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

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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...
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.

Keywords: Irrigation; varieties; ber; electrical conductivity; sodium adsorption ratio.

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 KMnO₄ 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].

\[
\text{SAR} = \frac{\text{Na}}{\sqrt{(Ca+Mg)/2}}
\]

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 (HCO₃⁻) ions in the water sample were determined by titrating it against H₂SO₄. Cations like Ca²⁺, Mg²⁺ and Na⁺ was determined with 0.01N EDTA titration method. The Cl⁻ contents by Mohr’s titration method and SO₄²⁻ by turbid metric method.
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 I₁ (irrigation at 15 days interval) and I₂ (irrigation at 30 days interval). The sub-plots comprised of two varieties V₁ (Seb) and V₂ (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),
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 I₁ (irrigation at 15 days interval), which was significantly superior over irrigation I₂ (lifesaving irrigation at 30 days interval). Number of fruits per plant and fruit yield in I₁ was 22.27% and 26.66% higher than I₂ (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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum value</th>
<th>Minimum value</th>
<th>Average value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.87</td>
<td>7.47</td>
<td>8.17</td>
</tr>
<tr>
<td>EC (dSm⁻¹)</td>
<td>1.91</td>
<td>1.11</td>
<td>1.51</td>
</tr>
<tr>
<td>Na⁺ (meqL⁻¹)</td>
<td>18.2</td>
<td>17</td>
<td>17.6</td>
</tr>
<tr>
<td>Ca²⁺ (meqL⁻¹)</td>
<td>6.85</td>
<td>5.95</td>
<td>6.40</td>
</tr>
<tr>
<td>Mg²⁺ (meqL⁻¹)</td>
<td>8.24</td>
<td>7.34</td>
<td>7.79</td>
</tr>
<tr>
<td>Cl⁻ (meqL⁻¹)</td>
<td>11.2</td>
<td>9.6</td>
<td>10.40</td>
</tr>
<tr>
<td>SO₄²⁻ (dSm⁻¹)</td>
<td>11.5</td>
<td>10.1</td>
<td>10.80</td>
</tr>
<tr>
<td>HCO₃⁻ (meqL⁻¹)</td>
<td>4.3</td>
<td>3.2</td>
<td>3.75</td>
</tr>
<tr>
<td>SAR</td>
<td>6.63</td>
<td>6.59</td>
<td>6.61</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Girth (cm)</th>
<th>No. of branches</th>
<th>Dry leaf biomass (kg)</th>
<th>Dry shoot weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I₁</td>
<td>326.87</td>
<td>60.75</td>
<td>7.24</td>
<td>3.96</td>
<td>16.65</td>
</tr>
<tr>
<td>I₂</td>
<td>275.64</td>
<td>42.03</td>
<td>6.03</td>
<td>2.21</td>
<td>7.44</td>
</tr>
<tr>
<td>S. E. (m.±)</td>
<td>12.64</td>
<td>4.26</td>
<td>0.31</td>
<td>0.63</td>
<td>3.44</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>39.84</td>
<td>13.42</td>
<td>0.97</td>
<td>1.99</td>
<td>10.84</td>
</tr>
<tr>
<td>Varieties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V₁ (Seb)</td>
<td>296.65</td>
<td>50.44</td>
<td>6.33</td>
<td>3.28</td>
<td>11.49</td>
</tr>
<tr>
<td>V₂ (Gola)</td>
<td>305.76</td>
<td>52.33</td>
<td>6.93</td>
<td>2.89</td>
<td>12.59</td>
</tr>
<tr>
<td>S. E. (m.±)</td>
<td>27.43</td>
<td>2.54</td>
<td>0.47</td>
<td>0.79</td>
<td>2.40</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

*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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruits per plant (No)</th>
<th>Fruit Weight (g)</th>
<th>Fruit Yield (kg/plant)</th>
<th>Fruit Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I&lt;sub&gt;1&lt;/sub&gt;</td>
<td>337.58</td>
<td>56.96</td>
<td>19.43</td>
<td>5400</td>
</tr>
<tr>
<td>I&lt;sub&gt;2&lt;/sub&gt;</td>
<td>276.08</td>
<td>55.37</td>
<td>15.34</td>
<td>4265</td>
</tr>
<tr>
<td>S. E. (m±)</td>
<td>13.14</td>
<td>0.78</td>
<td>0.87</td>
<td>241</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>41.40</td>
<td>2.45</td>
<td>2.74</td>
<td>760</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Varieties</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;1&lt;/sub&gt; (Seb)</td>
<td>260.82</td>
<td>53.73</td>
<td>14.01</td>
<td>3894</td>
</tr>
<tr>
<td>V&lt;sub&gt;2&lt;/sub&gt; (Gola)</td>
<td>352.83</td>
<td>58.60</td>
<td>20.76</td>
<td>5770</td>
</tr>
<tr>
<td>S. E. (m±)</td>
<td>17.02</td>
<td>3.99</td>
<td>1.29</td>
<td>358</td>
</tr>
<tr>
<td>C.D. (P=0.05)</td>
<td>9.61</td>
<td>NS</td>
<td>4.69</td>
<td>1304</td>
</tr>
</tbody>
</table>

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

EC (dSm<sup>-1</sup>)

Initial | V111 | V112 | V211 | V212

5.00 | 5.50 | 6.00 | 6.50 | 7.00 | 7.50 | 8.00 | 8.50

pH | SAR

- **EC (dSm<sup>-1</sup>):**
  - Initial: 0.83, 0.85, 0.88, 0.90
  - V111: 0.92, 0.94, 0.96, 0.98
  - V112: 0.88, 0.90, 0.92, 0.94
  - V211: 0.90, 0.92, 0.94, 0.96
  - V212: 0.86, 0.88, 0.90, 0.92

- **pH:**
  - Initial: 6.5
  - V111: 6.8
  - V112: 6.7
  - V211: 6.6
  - V212: 6.5

- **SAR:**
  - Initial: 2.0
  - V111: 2.1
  - V112: 2.2
  - V211: 2.3
  - V212: 2.4
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 Ratio (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 RECOMMENDATION

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

