and WUE of okra were higher under soil moisture sensor based drip irrigation with 100 per cent RDF. A similar trend was reported by Dukes *et al*., (2007) in bell pepper crop. Whereas, a conventional method of irrigation (T5) registered a lower fruit yield of 11.03 t ha^{-1} during *rabi* 2019-20 and 11.00 t ha^{-1} during *rabi* 2020-21, respectively. It might be due to larger intervals between the irrigation as well as water loss through evaporation, percolation and conveyance losses will reduce the water uptake resulted in lower yield.

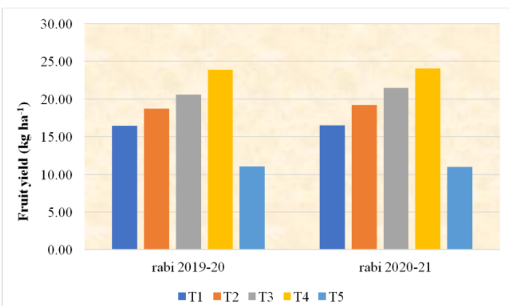

Fig. 1. Effect of automated drip irrigation on yield (t ha^{-1}) of bhendi during *rabi* 2019-20 and *rabi* 2020-21.

CONCLUSION

An automated irrigation system providing water on-demand was designed using time based, volume based, sensor based, tensiometer based drip irrigation is proved to be a real-time feedback control system that competently monitors and panels all events of the drip irrigation system. The findings will be utilized to modernize farm operations on a wider scale as well as save manpower, water and increase productivity. The present study indicated that tensiometer based drip irrigation (T_4) resulted in a significantly higher plant height, dry matter production at 30, 60, 90 DAS and at the final harvest stage as well as highest fruit yield (23.86 and 24.05 t ha^{-1}) than the conventional method of irrigation in bhendi during *rabi* 2019-20 and *rabi* 2020-21.

Future aspects of the study can conduct the field trial on automation irrigation using wireless sensors with mobile-controller to irrigate the crops will reduce the initial investment cost and labour intervention.

Acknowledgment. The authors wish to express their sincere gratitude for the financial support from the Department of Agronomy and Water technology centre, Tamil Nadu Agricultural University, Coimbatore, India.
Conflict of Interest. None.

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How to cite this article: Suvitha, R.; Velayutham, A. and Geethalakshmi, V. (2021). Impact of Automated Drip Irrigation System on Growth and Yield of Bhendi (*Abelmoschus esculentus* (L) Moench.). *Biological Forum – An International Journal*, *13*(4): 848-851.