International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 9, Issue 48, 2017, pp.-4810-4815.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

EFFECT OF SALINE WATER DRIP IRRIGATION ON GROWTH PARAMETERS OF BHENDI CROP UNDER VARIOUS IRRIGATION TREATMENTS

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Received: October 14, 2017; Revised: October 16, 2017; Accepted: October 17, 2017; Published: October 24, 2017

Abstract- With increasing demand and decreasing supplies of good quality water there is an increasing tendency among the farmers to use saline water for irrigation. Salinity range of ground water used for irrigation in most of the districts of Tamil Nadu is 1 to 8 dS m^{-1}. In this context, the proper use of saline irrigation water, without development of salinity is the most important challenging task and herein lies the value of scientific knowledge on the use of saline water in agriculture. Okra (*Abelmoschus esculentus*) or lady's finger, commonly known as 'Bhendi' in India is one of the most important vegetables grown throughout the tropics and warmer parts of the temperate zone. Average productivity for okra is 9.5 t ha^{-1}. Okra is sensitive to salinity; it was selected and used as a test crop to assess the effect of saline water through drip irrigation on Plant growth parameters. Hence a study was formulated to find the effect of irrigation frequency and quantity on growth parameter and yield of okra under drip irrigation with moderate saline ground water. The plant growth components like plant height, inter nodal length, fruit length, total number of fruits, and yield particulars were collected under different treatment combinations of irrigation frequency and irrigation quantity of saline water applied were collected and analyzed. Maximum plant height of 168.7 cm, Internodal length of 15.6 cm, fruit length of 15.7 cm, number of fruits 12.3, and hight yields of 12.07 t/ha was observed under twice a day irrigation with 140 per cent CWN treatment (F_4Q_3). The lower salt accumulation in the root zone of F_4Q_3 treatment resulted in higher plant height internodal length, fruit length, number of fruits and highest yield. Drip irrigation twice a day with 140 per cent CWN was found to be the best combination of frequency and quantity of irrigation by maintaining less salt accumulation in the root zone.

Keywords- Bhendi, Drip Irrigation, Yield, Saline water, Frequency.

Citation: Sharmiladevi R., et al., (2017) Effect of Saline Water Drip Irrigation on Growth Parameters of Bhendi Crop under Various Irrigation Treatments. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 48, pp.-4810-4815.

Academic Editor / Reviewer: Dr Hans Raj

Introduction

Tamil Nadu has a geographical area of about 13.058 m. ha as against the total area of 329 m. ha of the country. The population and area of Tamil Nadu is 7 per cent and 4 per cent, respectively of that of the country but the available water resources is only 3 per cent of the country. The average rainfall in Tamil Nadu is 925 mm as against the average rainfall of 1170 mm in the country. With increasing demand and decreasing supplies of good quality water there is an increasing tendency among the farmers to use saline water for irrigation. Salinity range of ground water used for irrigation in most of the districts of Tamil Nadu is 1 to 8 dS m^{-1}. In this context, the proper use of saline irrigation water, without development of salinity is the most important challenging task and herein lies the value of scientific knowledge on the use of saline water in agriculture.

Under suitable irrigation procedures and crop management, many vegetable crops could be cultivated successfully with saline water [1,2].

India is the second largest producer of vegetables next to china. Okra (*Abelmoschus esculentus*) or lady's finger, commonly known as 'Bhendi' in India is one of the most important vegetables grown throughout the tropics and warmer parts of the temperate zone. Average productivity for okra is 9.5 t ha^{-1}. Okra is classified as salt sensitive crop [3].

Okra is sensitive to salinity; it was selected and used as a test crop to assess the effect of saline water through drip irrigation on Plant growth parameters.

Drip irrigation is gaining momentum in raising vegetable crops even though the available irrigation water is with salinity. Hence a study was formulated to find the effect of irrigation frequency and quantity on growth parameter and yield of okra under drip irrigation with moderate saline ground water.

Materials and Methods

Experiment was conducted in precision farming development center farms of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The farm is located at 11°N latitude and 77°E longitude with an altitude of 427 m above MSL.

Weather and Climate

Based on the meteorological data recorded in the department of meteorology TNAU, Coimbatore, the 30 year average weather data were collected.

The mean annual rainfall is 674.2 mm. The mean maximum and minimum temperatures are 32.7°C and 21.7°C, respectively. The relative humidity ranges from

21 per cent (14.22 hrs) to 92 per cent (07.22 hrs). The mean monthly evaporation ranges from 3.5 to 7.6 mm. The sunshine hours range from 3.4 to 10.6 hrs day^{-1}.

The weekly weather data recorded during the crop study period is depicted in [Fig-1]. During the period of study, the mean weekly maximum and minimum temperatures were found as 32.9°C and 18°C, respectively. The relative humidity was from 94 per cent (07.22 hrs) to 42 per cent (14.22 hrs). Mean weekly evaporation was

found between 2 and 5.3 mm. The wind velocity was in the range of 2.4 and 5 km h^{-1}. The maximum and minimum sunshine hours were recorded as 8.3 to 2.1 hrs day^{-1}, respectively. The climatic condition was favourable for raising bhendi crop.

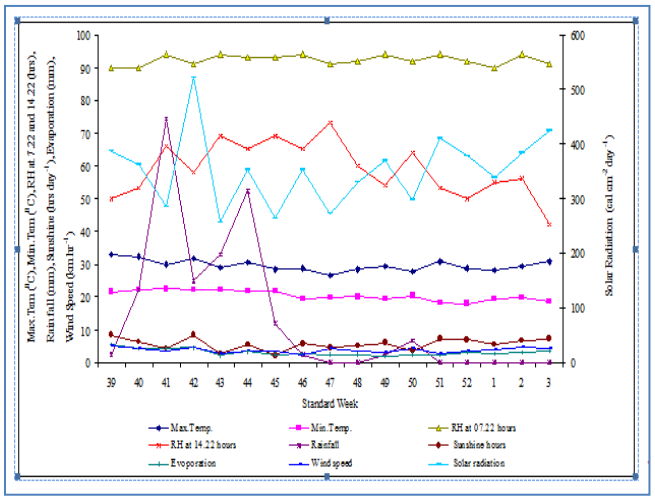


Fig-1 Weather data during the cropping period

Soil Properties

The soil of the experimental field is sandy clay loam in texture having pH 9.25 and electrical conductivity of 0.17 dS m^{-1}.The average depth of soil is about 25 to 30 cm.

The available nutrient contents in the soil were found as 250 kg ha^{-1} N, 10 kg ha^{-1} P and 500 kg ha^{-1} K.

Crop and variety

Bhendi (*Abelmoschus esculentus* (L) Moench) variety Mahyco hybrid-10 was raised as the test crop. The duration of the crop is 90 –110 days.

Irrigation source

The experimental field was irrigated by pumping water from a bore well. The quality of irrigation water is moderately saline.

The irrigation water is having pH of 7.25 and electrical conductivity 5.53 dS m^{-1}. Bicarbonates, chlorides and sulphates were 14.80, 29.60, and 10.27 meq. $litre^{-1}$. Calcium, magnesium, sodium, and potassium were 14.4, 14.8, 25.65 and 0.72 meq. $litre^{-1}$, respectively. Sodium adsorption ratio was found to be 6.71.

Treatments

The experiment was conducted by adopting the following treatments.

Main plot: Irrigation frequency (Four)

F_1 = Daily irrigation

F_2 = Alternate day irrigation

F_3 = Every third day irrigation

F_4 = Two irrigation in a day

Sub plot : Irrigation quantity (Three)

Q_1 = Crop water need (100 per cent CWN)

Q_2 = Crop water need + 20 per cent excess of Crop water need (120 per cent CWN)

Q_3 = Crop water need + 40 per cent excess of Crop water need (140 per cent CWN)

The experiment was laid out in strip plot design with three replication.

Field preparation and layout of the plots

The experimental plot was thoroughly ploughed with disc plough and repeatedly tilled with cultivator to bring optimum soil tilth. Then the layout was taken up and drip system was installed. Paired row geometry was adopted for drip treatments with 30 cm between rows in a pair and 30 cm spacing in between two pairs of rows. The inline laterals having dripper spacing of 40 cm were laid at 60 cm spacing between laterals. Layout of paired row is depicted in [Fig-2].

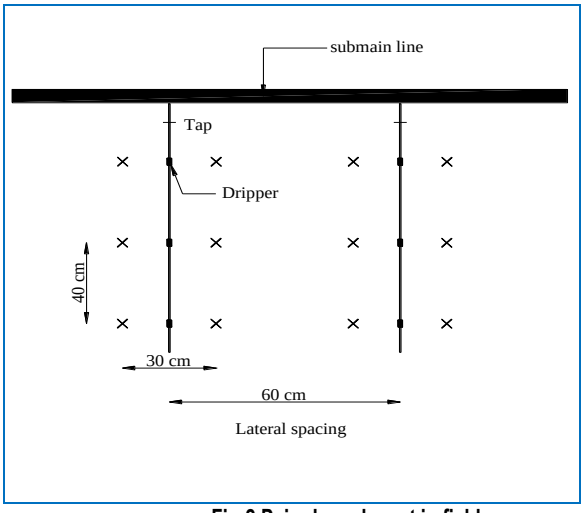


Fig-2 Paired row layout in field

Dibbling of bhendi seeds

Mahyco-10 hybrid bhendi seeds were dibbled at 30 × 40 cm spacing with a recommended seed rate of 7.5 kg ha^{-1}.

Irrigation

Irrigation was given to all the treatments immediately after dibbling the seeds. Irrigation was given as per the treatment schedule according to the crop growth stages.

Irrigation was given based on daily evaporation rate recorded from class A open pan evaporimeter. Drip operating time was calculated according to different treatments. Flow through each lateral was controlled by separate valves.

Water requirement for single plant was calculated by the method given below [4].

$$ET_{crop} = E_{pan} \times K_p \times K_c$$

Where,

ET_{crop} = Crop evapotranspiration or Crop water need (mm day^{-1})

E_{pan} = Pan evaporation in mm day^{-1},

K_p = Pan factor (0.85 collected from TNAU Meteorological Department)

K_c = Crop factor,

Water required per emitter is calculated by

$$WR/Day/Emitter = (ET_{crop}) \times 2$$

WR = Water required per emitter in mm day^{-1}

Time of operation of single emitter is calculated by

Time of operation (min) = (Area covered by emitter (m^2) × depth of water applied (m))/Discharge of emitter (m^3 min^{-1})

Based on the different treatments, the water requirement and the time of operation were calculated and based on the calculated value irrigation water was supplied.

The crop factor value for bhendi crop were adopted based on the recommendation given by Allen *et al.* (1998), the crop factor values are ranging from 0.7 to 1.05, which depends upon different growth stages of the crop. The details of the crop factor values adopted for bhendi crop are presented in [Table-1].

Table-1 *The crop factor for Bhendi depending upon the stages of crop growth*

S.No	Stages of crop growth	K_c value
1	Initial stage	0.7
2	Crop development stage	0.7-1.05
3	Mid stage	1.05
4	Late stage	0.95

Fertilizer application

The fertility status of the field was low in N and P and high in K. Normal recommendation as prescribed in Anonymous (2004) was adopted for supplying fertilizer to the crop [5].

The recommended levels of fertilizer for bhendi crop are as follows.
Nitrogen : 40 kg ha^{-1} in the form of urea (86.96 kg ha^{-1}).
Phosphorus : 50 kg ha^{-1} in the form of super phosphate (312.5 kg ha^{-1}).
Potassium : 30 kg ha^{-1} in the form of muriate of potash (50 kg ha^{-1}).
FYM : 25 t ha^{-1}.
Recommended levels of P and K were applied as basal. The 50 per cent of recommended N as urea was given as basal, and remaining 50 per cent was given on 30 DAS.

Weeding, Pest and disease control
Weeding was done to avoid competition for nutrients and water. Adequate plant protection measures were given against pest and diseases as and when needed.

Observations recorded
The methods of collection of data related to plant parameters and yield particulars were presented here with. Besides the above, the cost economic analysis and statistical method of evaluation conducted are also explained.

Plant height
Three plants were selected randomly at each treatment and the height of the plant was measured from the base to tip of the plant and expressed in cm.

Internodal length
The length between the each node was measured. Mean arrived from the selected three plants are expressed in cm at 60, 75, 90 and 105 DAS and at harvest stages.

Fruit length
The fruit lengths from tagged plants were measured and mean values were calculated.

No of fruits
The number of fruits in the selected plants was counted upto last harvest in each treatment.

Yield
Yield from each plot was recorded and expressed in t ha^{-1}.

Economics
The cost of drip system per hectare was worked out based on the prevailing market rates of the components. Gross income per ha and benefit–cost ratios were worked out based on the cost of cultivation and sale of produce. Benefit cost ratio was worked out as

Benefit - Cost ratio = Gross income / Cost of cultivation

Results and Discussion
Growth parameters
The plant growth components like plant height, internodal length, fruit length, total number of fruits, and yield particulars were collected under different treatment combinations of irrigation frequency and irrigation quantity of saline water applied were collected and analysed. The experimental crop during crop development and flowering stage are shown in [Plate-1] and [Plate-2], respectively.

Plate-1 Bhendi at Initial Stage

Plate-2 Bhendi at maturity stage

Plant height
The plant height of bhendi showed a marked difference among different frequency and irrigation levels during the experimental season. There was no significant difference in the plant height values recorded on 60 DAS. Irrigation frequency significantly affected the plant height in all observation. F_4 treatment recorded maximum height of 114.3, 139.7 and 164.8 cm on 75, 90and 105 DAS respectively. The minimum height was recorded as 93.2, 126.7 and 150.6 cm in F_3 treatment on 75, 90 and 105 DAS, respectively. The graphical representation of plant height is given in [Fig-3]. Increased frequency of irrigation, decreased soil moisture tension and salt stress in the root zone results more available water to plants and recorded the highest plant height.
Increasing quantity of irrigation water increased plant height in 75 DAS treatments. Same trend was observed in 90 and 105 DAS.
In the interaction maximum plant height of (119.2, 143.3 and 168.7 cm) were recorded in the treatment F_3Q_1 on 75, 90 and 105 DAS respectively. The lowest plant heights (89.3, 120.3 and 147 cm) were recorded in the treatment F_3Q_1 on 75, 90 and 105 DAS respectively.
Similar results were reported by Srinivas, (1996) [6]. They found that increasing the evaporation replenishment rates 20 to 120 per cent increased the relative plant height by 21.9 per cent.

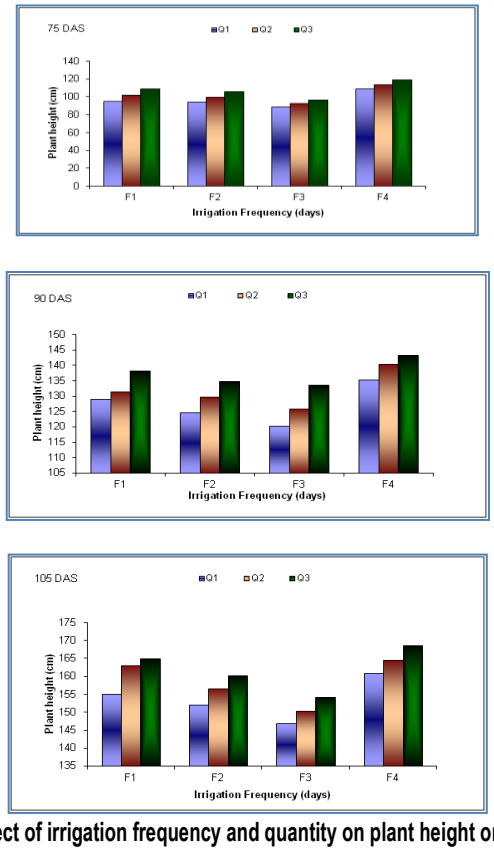


Fig-3 Effect of irrigation frequency and quantity on plant height on different days

Internodal length

Inter nodal length recorded on 60 DAS did not show much difference in all the treatments, it was observed because of rain in the starting of the growing period. In 75 DAS higher internodal length of 12.7 cm was recorded in F_4 treatment. It was observed that the internodal length in F_4 and F_1 were on par, followed by F_2 (11.7 cm) and the lower value of 11.3 cm was recorded in F_3 treatment.

In 90 and 105 DAS higher values of internodal length were recorded in F_4 treatment followed by F_1 and F_2. Lower value was recorded in F_3 treatment in all the observation. Effect of irrigation frequency and quantity on internodal length is shown graphically in [Fig-4].

Irrigation levels affected the internodal length significantly. The maximum length of 12.3, 14.6 and 15 cm, and minimum length of 11.7, 13.8 and 14.7 cm were recorded in Q_3, Q_2 and Q_1 treatments on 75, 90 and 105 DAS, respectively. The increased quantity of irrigation water increased the internodal length.

Frequency and quantity interaction significantly affected the internodal length. The maximum internodal length values of 13.1, 15.2 and 15.6 cm were recorded in F_4Q_3 interaction on 75, 90 and 105 DAS respectively. Minimum values of 11.2, 13.1 and 14.3 cmwere recorded in F_3Q_1 treatment on 75, 90 and 105 DAS, respectively. The maximum availability of water and low salt stress in the root zone caused maximum internodal length in F_4Q_3 treatment.

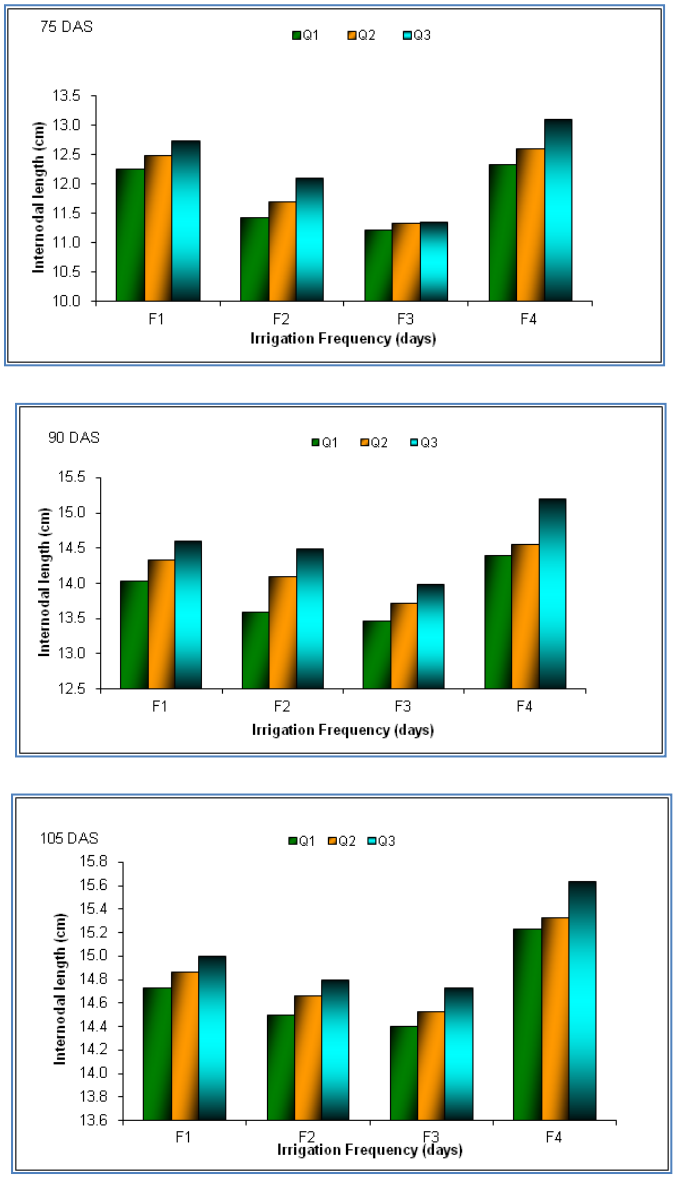


Fig-4 Effect of irrigation frequency and quantity on internodal length on different days

Fruit length

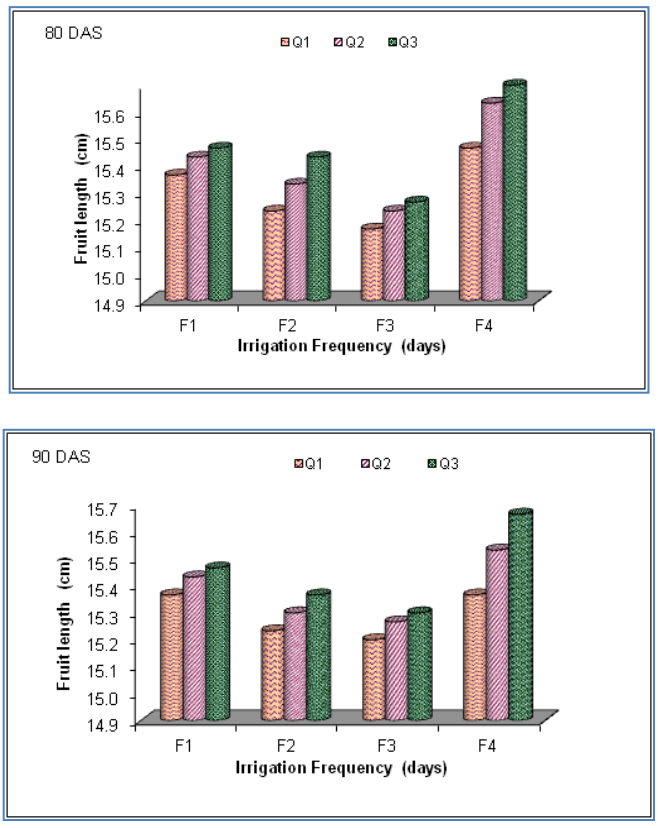
Fruit length observed at different growth periods of the crop is furnished. Frequency of irrigation affected the length of fruit significantly. The maximum fruit length of 15.6, 15.5 and 15.3 cm were observed in 80, 90 and 100 DAS, respectively in F_4 treatment. Minimum length of 15.2, 15.3 and 15.1 cm were observed in F_3 treatment at 80, 90 and 100 DAS respectively. Reduction in length of fruits in F_3 treatment was caused by increased soil salinity and increased soil moisture tension in the root zone. Graphical representation of fruit length is shown in [Fig-5].

Increased quantity of irrigation water increased the length of fruit. The maximum length was observed in Q_3 treatment followed by Q_2 and Q_1. Fruit length of Q_3 treatment in all frequency is shown in [Plate-3].

Plate-3 Length of Bhendi under different treatments

Interaction of frequency and quantity of irrigation has shown considerable effect on fruit length. Maximum length of 15.7, 15.6 and 15.4 cm were recorded at 80, 90 and 100 DAS, respectively in F_4Q_3 treatment, and minimum length of 15.2, 15.2 and 14.9 cm were recorded in 80, 90 and 100 DAS, respectively in F_3Q_1 treatment. The higher length of fruits recorded in F_4Q_3 treatment revealed the effect of lower stress of soil moisture available to the plants. Lower salt concentration in the root zone decreased the salt and moisture stress in the root zone.

Meiri *et al*. (1981) reported that increased salinity reduced the fruit size in muskmelons [7].



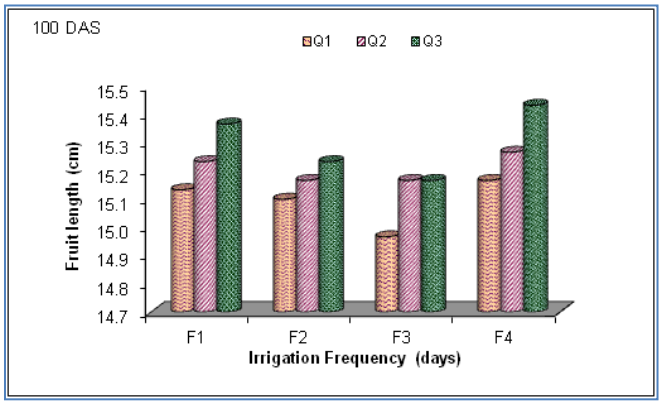


Fig-5 Effect of irrigation frequency and quantity on fruit length on different days

Total number of fruits

Total number of fruits observed in each treatment isshown in [Fig-6]. Irrigation frequency significantly affected the total number of fruits. The maximum number of fruits was observed in F_4 (11.8) treatment. The statistical analysis revealed that the treatment F_1 is on par with F_4. The treatment F_3 recorded minimum number of fruits (9.4). Daily irrigation and two irrigation per day did not show much difference in total number of fruits per plant. But once in two day and once in three day showed decreased number of fruits. Increased salt and moisture stress reduced total number of fruits in these treatments.

Quantity of irrigation significantly affected the total number of fruits. Maximum of 11.3 fruits were observed in Q_3 treatment. Minimum values of 10.1 fruits were observed in Q_1 treatment.

In frequency and quantity interaction higher numbers of fruits (12.3) were observed at F_4Q_3 treatment and less number of fruits (8.7) was observed in F_3Q_1 treatment. Two irrigations per day with 40 per cent excess CWN leaches the most of salt settled in the root zone to lower layer and offered more available water to plants.

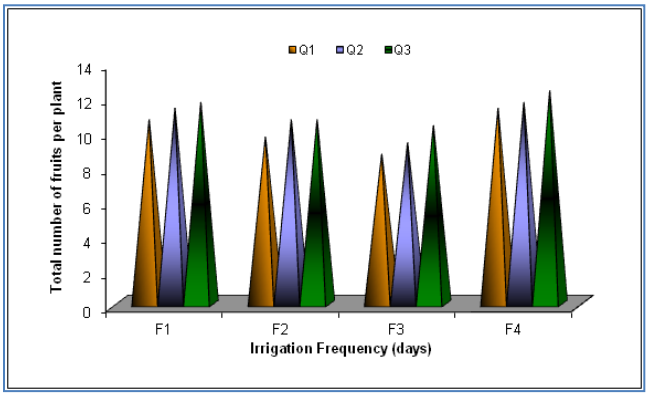


Fig-6 Effect of irrigation frequency and quantity on total number of fruits

Yield Analysis

Yield data recorded per plot in various treatments were converted as the yield per ha values and presented in Fig. The yield was significantly influenced by frequency of irrigation. Maximum yield of 11.49 t ha^{-1} was recorded in twice a day irrigation treatment (F_4). A lower yield of 9.46 t ha^{-1} was recorded in once in three days irrigation treatment (F_3).

Quantity of irrigation water supplied influenced the yield of bhendi. Higher yield of 10.98 t ha^{-1} was recorded in 140 per cent CWN treatment (Q_3) followed by 120 per cent CWN (Q_2 = 10.57 t ha^{-1}) and 100 per cent (Q_1 = 10.33 t ha^{-1}) treatments.

Frequency and quantity of irrigation water significantly influenced the yield of bhendi. Higher yield of 12.07 t ha^{-1} was recorded in in twice a day with 140 per cent CWN treatment (F_4Q_3) and a lower value of 9.35 t ha^{-1} was recorded in once in three days with 100 per cent CWN treatment (F_3Q_1).

Similar results were observed by Pasternak and De Malach (1995). They observed that tomato with brackish water irrigation in twice a day and once a day produced same yield. But every two days and every three days irrigation significantly reduced the total yield.

Cost economics

The life of the drip material was taken as 8 years, interest at 8 per cent of fixed cost and repair and maintenance costs at 2 per cent of fixed cost were taken in to consideration to work out the cost economics. The data on cost of cultivation, fixed cost, seasonal cost and net income for different treatment for the bhendi crop were recorded.

The benefit cost (B-C) ratio was worked out for the treatments using the gross income generated and the cost of cultivation of bhendi crop. The higher benefit cost ratio of 2.05 was recorded in twice a day with 140 per cent CWN treatment (F_4Q_3), followed by treatment F_1Q_3 treatment with B-C value of 2.03. The lower benefit cost ratio of 1.59 was recorded in once in three days with 100 per cent CWN treatment (F_3Q_1), which recorded lowest yield of 9.35 t/ha. The increased B–C ratio in F_4Q_3 drip treatment may be due to the higher yield registered because of lower salt concentration observed in the root zone. The B-C ratio of twice a day irrigation treatment (F_4) and once a day irrigation treatment (F_1) did not show much difference. Even though the B-C ratios were same, it was observed that in the F_4 treatment the salt accumulation was found to be less than the F_1 treatment.

Summary and Conclusions

Maximum plant height of 168.7 cm was observed under twice a day irrigation with 140 per cent CWN treatment (F_4Q_3)and minimum height of 147 cm was observed under once in three days with 100 per cent CWN (F_3Q_1) at the end of harvest (105 DAS). Similarly higher value of internodal length 15.6 cm was observed under F_4Q_3 treatment and lower value of 14.4 cm internodal length was recorded in F_3Q_1 treatment. The lower salt accumulation in the root zone of F_4Q_3 treatment resulted in higher plant height and internodal length. The higher salt accumulation in the F_3Q_1 treatment reduced the plant height and internodal length.

The fruit length measured on 80 DAS showed that the higher fruit length of 15.7 cm was recorded twice a day irrigation with 140 per cent CWN treatment (F_4Q_3) on 80 DAS, and lower value of 15.2 cm in F_3Q_1 treatment. Similarly more number of fruits12.3 was observed in F_4Q_3 treatment. Increased quantity of irrigation water supplied excess water to leach the salts from the root zone and recorded more number of fruits in this treatment. Lower number of fruits (8.7) was recorded under F_3Q_1 treatment.

The highest taproot length of 30.4 cm was recorded in F_3Q_3 treatment and lower length of taproot 21.5 cm was recorded in F_4Q_1 treatment. Increased wetted depth once in three days irrigation increased the length of taproot in F_3Q_3 treatment. Root spread diameter of 42.3 cm and total number of roots (40) were found to be higher in twice a day irrigation with 140 per cent CWN treatment (F_4Q_3) and lower values of root spread diameter (35.2 cm) and total number of roots (31.7) were recorded in F_3Q_1 treatment.

The highest yield of 12.07 t ha^{-1} was recorded in the treatment twice a day irrigation with 140 per cent CWN (F_4Q_3) which recorded lower salt accumulation. And lower yield of 9.35 t ha^{-1} was recorded in F_3Q_1 treatment. Lower salt accumulation in the root zone of F_4Q_3 treatment facilitates better uptake of water and nutrients from the soil and this resulted in better crop growth and higher yield.

Maximum Water Use Efficiency of 448.61 kg ha^{-1} cm^{-1} was observed in twice a day irrigation treatment (F_4) and minimum Water Use Efficiency of 369.87 kg ha^{-1} cm^{-1} was observed at once in three day irrigation treatment (F_3). Increased quantity of irrigation water decreased the WUE significantly. Maximum WUE of 438.98 kg ha^{-1} cm^{-1} was observed in Q_1 treatment and minimum WUE of 394.79 kg ha^{-1} cm^{-1} was observed in Q_3 treatment. But increased quantity of irrigation water maintained less salinity in the root zone.

The higher benefit cost ratio of 2.05 was recorded in the treatment twice a day irrigation with 140 percent CWN and lower benefit cost ratio of 1.59 was recorded in the treatment once in three days irrigation with 100 per cent CWN. The B-C ratio of twice a day irrigation treatment (F_4) and once a day irrigation treatment (F_1) did not show much difference. Even though the B-C ratios were same as it was

observed that of F_4 treatment the salt accumulation was found to be less than the F_1 treatment.

Drip irrigation twice a day with 140 per cent CWN was found to be the best combination of frequency and quantity of irrigation by maintaining less salt accumulation in the root zone.

Application of Research:

Concluded result will help researcher to do further studies in growth parameters and yield of Bhendi under drip irrigation

Acknowledgement/Funding:

Author are thankful to Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu 641003 for the support provided for conducting field Experiment.

Author Contributions: First author post graduate research work

Abbreviations:

B-C ratio	: Benefit- cost ratio
CWN	:Crop water Need
DAS	: Days After Sowing
ET	:Evapotranspiration
K	:Potassium
LPH	:Litre per hour
m.ha	:million hectare
MSL	:Mean Sea Level
N	:Nitrogen
P	:Phosphorous
TNAU	:Tamil Nadu Agricultural University

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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