Performance of Ber (*Zizyphus mauritiana* lamk.) Varieties under Two Irrigation Scheduling of Saline Water in Central Gujarat Conditions in India

L. M. Patil[1*], S. R. Gomkale[1], S. S. Roy[1], J. R. Mori[1] and V. K. Kauthale[1]

[1]*BAIF Development Research Foundation, Vadodara, Gujarat, India.*

Authors' contributions

This work was carried out in collaboration among all authors. Author LMP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SRG and SSR managed the analyses of the study. Authors JRM and VKK managed the literature searches. All authors read and approved the final manuscript.

Article Information

Original Research Article

ABSTRACT

The field experimentation was carried out at Instructional Farm, BAIF Development Research Foundation, Nanodara of Ahmadabad district during 2014 to 2018 with an objective to evaluate the response of the two ber varieties (Seb and Gola) to number of irrigations on the growth and yield of ber crop. It was also intended to understand effect of saline irrigation water on soil status as irrigation water of the study location is slightly saline in nature. The study was conducted in Split Plot Design with six replications. Treatments consisted of two irrigation schedule; normal irrigation at 15 days interval and life saving irrigation at 30 days interval and two varieties (Seb and Gola). Soil and irrigation water of the study location was analyzed using standard procedures for initial and yearly status, respectively. Two ways ANOVA was carried out using R Studio Statistics Rx 64 software. Significance levels were tested at p≤0.05. The highest plant height (326.87 cm), girth size (60.75 cm), number of secondary branches per plant (7.24), dry leaf biomass per plant (3.96 kg), dry shoot weight per plant (16.65) as well as fruits per plant (337.58), fruit weight (56.96 g), fruit yield per plant (19.43 kg) and fruit yield per ha (5400 kg) were increased significantly with normal

---

Corresponding author: E-mail: lalit.patil@baif.org.in;

irrigation treatment (irrigations at 15 days interval) which was significantly superior over life saving irrigation. In case of varieties, all the parameters of the growth and yield of the crop were maximum for Gola variety compared to Seb. The pH, EC and SAR were comparatively lower in soil under life saving than normal irrigation.

1. INTRODUCTION

Ber (*Zizyphus mauritiana* Lamk.) is a sturdy fruit tree that belongs to family *Rhamnaceae*. It can be successfully grown in arid and semi-arid zones of Indian states particularly Haryana, Rajasthan, Madhya Pradesh and Gujarat. India has a rich source of underutilized native and exotic fruit trees, which have a high agro industrial potential and represent an important economic source for the local populations. Ber is also considered as poor man's apple since fruits are available at low cost and rich in protein, minerals and vitamin C [1]. Ber is remunerative fruit, which can be grown successfully even in marginal and saline soils with little care. Due to its hardy nature, adaptability to marginal conditions of soil and climate and the nutritive value of its fruit, it has now become the most important fruit of arid regions [2].

Water is a key input among all the inputs however, water for irrigation is a scarce resource therefore its efficient utilization for irrigation is essential. Optimal use of irrigation water allows better utilization of all other production factors and resulting into increased yield per unit area and time. Proper water management for crop production is a key factor to check soil and water salinity as it is the major problems in arid and semiarid regions of the country. High concentration of salt in the root zone reduces soil water potential and the availability of water. It is estimated that about 20% of the earth's land mass and nearly half of the total irrigated land is affected by salinity [3].

2. MATERIALS AND METHODS

2.1 Experimental Location

The field experiment was carried out during 2014 to 2018 at BAIF Development Research Foundation, Nanodara of Ahmadabad district. The experimental site is situated at central part of Gujarat at an altitude of 29 meter above mean sea level and at 22°49'33''N latitude and 72°10'16''E longitude. The average annual rainfall of the study location is 777 mm with average temperature of 27.4°C.

2.2 Soil Sampling and Analysis

Soil Samples was collected using soil auger at a depth of 0 – 25 cm randomly in the field at twelve different points. The soil pH, electrical conductivity (EC), organic carbon and available nitrogen, phosphorus and potassium were determined. Soil reaction (pH) was measured in 1:2.5 soil extract. Electrical conductivity (EC) was measured by electrical conductivity meter as dSm^{-1} at 25°C. Soil organic carbon was determined by following rapid titration method [4]. Available N was determined using Alkaline $KMnO_4$ Kjeldahl method [5], Available P was determined using sodium bicarbonate method according to Olsen et. al. [6]. Available K was extracted by 1N Ammonium Acetate (pH 7) and determined by a flame photometer [7]. Sodium adsorption ratio (SAR) was calculated by using following formula of Richards [8].

$$SAR = \frac{Na}{\sqrt{(Ca + Mg)/2}}$$

2.3 Irrigation Water Sampling and Analysis

Ground water sample was collected after the bore well had pumped for a period of 15 to 30 min. The quality of water used for irrigation was assessed every year during four year study. The water used for irrigation was analyzed for different water quality parameters by following standard methods [9]. The pH and Electrical Conductivity (EC) of water was determined using micro controller based pH system and conductivity meter, respectively. Bicarbonate (HCO_3) ions in the water sample were determined by titrating it against $H_2SO_4^-$. Cations like Ca^{++}, Mg^{++} and Na^+ was determined with 0.01N EDTA titration method. The Cl^- contents by Mohr's titration method and SO_4^{2-} by turbid metric method.
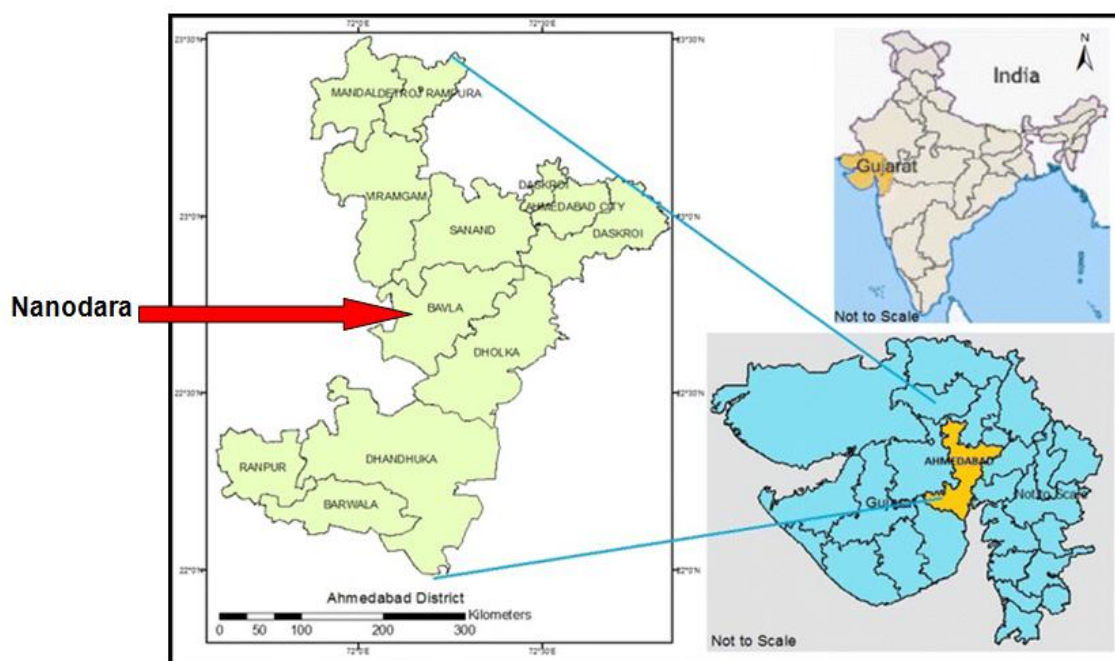
Fig. 1. Area map of study location

2.4 Experimental Design and Management

The experiment was laid out in Split Plot Design with 6 replications. The treatments comprised of two irrigation schedule in the main plots, viz., the I_1 (irrigation at 15 days interval) and I_2 (irrigation at 30 days interval). The sub-plots comprised of two varieties V_1 (Seb) and V_2 (Gola). The spacing at row-to-row and plant-to plant maintained at 6 m x 6 m. The plants were pruned with 25 % branches of the total branches during May 2018. The recommended agronomic package of practices was followed for growing of crop.

2.5 Statistical Analysis

The observations were recorded and statistically analyzed on completion of 4 years after plantation. The soil was analyzed for fertility status after completion of the experiment. The effects of irrigations and varieties on ber plant height, girth size, number of secondary branches, dry leaf biomass, dry shoot weight, number of fruits, fruit weight, fruit yield were analyzed using analysis of variance (ANOVA) procedures using R-studio a Statistical Analysis System (SAS), version Rx64 3.6.2 Software. The means were compared between treatments using Tukey's test at α=5% level of significance.

3. RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

3.1 Chemical Properties of Soil and Irrigation water

The chemical properties of experimental soil are pH 8.20, EC 0.85 dS/m, Organic Carbon 0.28%, available nitrogen 275.90 kg/ha, available phosphorous 34 kg/ha and available potash 172.2 kg/ha.

The ranges of analytical values of irrigation water obtained during four years are placed with maximum, minimum and average value as depicted in Table 1.

3.2 Effect Irrigations and Varieties on Growth Parameters

The irrigation schedules affected significantly (P=0.05) the growth attributes viz., plant height, stem girth, number of primary branches per plant, dry matter accumulation per plant, of the crop. The data pertaining to growth attributes yield are given in Table 2. The highest plant height (326.87 cm), girth size (60.75 cm), number of secondary branches per plant (7.24),

88

dry leaf biomass per plant (3.96 kg), dry shoot weight per plant (16.65) were recorded with the application of normal irrigation at 15 days interval which was significantly superior over lifesaving irrigation schedule (irrigation at 30 days interval). The effect could be due to ample irrigation that increased the nutrient availability to crop which triggers rapid cell elongation. Similar results were also reported by [10] Sharma et al. Highest dry matter accumulation was recorded due to increased plant height, number of branches and LAI under adequate moisture supply. All these contributed for cell turgidity and opened leaves which increased the photosynthetic activity of plants resulted in higher dry matter accumulation. Increased dry matter accumulation due to irrigation had also been reported by Meghwal and Kumar [11].

The highest plant height (305.76 cm), number of secondary branches per plant (6.93) dry leaf biomass per plant (3.28) and dry shoot weight per plant (12.59) were recorded in Gola variety which was superior over Seb variety. In general, the growth parameters viz., plant height number of branch and dry matter accumulation per plant were observed significantly higher in Gola due to variety character.

3.3 Effect Irrigations and Varieties on Yield Attributes and Yield

The data summarized in Table 3 shows that irrigation schedule and varieties have influenced significantly on number of fruits per plant and fruit yield. The maximum number of fruits per plant (337.58), fruit weight (56.96 g), fruit yield per plant (19.43 kg) and fruit yield per ha (5400 kg) were recorded under I_1 (irrigation at 15 days interval), which was significantly superior over irrigation I_2 (lifesaving irrigation at 30 days interval). Number of fruits per plant and fruit yield in I_1 was 22.27% and 26.66% higher than I_2 (irrigation at 30 days interval). The varieties also significantly influenced fruits per plant and fruit yield. Significantly higher fruits per plant (352.83 Nos), fruit weight per plant (58.60 g), fruit yield per plant (20.76 kg /plant) and fruit yield per ha (5770 kg /ha) recorded in Gola variety.   This conforms with the studies performed by Baloda et al. [12] and Ibrahim et al. [13] who found 'Gola' had relatively high yield, big fruits and a high Total Soluble Solids (TSS).

Table 1. Quality of irrigation water used in the trial

Parameter	Maximum value	Minimum value	Average value
pH	8.87	7.47	8.17
EC (dSm^{-1})	1.91	1.11	1.51
Na$^+$ (meqL^{-1})	18.2	17	17.6
Ca$^+$ (meqL^{-1})	6.85	5.95	6.40
Mg$^+$ (meqL^{-1})	8.24	7.34	7.79
Cl$^-$ (meqL^{-1})	11.2	9.6	10.40
SO$_4^-$ (dSm^{-1})	11.5	10.1	10.80
HCO$_3^-$ (meqL^{-1})	4.3	3.2	3.75
SAR	6.63	6.59	6.61

Table 2. Effect of irrigations and varieties on growth of ber at fourth year

Treatments	Plant height (cm)	Girth (cm)	No. of branches	Dry leaf biomass (kg)	Dry shoot weight (kg)
Irrigations					
I_1	326.87	60.75	7.24	3.96	16.65
I_2	275.64	42.03	6.03	2.21	7.44
S. E. (m.+)	12.64	4.26	0.31	0.63	3.44
C.D. (P=0.05)	39.84	13.42	0.97	1.99	10.84
Varieties					
V_1 (Seb)	296.65	50.44	6.33	3.28	11.49
V_2 (Gola)	305.76	52.33	6.93	2.89	12.59
S. E. (m.±)	27.43	2.54	0.47	0.79	2.40
C.D. (P=0.05)	NS	NS	NS	NS	NS

S. E. (m.±): Standard Error of Mean, C.D. (P=0.05): Critical Difference

Table 3. Effect of irrigation and varieties on yield attributes and yield of ber at fourth year

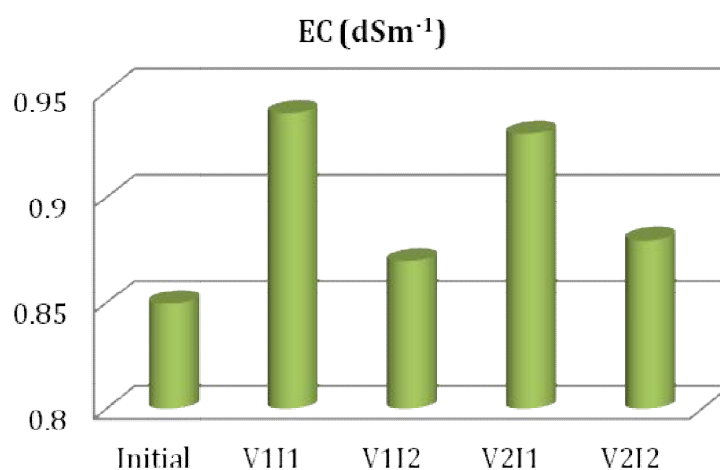| Treatments	Fruits per plant (No)	Fruit Weight (g)	Fruit Yield (kg/plant)	Fruit Yield (kg/ha)
Irrigations				
I$_1$	337.58	56.96	19.43	5400
I$_2$	276.08	55.37	15.34	4265
S. E. (m.±)	13.14	0.78	0.87	241
C.D. (P=0.05)	41.40	2.45	2.74	760
Varieties				
V$_1$ (Seb)	260.82	53.73	14.01	3894
V$_2$ (Gola)	352.83	58.60	20.76	5770
S. E. (m.±)	17.02	3.99	1.29	358
C.D. (P=0.05)	9.61	NS	4.69	1304

Fig. 2(a). Changes in soil EC after four years of experimentation
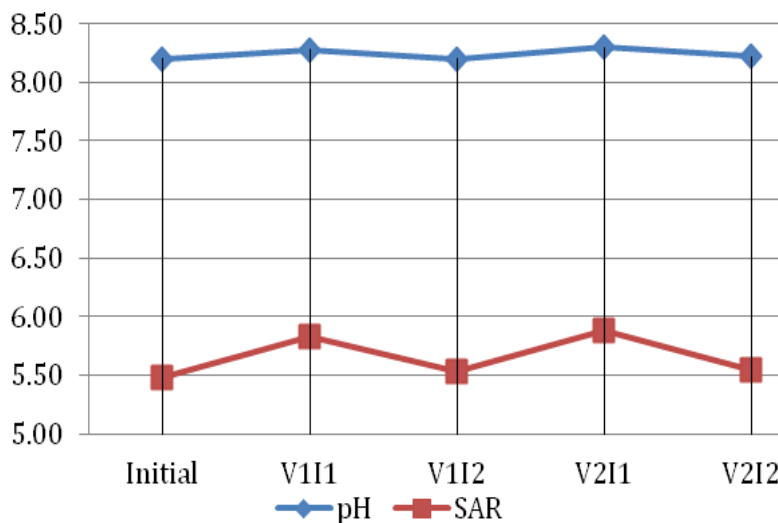

Fig. 2(b). Changes in soil pH and SAR after four years of experimentation

3.4 Effect of Irrigation on Soil Fertility Status

A data summarized in Fig. 2(a) and 2(b) indicated that frequent irrigation schedule increases the pH, Electrical Conductivity (EC) and Sodium Adsorption Ration (SAR) of soils against the initial value. The increases in parameters are irrespective of ber varieties under trial. Huang et al. [14] and Askri et al. [15] reported that frequent irrigation with saline water can accelerate the soil salinization process significantly, degrading the quality of soil in different ways. A high concentration of salt, especially sodium salt, in the soil can cause physicochemical deterioration of the soil. This can lead to structural damage to the soil due to the dispersion of clay particles, decreased soil hydraulic conductivity, soil instability due to the clogging of soil pores, and the formation of a thin crust at the surface of the soil, which reduces the rate of infiltration of irrigation water into the soil profile. This result is similar to a study by Singh et al. [16] have addressed the negative effect of saline irrigation water on soil physicochemical characteristics.

4. CONCLUSION AND RECOMMENDA-TION

The findings of the four years study showed that "Gola" variety is more suitable for central Gujarat agro climatic conditions with saline soils. The irrigation scheduling at 15 days interval has greater impact on growth and yield in both the varieties. However, the life saving irrigation at monthly interval has less salt accumulation, pH and sodium adsorption ratio (SAR) of soils.

The findings generated from the study may be limited to the specific environmental conditions of Central Gujarat. Nevertheless, experimental results clearly showed Gola variety of Ber performs better, suggesting its commercial cultivation. The ber growers could also be advised to adopt restrict irrigation scheduling to avoid salt accumulation in soil.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Pareek S, Yahia EM. Postharvest biology and technology of ber fruit. In: Horticultural Reviews (Editors: Jules Janick). Published by Wiley. 2013;41:200-240.
2. Singh A, Yadav RK. Nursery management in fruit crops in saltaffected soils. In book: Nursery management in fruit crops in salt affected soils. Publisher: ICAR-CSSRI, Karnal, Haryana; 2017.
3. Agrawal R, Gupta S, Gupta NK, Khandelwal SK, Bhargava R. Effect of sodium chloride on gas exchange, antioxidative defense mechanism and ion accumulation in different cultivars of Indian jujube (*Ziziphus mauritiana* L.). Photosynthetica. 2013;51:95-101.
4. Walkley AJ, Black IA. An estimation of the digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 1934;37:29-38.
5. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soils. Current Science. 1956;25:259 260.
6. Olsen SR, Cale CV, Watenable FS, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bicarbonate U.S. Dept., Agric. Circ. 1954;939.
7. Jackson ML. Soil chemical analysis-advanced course. 2nd Edition, 11th printing; 1985.
8. Richards LA. Diagnosis and improvement of saline and alkali soils. USDA Agricultural Handbook No. 60, US Department of Agriculture, Washington DC. 1954;160.
9. Dhyan Singh, Chhonkar PK, Dwivedi BS. Manual on soil, plant and water analysis. Westville Publishing House, New Delhi. 2005;1-200.
10. Sharma SK, Mendhe SN, Kolte HS, Rajput GR, Yenpreddiwar MD. Effect of sowing and irrigation management on growth and yield of mustard (*Brassica juncea*). J. Soil & Crops. 2006;16(2):455-459.
11. Meghwal PR, Kumar Pradeep. Effect of supplementary irrigation and mulching on vegetative growth, yield and quality of ber Indian J. Hort. 2014;71(4):571-573.
12. Baloda S, Sehrawat SK, Yadav BS, Ahlawat VP, Singh S. Present status of ber production and future thrusts in India – A review. Agricultural Reviews. 2012;33(3):256-264.
13. Ibrahim A, Pasternak D, Guimbo ID, Saidou AS, Amadou M. Rain-fed plantations of the domesticated *Ziziphus mauritiana* L. in the Sahel: Effects of varieties and rootstocks on yield and fruit

quality. Journal of Horticultural Research. 2015;23(1):33-38.

14. Huang CH, Xue X, Wang T, De Mascellis R, Mele G, You QG, Peng F, Tedeschi A. Effects of saline water irrigation on soil properties in northwest China. Environ Earth Sci. 2011;63:701–708.

15. Askri B, Ahmed AK, Abichou T, Bouhlila R. Effects of shallow water table, salinity and frequency of irrigation water on the date palm water use. J Hydrol. 2014;513:81–90.

16. Singh AP, Singh A, Tiwari HL, Dwivedi PK. The effect of salts of the hydraulic conductivity of the saline alkali soil. Indian J Sci Res. 2011;4:117–119.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/59255