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Performance of ber (*Ziziphus mauritiana* Lamk.) to saline water with different irrigation schedules under drip irrigation

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Abstract

An experiment to study the performance of ber (*Ziziphus mauritiana* Lamk.) to saline water using drip irrigation was started in 2005-06 on four years old plants planted in 2002. Yield and yield attributes were recorded from 2005-06 to 2008-09. The maximum average yield (43.6 kg/plant) was obtained in the treatment 0.8PET+canal water with mulch and the yields were at par with saline water in this treatment (39.6 kg/plant). Similar trend was also observed in case of average fruit diameter and average weight of fruits. The average per day water requirement by the ber plant from 2005-06 to 2008-09 at 1.0 and 0.8PET was maximum in the month of May i.e. 54.25 and 43.40 l/day and was minimum in the month of January i.e. 11.87 and 9.47 l/day, respectively. The average water required by the ber plant in a crop season from 2005-06 to 2008-09 were 8655 and 6927 liters at 1.0 and 0.8PET, respectively. Application of saline water resulted in salt accumulation in lower depth of the soil profile due to high hydraulic conductivity of sandy soils. Minimum salt accumulation in the soil profile existed just below the emitters. Comparatively, higher salinity levels existed in treatments with 0.8PET+without mulch conditions at almost every point of observation. This could be attributed to lower moisture level in soil profile as compared to 1.0PET thereby, increasing the salinity status. Application of plastic mulch resulted in lower salt concentration in surface soil.

Key words: Ber, saline water, drip irrigation, mulch

Introduction

Agriculture in western Rajasthan is faced with challenges such as extremely high summer temperatures, low relative humidity, strong winds, rapidly depleting groundwater resources and highly saline irrigation water. Farmers have to rely on the use of brackish water for irrigation. Perennial irrigation with brackish water without proper water management practices has resulted in severe salt buildup in the soil. Therefore, irrigation-induced salinization has become a widespread problem in irrigated agriculture in western Rajasthan. Consequently, application of simple, efficient salinity management strategies, such as use of freshwater to leach excess salts from the root zone and use of salt-tolerant crops have become increasingly important. Salinity tolerance of various fruit crops, including *Zizyphus*, has been investigated by several researchers (Dhankar *et al.*, 1978; Patil and Patil, 1983; Hooda *et al.*, 1990; Singh and Singh, 1994). *Ziziphus mauritiana* improved varieties of Ber (Gola, Seb and Mundia), have made a big impact in arid and semi-arid regions. It provides reasonable income to farmers even during drought years. Further, under arid and semi arid regions in the scenario of scarcity of good quality water the use of poor quality waters for agriculture is inevitable. The crops requiring more water for production are to be discouraged. *Ziziphus mauritiana* could be raised successfully having low water requirement. Therefore, the present investigation was undertaken to find out effect of saline water, irrigation schedules and mulching on water saving, yield attributes and yield of Ber and to determine salt accumulation in soil profile.

Materials and Methods

An experiment was undertaken to evaluate the Performance of ber (*Ziziphus mauritiana* Lamk.) to saline water using drip irrigation with irrigation schedules with mulch and without mulch was started in 2005-06 on four year plants planted in 2002. Yield and yield attributes were recorded from 2005-06 to 2008-09. The objectives of the experiment was to find out the effect of saline water, irrigation schedules and mulching on water saving, yield attributes and yield and to determine salt accumulation in soil profile. The treatments consisted of two levels of water application as per water requirement i.e. 1.0 and 0.80PET, two levels of water salinity i.e. canal water (EC 0.25 dSm^{-1}) and saline water (EC 8.0 dSm^{-1}) and two levels of mulching i.e. with mulch and without mulch. Four plants were planted for each treatment. Total 96 plants of Ber variety Gola were planted with three replications under split plot design with spacing of 8 x 8 m in the sandy soil of ARS, Bikaner in the year 2002. The observations recorded were plant growth, yield, and yield attributes, quantity of water applied and periodic soil sampling for pH, and EC_e. pHs and ECe of soil and water were determined by the methods outlined by Richards (1954).

The soil of the experimental field was alkaline in nature and sandy in texture with poor fertility status. pH and ECe of soil ranged from 8.31 to 8.70 and 0.53 to 0.71 dSm^{-1}, respectively in the soil profile up to 150 cm depth. Organic

carbon content was very low (0.09 %). Available nitrogen (105.0 kg N/ha), available phosphorus (14.6 kg P_2O_5/ha) and potash (198 kg K_2O/ha) was also of low magnitude. $CaCO_3$ in surface soil was 1.17 per cent whereas, at 150 cm depth it was 3.75 per cent. The texture of the soil was sand, and the hydraulic conductivity ranged from 7.2 to 7.9 cm h^{-1} thus, the drain ability of these soils is high whereas, the water holding capacity was only 6.18 cm m^{-1}, thereby the irrigation frequency was of short duration. Bulk density ranged from 1.52 to 1.57 Mgm^{-3}. The sand, silt and clay content ranged from 90.2 to 86.3, 2.1 to 3.7 and 6.4 to 5.7 per cent in the soil profile, respectively.

The water requirement of ber crop (Table 1) at different stages and for different period of the year was estimated by using open pan evaporation and FAO guidelines. The volume of water required is calculated by the formula as under:

$$V = Ep. \times Kc. \times Kp. \times Sp. \times Sr. \times Wp$$

Where,

V = Volume of water required litre/day/plant

Ep = Pan evaporation (mm/day)

Kc = Crop coefficient

Kp = Pan coefficient

Sp = Plant to plant spacing (m)

Sr = Row to row spacing (m)

Wp = Wetted area (0.3 for widely spaced crops)

The daily water requirement is presented in Table 1 revealed that average per day water requirement by the ber crop for the seasons from 2005-06 to 2008-09 at 1.0 and 0.8PET was maximum in the month of June i.e. 55.45 and 44.30 l/day and was minimum in the month of January i.e. 11.87 and 9.47 l/day, respectively.

Results and Discussion

Yield

In 2005-06 the maximum yield i.e.35.87 kg/plant was recorded in the treatment 0.8PET+plastic mulch with canal water. With saline water this treatment yielded 32.63 kg/plant. In 2006-07 also the maximum average yield i.e. 37.08 kg/plant was obtained in treatment 0.8PET+plastic mulch with canal water. Even under saline water this treatment resulted in maximum yield of 35.40 kg/plant. In 2007-08 the maximum average yield i.e.40.05 kg/plant was recorded in the treatment 0.8PET+plastic mulch with best available water. Under saline water this treatment yielded average fruit yield of 38.03 kg/plant. Similarly in 2008-09 the maximum average yield i.e.52.2 kg/plant was obtained in treatment 0.8PET+canal water with mulch. Even under saline water this treatment resulted in maximum yield of 44.5 kg / plant. The average of all four years (Table 2) showed that the maximum average yield of 43.6 kg/plant was obtained in the treatment 0.8PET+canal water with mulch. Even under saline water this treatment resulted in maximum yield of 39.6 kg/plant. Singh and Singh (1994) and Avasthi *et al.* (1997) also reported that Z. *mauritiana* grew well under moderate sodicity and salinity levels. In general, higher yields were obtained in treatment of 0.8PET as compared to 1.0PET under both canal and saline application. Comparatively higher yields were recorded under mulch conditions irrespective of water quality. Data presented in Table 4 showed that maximum increase in the ber fruit yield was 45.7 and 32.4 per cent in the treatment 0.8PET+canal+mulch and 0.8PET+saline+mulch respectively, over 1.0PET+canal+without mulch.

Yield parameters

In 2005-06 the average fruit diameter varied from 2.60 to 3.90 cm in different treatments with highest in 0.8PET + canal water with plastic mulch and lowest in 1.0PET+ saline water without mulch. In 2006-07 the average fruit diameter varied from 2.66 to 3.96 cm in different treatments highest being in 0.8PET+canal water with mulch and lowest in 1.0PET+saline water without mulch. Similar trend was also observed in case of average fruit weight. Similarly in 2007-08 the average fruit diameter varied from 2.82 to 3.74 cm in different treatments with highest in 0.8PET+canal water with plastic mulch and lowest in 1.0PET+saline water without mulch. In 2008-09 also the average fruit diameter varied from 2.84 to 3.77 cm in different treatments highest being in 0.8PET+canal water with mulch and lowest in 1.0PET+ saline water without mulch. Similar trend was also observed in case of average weight of fruits. The average of all four years showed that average fruit diameter varied from 2.84 to 3.77 cm in different treatments highest being in 0.8PET+canal water with mulch and lowest in 1.0PET+canal water without mulch. The average fruit weight was also recorded highest 36.7g in treatment 0.8PET+canal water with mulch. In general higher values of yield attributes were recorded in treatment of 0.8PET as compared to 1.0PET under both canal and saline application. Comparatively higher values of yield attributes were recorded under mulch conditions irrespective of water quality (Table 3).

Water Use Efficiency

In the treatments of 1.0PET the volume of water applied was 11.48 lac l/ha/year, whereas it was 9.19 lac l/ha/year in 0.8 PET treatments. The maximum water use efficiency i.e. 7.40 g/l was in 0.8+canal+mulch treatment and followed by 6.72 g/l in the treatment 0.8+saline+mulch. The minimum WUE was 4.06 g/l in 1.0PET+canal+without mulch treatment.

Salt build-up in soil profile

The distribution of salts in the soil profile after completion of harvesting of fruits in the month of April 2009 is presented in Table 5. It is clear that application of saline water resulted in salt accumulation in lower depth of the soil profile. Bhat *et al.* (2009) also reported that saline water application resulted in salt build-up in the soil profile. The salts leached from the upper layers are being piled up in the lower depths. Minimum salt accumulation in the soil profile existed just below the emitters. Comparatively, high salinity levels existed in treatments with 0.8PET in without mulch conditions at almost every point of observation. This could be attributed to lower moisture level in soil profile as compared to 1.0PET, thereby, increasing the salinity status.

Application of plastic mulch resulted in lower salt concentration in the soil profile. This might be due to the fact that since equal amount of water was given to plants at one irrigation level irrespective of considering the plastic mulch and under mulching soil evaporation is restricted to considerable extent, hence higher moisture existed causing less concentration of salts.

It can be concluded that the highest yield and yield attributes and WUE were obtained at 0.8PET for both saline and canal water. Further, no significant difference was observed in yield levels for saline and canal water both with mulch and without mulch conditions. It can be inferred that saline water up to 8.0dSm^{-1} can be successfully used for ber cultivation under drip irrigation without any significant reduction in yield and without much salt accumulation in the upper layers of these sandy soils. The results are in corroboration with the findings of Dhankar *et al.*, 1978; Patil and Patil, 1983; Hooda *et al.*, 1990; Singh and Singh, 1994.

Table 1: Volume of water applied (litres) per day/plant

Months	2005-06		2006-07		2007-08		2008-09		Average	
	1.0 PET	0.8 PET	1.0 PET	0.8 PET	1.0 PET	0.8 PET	1.0 PET	0.8 PET	1.0 PET	0.8 PET
June	47.4	37.9	50.2	40.2	64.9	51.6	59.3	47.5	55.45	44.30
July	36.3	29.0	36.4	29.1	48.7	38.9	40.1	32.0	40.37	32.25
August	32.4	25.9	31.2	25.0	42.9	34.3	37.2	29.8	35.92	28.75
September	27.0	21.6	24.4	19.5	36.2	28.9	31.4	25.1	29.75	23.77
October	23.4	18.7	22.0	17.6	27.4	21.9	21.6	17.3	23.60	18.87
November	19.2	15.4	16.2	13.0	17.0	13.6	19.1	15.3	17.87	14.32
December	18.1	14.5	14.6	13.7	11.2	8.9	10.4	8.3	13.57	11.35
January	12.4	9.9	11.3	9.0	12.5	9.9	11.3	9.1	11.87	9.47
February	14.0	11.2	13.0	10.4	13.7	10.9	14.3	11.4	13.70	11.00

Table 2: Yield of Ber fruits per plant under different treatments of canal and saline water applications and mulching

Treatment	Fruit yield / plant (kg)				
	05-06	06-07	07-08	08-09	Mean
1.0PET+Canal+Without Mulch	27.9	28.1	32.5	31.2	29.9
1.0PET+Canal+Mulch	30.0	31.6	39.4	37.3	34.6
1.0PET+Saline+Without Mulch	26.4	27.0	41.2	33.7	32.1
1.0PET+Saline+Mulch	28.7	29.9	39.4	35.3	33.6
0.8PET+Canal+Without Mulch	31.1	34.9	44.2	42.9	38.3
0.8PET+Canal+Mulch	35.9	39.5	46.8	52.2	43.6
0.8PET+Saline+Without Mulch	30.4	32.2	49.9	41.2	38.4
0.8PET+Saline+Mulch	32.6	38.2	43.3	44.5	39.6
S.Em ±	1.4	1.7	1.3	3.2	1.9
CD (5%)	4.3	5.1	3.9	9.6	5.7

Table 3: Effect of different treatments of canal and saline water applications on average weight and average diameter of Ber fruits

Treatment	Average weight of fruits(g)					Average diameter (cm)				
	05-06	06-07	07-08	08-09	Mean	05-06	06-07	07-08	08-09	Mean
1.0PET+Canal+Without Mulch	29.0	30.7	28.1	30.3	29.5	2.71	2.84	2.92	2.91	2.84
1.0PET+Canal+Mulch	30.5	32.3	26.3	30.7	29.9	3.10	3.30	2.77	3.02	3.05
1.0PET+Saline+Without Mulch	27.5	29.1	30.1	28.7	28.8	2.60	2.71	3.27	2.97	2.89
1.0PET+Saline+Mulch	30.0	31.8	29.9	31.5	30.8	2.83	2.94	3.27	2.93	2.99
0.8PET+Canal+Without Mulch	33.0	34.3	32.9	34.1	33.6	3.51	3.72	3.45	3.60	3.57
0.8PET+Canal+Mulch	37.5	39.7	32.8	37.0	36.7	3.90	4.01	3.37	3.79	3.77
0.8PET+Saline+Without Mulch	31.0	32.8	35.3	34.4	33.4	3.40	3.60	3.90	3.70	3.65
0.8PET+Saline+Mulch	34.5	36.5	35.0	35.1	35.3	3.65	3.84	3.73	3.81	3.76
S.Em ±	1.5	1.3	1.2	0.8	1.2	0.16	0.18	0.20	0.13	0.17
CD (5%)	4.7	3.8	3.6	2.4	3.6	0.50	0.54	0.61	0.39	0.51

Table 4: Fruit yield, water applied and water use efficiency as influenced by drip irrigation in ber

Treatment	Yield (q/ha)	Increase in yield (%)	Water use (lac. l/ha/y)	WUE g/ht
1.0PET+Canal+Without Mulch	46.64	-	11.48	4.06
1.0PET+Canal+Mulch	53.98	15.6	11.48	4.70
1.0PET+Saline+Without Mulch	50.07	7.3	11.48	4.36
1.0PET+Saline+Mulch	52.41	12.4	11.48	4.56
0.8PET+Canal+Without Mulch	59.74	28.0	9.19	6.50
0.8PET+Canal+Mulch	68.01	45.7	9.19	7.40
0.8PET+Saline+Without Mulch	59.90	28.4	9.19	6.51
0.8PET+Saline+Mulch	61.71	32.4	9.19	6.72

Table 5: Salinity (ECe) distribution in soil profile under drip with saline water (8.0dSm^{-1}) for ber crop

Distances from emitter (cm)	Soil depths	1.0PET+without Mulch	0.8PET+without Mulch	1.0PET+Mulch	0.8PET+Mulch
15	0-15	2.28	2.00	2.02	1.83
	15-45	2.68	2.46	2.22	2.33
	45-75	2.80	2.71	2.61	2.56
	75-105	3.42	3.26	2.95	2.91
30	0-15	2.88	2.50	2.53	2.28
	15-45	3.06	3.09	2.88	2.81
	45-75	3.36	3.25	3.17	3.00
	75-105	3.14	3.30	2.97	2.91
60	0-15	3.01	2.89	2.69	2.50
	15-45	3.38	3.31	3.08	2.91
	45-75	3.68	3.49	3.47	2.98
	75-105	3.44	3.51	3.34	3.21
90	0-15	3.35	3.09	2.91	2.52
	15-45	3.95	3.67	3.44	2.78
	45-75	3.97	3.04	3.68	3.59
	75-105	3.97	3.59	3.96	3.75

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