International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 9, Issue 47, 2017, pp.-4787-4791.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

EFFECT OF IRRIGATION FREQUENCY AND QUANTITY ON SOIL SALT DISTRIBUTION IN THE ROOT ZONE OF BHENDI UNDER DRIP IRRIGATION

SHARMILADEVI R.*, RANGHASWAMI M. V. AND RAJENDRAN V.

Department of Soil and Water Conservation Engineering, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Tiruchirappalli, 621712, India.
*Corresponding Author: Email-devi.sharmila@gmail.com

Received: October 14, 2017; Revised: October 16, 2017; Accepted: October 17, 2017; Published: October 18, 2017

Abstract- A field experiment was conducted to assess the salt distribution under drip irrigation by varying frequency of irrigation and amount of water supply. The experiment was laid out in strip plot design with three replications. Four irrigation frequencies and three irrigation quantities were adopted. The low value of Coefficient of variation (0.0395), the Christiansen uniformity of 96.85 per cent and the statistical uniformity of 96.05 per cent obtained for the discharge values recorded at various emitter positions revealed that the entire field was supplied with uniform distribution of water.

The salt distribution was observed by analyzing the pH and EC values of the soil samples collected from number of points around the emitter positions. The soil reaction (pH) values of the treatment twice a day irrigation with 140 per cent crop water need (CWN) shown higher value of pH (8.5) found to be with low salinity environment than the pH value of 8.28 obtained in the treatment once in three days irrigation with 100 per cent CWN irrigation treatment.

The lower EC value of 0.44 dS m^{-1} was recorded in the treatment twice day irrigation with 140 per cent CWN. In this treatment the effect of frequency of irrigation and application of excess water leached the salts beyond root zone depth. The higher EC value of 0.71 dS m^{-1} recorded once in three days with 100 per cent CWN treatment shown the progressive accumulation of salts in the root zone.

The highest yield of bhendi (12.07 t ha^{-1}) was recorded in the treatment twice a day irrigation with 140 percent CWN which recorded lower salt accumulation. Maximum water use efficiency of 448.61 kg ha^{-1} cm^{-1} was observed in this treatment. The higher benefit cost of 2.05 was recorded in the treatment twice a day irrigation with 140 percent CWN.

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- *Drip irrigation, Saline water, Root zone, Soil Salt Distribution, Bhendi*

Citation: Sharmiladevi R., et al., (2017) Effect of Irrigation Frequency and Quantity on Soil Salt Distribution in the Root Zone of Bhendi under Drip Irrigation. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 47, pp.-4787-4791.

Academic Editor / Reviewer: Sharmila S

Introduction

The scarcity of good quality irrigation water is a serious problem in arid and semi arid zones of the world that comprise one third of the earth. Fresh water resources, which are very scarce, forming only 3 per cent of the total water reserves, are over exploited and consequently have been tending to cause salinisation. Remaining 97 per cent water in sea is excessively saline and generally not suitable for large-scale exploitation to agriculture. As competition for fresh water increases, water of better quality is used primarily for domestic purposes, whereas water of lower quality e.g. saline or polluted water often is used for irrigation [1]. 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. Proper use of 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.

Depending upon the method and frequency of irrigation and the leaching fraction, salt distribution may be fairly uniform or non-uniform, with salinities ranging from a low level not greatly exceeding the salinity of applied irrigation water to levels many times higher in parts of the root zone. If the salinisation process is allowed to continue the problem grows to an extent where the land eventually has to be abandoned. Out of the total of 230 m.ha of irrigated land around the world, some 45 m.ha suffer from severe irrigation induced salinity problems. The annual increase in salt affected land in the world is approximately 2.5 to 5 million acres [2].

Where salinity is prominent, deficit irrigation can lead to soil salinasation and yield loss [3,4]. To avoid salinisation, excess water has to be applied to the field in order to leach the salt from the root zone. Frequency of irrigation affects salt distribution in the soil [5] and optimum frequency should be scheduled to reduce salt accumulation in the crop root zone.

Drip irrigation is gaining momentum in raising vegetable crops even though the available irrigation water is with salinity. By adopting drip irrigation, controlling as per the requirement of crop or excess irrigation can also be done. Hence a study was formulated to find the effect of irrigation frequency and quantity on salt distribution under drip irrigation with moderate saline ground water.

Materials and Methods

Experiment was conducted in precision farming development centre farms (Eastern Block-NA4) of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. 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.

Bhendi (*Abelmoschus esculentus* (L) Moench) Mahyco hybrid M-10 was raised as the test crop. The duration of the crop is 90 –110 days. The irrigation water is having pH of 7.25 and electrical conductivity 5.53 dS m^{-1},

Treatments

The experiment was conducted by adopting the following treatments. The experiment was laid out in strip plot design with three replication.

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)

Mahyco-10 hybrid bhendi seeds were dibbled at 30 × 40 cm spacing with a recommended seed rate of 7.5 kg ha^{-1}. Irrigation was given based on daily evaporation rate recorded from class A open pan evaporimeter. The crop factor value for bhendi crop were adopted based on the recommendation given by Allen *et al.* (1998) [6]. 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 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 discharge from the emitter for assessing the uniformity of water distribution, determination of pH and electrical conductivity and statistical method of evaluation conducted were presented here with.

The discharge rate of randomly selected 24 emitters were measured to assess the uniformity of water distribution by collecting the water for a known time of 180 seconds, by placing the measuring jars directly under the emitters at 1.2 ksc operating pressure. The Coefficient of variation (Cv), the Statistical Uniformity (US) and Christiansen's Uniformity (CU) are used to determine the efficiency of drip irrigation system. These parameters were evaluated for the discharge measurements recorded in the field.

Co-efficient of variation

The Co-efficient of variation is given by

$$Cv = \left(\frac{S_q}{\bar{q}}\right) \qquad [1]$$

where

Cv – Co efficient of variation

S_q – standard deviation of the observation

$\bar{q}$ – mean of the observation

Statistical Uniformity

The statistical uniformity is obtained as,

US = 100 (1 – Cv) [2]

where

US – Statistical Uniformity

Cv – Co efficient of variation

Christiansen's Uniformity

$$CU = 100\left[1 - \frac{\sum\left|\bar{q}_i - \bar{q}\right|}{Nq_i}\right] \qquad [3]$$

where

CU – Christiansen's Uniformity

$\sum\left|\bar{q}_i - \bar{q}\right|$ – sum of absolute deviation of individual observation from the mean value

q_i – discharge of ith emitter,

$\bar{q}$ – mean discharge

Soil reaction and Electrical Conductivity

Representative surface soil samples (0 to 15 cm) were colleted from the trail plot before irrigation. After the treatments are imposed soil samples were collected at emitter point, 10 cm and 20 cm radius from the emitter and depths of 10 cm, 20 cm and 30 cm on 60th and 105th day after the start of irrigation. The soil sample was air dried in shade, powdered gently with a wooden mallet and then sieved through a 2 mm sieve. The sieved soil sample was used for the estimation of pH and EC as the method prescribed by Jackson, 1973 [8]. Yield from each plot was recorded and expressed in t ha^{-1}. Water Use Efficiency (WUE) was calibrated for each treatment, which is the ratio of yield of the crop in kg ha^{-1} and total water utilized in cm.

The cost of drip system per hectare was worked out based on the current 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. The data were analysed as per standard programmes for strip plot design. Wherever the treatment differences were found significant ('F' test), critical differences were worked out at 5 per cent probability level and values furnished. Non-Significant treatment differences were denoted by 'NS' [7].

Results and Discussion

The results obtained on the investigation are presented and discussed here.

Uniformity of drip irrigation

The efficiency of drip irrigation depends on the uniformity of distribution of water from the system. The discharge rate at different points of emission was measured for a fixed period of operation (180 sec). At 1.2 ksc operating pressure, the co-efficient of variation was found as 0.0395. Statistical uniformity of 96.05 per cent and Christiansen's uniformity 96.85 per cent were calculated.

The low value of coefficient of variation (0.0395) obtained for the discharge values recorded at various emitter positions indicated that the discharge distribution throughout the system layout was not varying much. The Christiansen Uniformity (96.85) and the Statistical Uniformity (96.05) values determined for the discharge rates were also indicated that the water delivery from the emitters was found to be not varying much. Thus the entire field was found to be supplied with uniform distribution of water.

Soil reaction (pH)

The salt concentration represented as the soil reaction expressed as pH was recorded as 9.25 and the electrical conductivity was found as 0.17 dS m^{-1} in the experimental field before planting the crop. The results of the pH values recorded across the lateral are presented in [Table-1]. The data on soil reaction (pH) on 60 DAS was found to be in the range of 8.80 in all treatments. The pH values recorded at the time of harvest revealed that the frequency of irrigation affected the soil reaction significantly. Higher pH range of 8.54 was recorded in emitter point at 10 cm depth in two irrigations in a day treatment (F_4). Lower value of 8.27 was recorded at 20 cm away from the emitter and at 30 cm depth in the treatment of once in three days irrigation (F_3). In all the treatments higher value of pH was observed at emitter point, if distance increased the pH was also decreased. This was due to the increased salinity in the outer zone. Increased quantity of irrigation water increased the soil pH value. Mean pH of 8.38 was recorded at 140 per cent of crop water need (Q_3) treatment and mean pH of-

8.36 recorded at 100 per cent of crop water need (Q_1) treatment. In frequency and quantity interaction higher mean value of pH (8.50) was recorded in 140 per cent crop water need twice a day irrigation treatment (F_4Q_3) and lower value of 8.28 was recorded at F_3Q_1 treatment.

Table-1 *Effect of frequency and quantity of irrigation water on soil reaction (pH value) across the lateral at the end of the experiment*

Treatments / Depth	Soil reaction at various distance from the emitter									
	Emitter point			10 cm from emitter			20 cm from emitter			Mean
	10 cm	20 cm	30 cm	10 cm	20 cm	30 cm	10 cm	20 cm	30 cm	
Irrigation Frequency										
F_1	8.41	8.41	8.41	8.38	8.37	8.35	8.35	8.34	8.33	8.37
F_2	8.36	8.34	8.35	8.32	8.31	8.30	8.30	8.28	8.27	8.32
F_3	8.31	8.31	8.31	8.30	8.28	8.29	8.29	8.28	8.27	8.29
F_4	8.54	8.52	8.52	8.50	8.49	8.47	8.47	8.46	8.44	8.49
SEd for F	0.003	0.006	0.003	0.003	0.004	0.003	0.003	0.002	0.003	
CD for F (P=0.05)	0.008	0.014	0.007	0.008	0.011	0.008	0.008	0.004	0.007	
Irrigation Quantity										
Q_1	8.39	8.38	8.38	8.36	8.36	8.34	8.34	8.33	8.31	8.35
Q_2	8.40	8.39	8.39	8.38	8.36	8.35	8.35	8.34	8.33	8.37
Q_3	8.40	8.39	8.39	8.39	8.38	8.37	8.37	8.35	8.35	8.38
SEd for Q	0.002	0.001	0.001	0.004	0.001	0.002	0.003	0.002	0.001	
CD for Q (P=0.05)	0.007	0.003	0.003	0.010	0.004	0.006	0.009	0.004	0.002	
Frequency × Quantity										
F_1Q_1	8.42	8.43	8.43	8.36	8.35	8.34	8.33	8.32	8.32	8.37
F_1Q_2	8.40	8.40	8.39	8.39	8.36	8.35	8.34	8.34	8.33	8.37
F_1Q_3	8.41	8.40	8.40	8.41	8.38	8.36	8.37	8.37	8.35	8.38
F_2Q_1	8.36	8.35	8.35	8.31	8.31	8.29	8.29	8.27	8.26	8.31
F_2Q_2	8.36	8.35	8.35	8.32	8.31	8.31	8.30	8.29	8.28	8.32
F_2Q_3	8.36	8.33	8.34	8.33	8.32	8.31	8.31	8.28	8.29	8.32
F_3Q_1	8.31	8.30	8.30	8.29	8.27	8.28	8.27	8.26	8.25	8.28
F_3Q_2	8.31	8.31	8.31	8.29	8.27	8.28	8.28	8.28	8.27	8.29
F_3Q_3	8.31	8.31	8.31	8.31	8.31	8.30	8.30	8.29	8.29	8.30
F_4Q_1	8.54	8.51	8.51	8.50	8.49	8.46	8.46	8.45	8.43	8.48
F_4Q_2	8.54	8.52	8.52	8.50	8.49	8.48	8.47	8.45	8.44	8.49
F_4Q_3	8.55	8.53	8.53	8.51	8.50	8.49	8.48	8.47	8.45	8.50
SEd for F at Q	0.005	0.006	0.004	0.006	0.005	0.004	0.005	0.004	0.004	
SEd for Q at F	0.002	0.001	0.001	0.004	0.001	0.002	0.003	0.002	0.001	
CD for F at Q (P=0.05)	0.012	0.014	0.009	0.013	0.012	0.009	0.013	0.010	0.009	
CD for Q at F (P=0.05)	0.006	0.003	0.003	0.008	0.003	0.005	0.008	0.004	0.002	

Salt Concentration

The data on electrical conductivity on 60 DAS was found to be in the range of 0.25 dS m^{-1} in all treatments. The EC values recorded at the time of harvest showed that the frequency of irrigation affected salt distribution significantly. Effect of frequency of irrigation on salt distribution is graphically represented in [Fig-1]. In emitter point and 10 cm depth minimum value of 0.40 dS m^{-1} was observed in twice a day (F_4) irrigation treatment. Maximum value of 0.50 dS m^{-1} was observed once in three days (F_3) irrigation treatment. F_1 and F_2 were on par at 10 cm depth. With increase in depth the salt concentration increased. It was observed by increased EC value at 20 and 30 cm depth. The lower EC value was observed in F_4 treatment followed by F_1, F_2 and F_3.

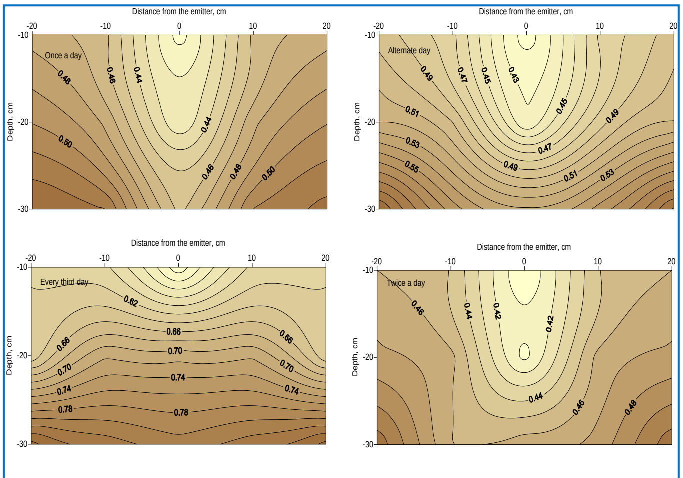

Fig. 1. Effect of irrigation frequency on salt distribution(dS m-1)

The point at 10 cm away from the emitter point, the salt concentration at all depths (10, 20 and 30 cm) showed an increased EC value than at the emitter point. Similar trend of salt concentration was observed at 20 cm away from the emitter. From all the observation F_4 recorded lower mean root zone salinity (0.46 dS m^{-1}) and higher mean root zone salinity of (0.70 dS m^{-1}) was observed in F_3 treatment.

Increased frequency of irrigation leaches the salt from the root zone, which caused lower soil salinity in F_4 treatment, followed by F_1 and F_2. The higher salinity in the F_3 treatment caused by capillary rise of salts to the root zone. Increasing irrigation interval increased the soil moisture tension, which caused capillary rise of water along with salts.

The effect of irrigation quantity in affecting the salt concentration at various depth points are expressed in the form of [Fig-2]. Quantity of irrigation water applied did not shown any significant change in salt concentration values recorded upto 10 cm depth of soil. But the quantity of irrigation water influenced the salt concentration between 10 and 20 cm depths. It was observed that the excess application of saline irrigation water decreased the salt concentration in the root zone. Among the irrigation quantity, the treatment 140 per cent of CWN (Q_3) has recorded the mean root zone salinity of 0.52 dS m^{-1}, followed by Q_2 (0.53 dS m^{-1}) and Q_1 (0.54 dS m^{-1})

The effect of frequency and quantity of irrigation water interaction treatments on salt distribution is graphically shown in [Fig-3]. and [Fig-4] which showed that at 10 cm depth from the emitter point no significant difference on salt concentration was observed in all treatments. However in all other points EC values were significantly influenced by treatments. The treatment 140 per cent CWN twice a day (F_4Q_3) showed lower mean root zone salinity of 0.44 dS m^{-1} than all other interaction treatments. The higher value of mean root zone salinity (0.71 dS m^{-1}) was observed in once in three days with 120 per cent of irrigation treatment (F_3Q_1).

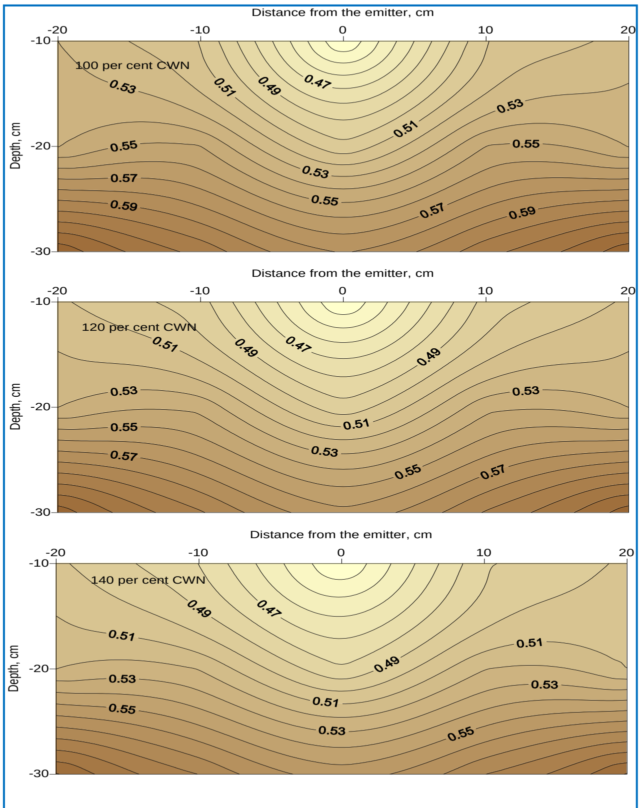

Fig. 2. Effect of irrigation quantity on salt distribution (dS m-1)

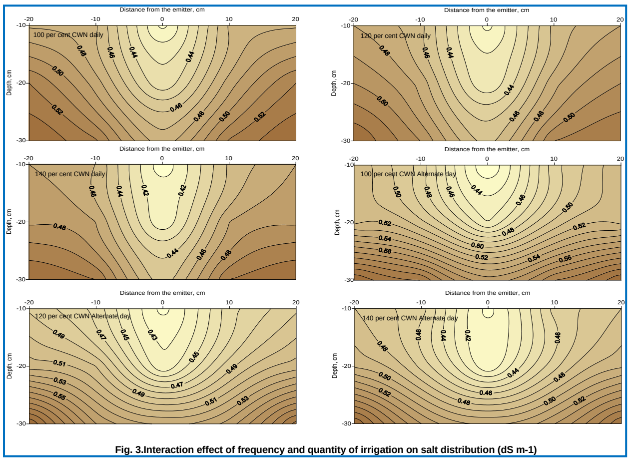

Fig. 3.Interaction effect of frequency and quantity of irrigation on salt distribution (dS m-1)

It was observed that the salt concentration of the soil was progressively increased as the distance from the emitter either radial direction or in vertical direction increased.

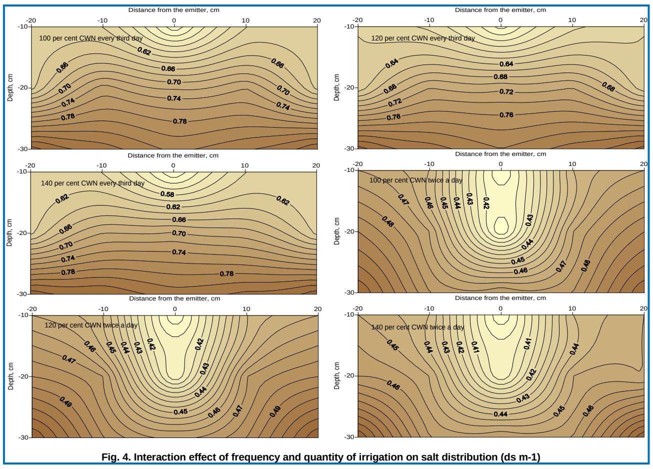

Fig. 4. Interaction effect of frequency and quantity of irrigation on salt distribution (ds m-1)

Yield Analysis

Frequency and quantity of irrigation water significantly influenced the yield of bhendi. Yield recorded is shown in [Fig-5]. Higher yield of 12.07 t ha^{-1} was recorded in twice a day irrigation 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 irrigation with 100 per cent CWN treatment (F_3Q_1).

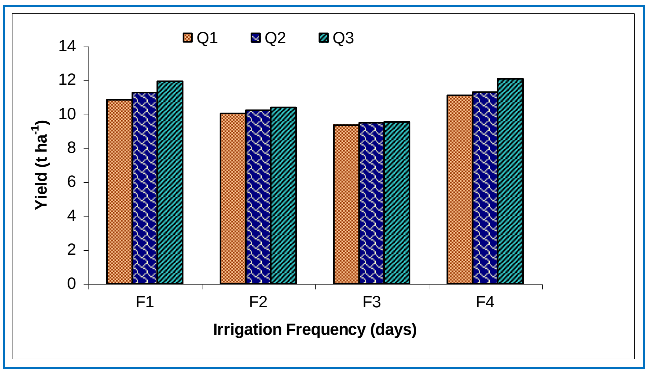

Fig-5 Effect of irrigation frequency and quantity of irrigation water on yield of bhendi

Water use efficiency (kg ha^{-1} cm^{-1})

Frequency of irrigation influenced the WUE significantly. Higher WUE of 448.61 kg ha^{-1} cm^{-1} was observed in F_4 treatment. F_1 is on par with F_4. But treatments F_2 and F_3 recorded lower WUE of 399.47 and 369.87 kg ha^{-1} cm^{-1}, respectively. The graphical representation of WUE is shown in [Fig-6].

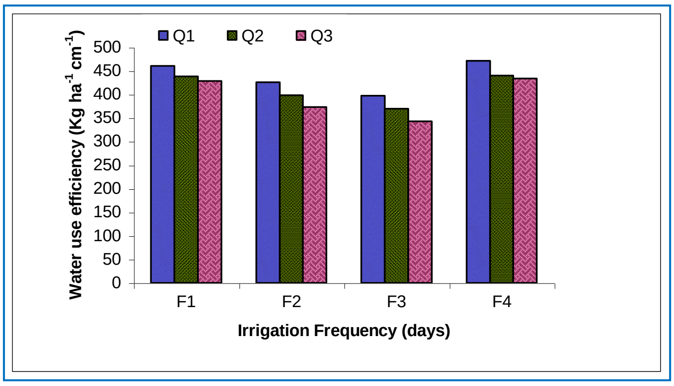

Fig-6 Effect of irrigation frequency and quantity of irrigation water on WUE

Among irrigation quantity 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 A progressive decline in water use efficiency with the increasing levels of irrigation through drip was observed. But increased levels of irrigation water maintained less salinity in the root zone. Interaction of frequency and quantity did not show significant difference in WUE.

Cost economics

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.

Conclusion

Drip irrigation twice a day with 140 per cent CWN recorded less salt accumulation of 0.44 dS m^{-1} in the root zone compared with all other treatments, which caused higher yield of 12.07 t ha^{-1} and B-C ratio of 2.05 in that treatment. Twice a day with 140 per cent CWN was found to be the best combination of frequency and quantity of irrigation among all the treatments.

Application of research:
Result can be suggested to farmers for adoption. Concluded result will help researcher to do further analysis in water and salt management studies of Bhendi under drip irrigation.

Acknowledgement / Funding: Authors are thankful to Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu 641003 for the support provided for conducting field experiments

Author Contributions: All author equally contributed

Abbreviations:

B-C ratio :	Benefit cost ratio
CU:	Christiansen's Uniformity
C_v:	Coefficient of Variation
DAS:	Days after sowing
EC:	Electrical Conductivity
K:	Potassium
N:	Nitrogen
NS:	Non Significant
P:	Phosphorous
S_q	Standard deviation of the observation
US:	Statistical Uniformity
WUE:	Water Use Efficiency

Conflict of Interest: None declared

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

References

[1] Khroda G. (1996) *Strain, social and environmental consequences and water management in the most stressed water systems in Africa. In: E. Rached, E. Rathgeber and D.B. Brooks (eds.), Water Management in Africa and the Middle East - Challenges and opportunities, IDRC, Canada*, pp 295.
[2] Ghassemi F., Jakeman A.J., Nix H.A. (1995) *Salinisation of land and water resources. CAB International abstracting and database, Wallingford*, pp 520. (www.cabi-publishing.org).
[3] Hoffman G.J., Jobes J.A. and Alves W.J. (1983) *Agricultural Water Management.* 7, 439-456.
[4] Meiri A., Lauter D.J. and Sharabani N. (1995) *Irrigation Science,* 16, 15-21.
[5] Patil S.L., Hunshal C.S., Viswanath D.P., Chimmad V.P., Kubsad V.S., Salimath S.B. and Hosmani R.M. (1992) *J. Maharashtra Agric. Univ.,* 17(2), 229-231.
[6] Allen R.G., Pereira L.S., Raes D. and Smith M. (1998) Crop Evapotranspiration – Guidelines for computing crop water requirements. FAO Irrigation and Drainage paper 56, Rome, ISBN 92-5-104219-5 .
[7] Rangaswamy R. (2002) A Text Book of Agricultural Statistics. New Age International (P) Limited, New Delhi, pp 409.
[8] Jackson M.L. (1973) *Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India.*