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# Effect of saline water irrigation through drip method on yield of okra and salt build-up in sandy soil of western Rajasthan

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**Abstract**

Effect of saline water irrigation on Okra through drip system was evaluated on sandy soils having high hydraulic conductivity (7.2-7.9 cmh$^{-1}$) and low moisture holding capacity (6.18 cm m$^{-1}$). Maximum yield of Okra (4.80 t/ha) was recorded at ECiw 3.0 dSm$^{-1}$ with drip irrigation method. Irrigation with saline water 6.0 dSm$^{-1}$ drastically decreased the yield (2.97 t/ha) and yield attributes of crop. Looking to the average yield of all three years under ECiw 0.25, 3.0 and 6.0 dSm$^{-1}$ treatments drip method was superior with 50.37 % higher yield compared to flood irrigation method. The increasing levels of salinity of irrigation water increased the $EC_e$ of soil profile. The salinization pattern in soil with saline water irrigation under drip system showed that the zone of minimum salt accumulation existed just below the emitters. The salt concentration in soil profile increased with increase in lateral as well as vertical distance from the emitters. This is due to differences in moisture content of ponded, wetted and wetting zone of area irrigated by a particular emitter. The ponded zone had always higher moisture both laterally and vertically which started decreasing toward wetted zone with minimum at the end of wetting zone. This moisture variation caused movements of salts from the near vicinity of emitter, creating comparatively much less saline zone (ECe 1.30 dSm$^{-1}$with ECiw 6.0 dSm$^{-1}$) in which root performed their activity providing better growing conditions. Salt concentration was highest (ECe 2.71) at 30 cm distance from emitter with saline water irrigation of ECiw 6.0 dSm$^{-1}$.

**Key words:** Okra, Saline water, Drip irrigation, Salt build-up

## Introduction

Okra (*Abelmoschus esculentus* L.) is one of the important vegetables grown throughout the tropics and subtropics. India is the topmost country, producing 4.18 million tonnes of okra annually, which is around 70% of global okra production (FAO, 2008). The nutritional value of 100 g of edible portion of okra contains 1.9 g protein, 0.2 g fat, 6.4 g carbohydrate, 0.7 g minerals and 1.2 g fiber (Gopalan *et al.*, 1989). The crop is also used in paper industry as well as for the extraction of fiber. Okra has a great scope in world trade. The crop is grown year round under varied soil and climatic conditions of India.

The sustainable use of scarce water resources in western Rajasthan is a priority for agricultural development. Further, in arid areas the underground water is saline in nature (> 1.5 dSm$^{-1}$) and its quality ranges from marginal (1.5 to 3.0 dSm$^{-1}$) to highly saline (> 6.0 dSm$^{-1}$). The agricultural and horticultural activities in the area are limited and on small commercial basis. Vegetables like okra, gourds, spinach, cauliflower, green chillies, radish and brinjal etc. are grown on small scale. The pressure of using water in agriculture sector is increasing to create ways to improve water use efficiency and taking a full advantage of available water. Therefore, adoption of modern irrigation techniques is needed to be emphasized to increase water use efficiency. Further, drip irrigation makes cultivation of saline land possible and makes saline water usable for irrigation. Today drip irrigation irrigates more than 55,000 ha. in India. However, as the underground water is saline which ranges from marginal to hazardous quality should be used for cultivation of vegetable crops through conducting research. Thus, keeping in view the importance and benefits of drip irrigation and to use marginal quality ground water for growing okra in the arid area, this research study was formulated and conducted to achieve the objectives.

## Material and Methods

To evaluate the effect of saline water irrigation on okra crop and to determine the salinization pattern under drip irrigation a field experiment was conducted at Agricultural Research Station, Bikaner in kharif seasons from 2006 to 2008. 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 8.30 and 0.51 to 0.74 dSm$^{-1}$, respectively up to 30 cm depth. Organic carbon content was very low (0.08 %). Available nitrogen (115.0 kg N/ha), available phosphorus (17.2 kg $P_2O_5$/ha) and potash (205 kg $K_2O$/ha) was also of low magnitude. The texture of the soil was sand, and the hydraulic

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conductivity ranged from 7.6 to 7.9 cm $h^{-1}$ thus, the drain ability of these soils is high whereas, the water holding capacity was only 6.23 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 90.1 to 86.4, 2.1 to 3.6 and 6.4 to 5.9 per cent in the soil profile, respectively.

Treatments comprised of three salinity levels of irrigation water (EC 0.25, 3.0 and 6.0 $dSm^{-1}$) under two methods of irrigation i.e. drip and flood. The experiment was laid out in factorial randomized block design with three replications in plot size of 3m X 3m. The drip lateral was installed in the centre of each plot with on line drippers (PC types) of 4.0 lph discharge. The healthy seeds of okra high variety Malav-27 were sown by dibbling method with spacing 60 x 30 cm in the last week of June during all three years of experimentation. The standard recommended agronomic practices were followed. In order to maximize the yield about 10 t of FYM and recommended dose of fertilizer (80 kg Nitrogen, 60 kg $P_2O_5$ and 75 kg $K_2O$/ha.) was applied. Nitrogen was applied through fertigation in three split doses.

Sintex tanks of 1000 litres capacity each were used to supply water of required salinity. The water available from the tube well was used as basic source of saline water having EC 4.1 $dSm^{-1}$. The required salinity was achieved by adding the pre calculated amount of salts (Table 1). Sodium was the dominant cation, whereas, chloride was the dominant anion. The SAR, Mg : Ca ratio and Cl : $SO_4$ ratio of 3.0 and 6.0 $dSm^{-1}$ irrigation water was 14.10 and 19.64, 3.0 and 2.8, 2.88 and 2.74, respectively.

Around sixteen irrigations were given each year. Twelve to thirteen pickings of fruits were done up to first week of December. The treatments were evaluated in terms of yield and yield attributing parameters. For analysis of salinity build up in soil profile due to saline water irrigation under drip and flood methods, soil samples were also taken at three points which were located horizontally at 0, 15 and 30 cm apart from the either side of emitter. At each of these three locations soil samples were collected from four depths i.e. 0-15, 15-30 and 30-45 cm. Similarly, in case of flood irrigation soil samples were taken from the same three depths but at only one location. Soil samples were collected at sowing and harvesting of crop and analyzed as per method outlined by Richards (1954).

## Results and Discussion

### Yield and Yield attributes

The yield data of three year from 2006 to 2008 presented in Table 2 showed that average fruit yield of okra was significantly influenced by salinity of water as well as method of irrigation. Significantly higher yield was observed under drip irrigation which was 66.5 per cent higher compared to flood method of irrigation. Singh *et al. (2004)* also reported 40% reduction in yield of tomato at ECiw 8.0 $dSm^{-1}$ in *rabi* season. Kadam and Kartikeyan (2004) also advocated superiority of drip method over surface method. Similarly, Tiwari *et al.* 1998a in tomato, Tiwari *et al.* 1998b in okra and Tiwari *et al.* 2003 in cabbage recorded significantly higher yields under drip method of irrigation.

As regards salinity of water maximum yield was observed with water having ECiw 3.0 $dSm^{-1}$ which was at par with canal water irrigation (0.25 $dSm^{-1}$). A significant decrease in yield was observed at ECiw 6.0 $dSm^{-1}$ (2.51t/ha) which was 65.5 and 70.1 per cent lower than ECiw 0.25 and 3.0 $dSm^{-1}$ respectively. The interaction between method of irrigation and salinity of water was also significant (Table 3). Maximum yield of okra 4.79 t/ha was observed under drip with ECiw 3.0 $dSm^{-1}$ which was significantly higher compared to rest of the treatments. Minimum yield of 2.04 t/ha was recorded under flood with ECiw 6.0 dS $m^{-1}$. Singh and Singh (1978) reported that drip method resulted in increased yields in case of long gourd, round gourd and water melon by 41-47 % when same level of saline water is used.

Like yield, yield parameters were also recorded of higher values under drip method compared to flood method of irrigation. Under drip method average plant height (68.61 cm) and average number of fruits per plant (19.02) were recorded which were 84.1 and 76.1 per cent higher compared to flood method of irrigation. Under different salinity levels maximum plant height (68.05 cm) and no. of fruits (18.45) were recorded with 3.0 $dSm^{-1}$ water, however, it was at par with 0.25 $dSm^{-1}$ water. A significant decrease in plant height and no. of fruits was observed at ECiw 6.0 $dSm^{-1}$ which was 80.2 and 81.6 percent lower for plant height and 76.3 and 79.4 per cent lower for no. of plants than ECiw 0.25 and 3.0 $dSm^{-1}$ respectively. (Table 2).

### Water Use Efficiency

Maximum water use was observed in flood method of irrigation which was 31.98 % higher than drip method of irrigation. The highest mean water use efficiency of 83.2 kg/ha-cm was observed with ECiw 3.0 $dSm^{-1}$ under drip method of irrigation whereas, the lowest mean water use efficiency of 25.9 kg/ha-cm was observed with ECiw 6.0 $dSm^{-1}$ under flood irrigation method (Table 4). Drip irrigation is the most effective way to apply directly water and nutrients to plants and not only save water but also increases yields of vegetable crops (Tiwari *et al.*, 1998a,b; Tiwari *et al.*, 2003). In a FAO report (1997), it has been stated that major benefit of drip irrigation is its high water application efficiency which can reach values of 90%, although 80% is practicable. This can be compared with surface irrigation schemes which normally have an efficiency of 50%.

### Salinity build-up

The resulting ECe at harvest as affected by salinity levels of irrigation water in 0-45 cm soil profile at 0, 15 and 30 cm lateral distances from the emitter are shown in Table 5. In general, the soil salinity increased

with increase in salinity of irrigation water at all depths and locations. With 3.0 $dSm^{-1}$ water irrigation the resultant ECe in the soil profile ranged from 0.94 to 1.85 $dSm^{-1}$ whereas, with 6.0 $dSm^{-1}$ water irrigation the resultant ECe in the soil profile ranged from 1.30 to 2.71 $dSm^{-1}$. Zone of minimum salt concentration existed just below the emitter in studied soil profile (ECe 0.94 and 1.30 $dSm^{-1}$ with 3.0 and 6.0 ECiw, respectively. The trend clearly indicate that the salt concentration in soil profile increased with increase in lateral as well as vertical distance from the emitters. This was due to differences in moisture content of ponded, wetted and wetting zone of area irrigated by a particular emitter. The ponded zone had always higher moisture both laterally and vertically which started decreasing as one moved toward wetted zone with minimum at the end of wetting zone. This moisture variation caused movements of salts from the near vicinity of emitter, creating comparatively much less saline zone (ECe 1.30 $dSm^{-1}$ with ECiw 6.0 $dSm^{-1}$) in which root performed their activity. In other words it can be inferred that the salts were leached away from the active root zone of plant providing better growing conditions. Salt concentration was highest at 30 cm distance from emitter (ECe 2.39, 2.63 and 2.71 $dSm^{-1}$ at 0-15, 15-30 and 30-45 cm depth respectively with ECiw 6.0 $dSm^{-1}$). This may be due to the fact that salts had moved with water away from active root zone. Thus, it can be concluded that Okra can be grown successfully with moderate saline water up to 3.0 $dSm^{-1}$ on sandy soils of western Rajasthan under drip method of irrigation.

Table 1: Composition of ions of irrigation waters used to irrigate okra crop

| S No | Characteristics | Unit | ECiw ($dSm^{-1}$) | | |
|---|---|---|---|---|---|
| | | | 0.25 | 3.0 | 6.0 |
| 1 | $Ca^{2+}$ | me $l^{-1}$ | 0.8 | 2.0 | 4.2 |
| 2 | $Mg^{2+}$ | me $l^{-1}$ | 0.9 | 6.0 | 11.8 |
| 3 | $Na^{+}$ | me $l^{-1}$ | 0.8 | 22.0 | 44.0 |
| 4 | $CO_{3^{2-}}+HCO_{3^-}$ | me $l^{-1}$ | 1.2 | 4.0 | 8.0 |
| 5 | $Cl^-$ | me $l^{-1}$ | 0.7 | 19.3 | 38.1 |
| 6 | $SO_{4^-}$ | me $l^{-1}$ | 0.6 | 6.7 | 13.9 |
| 7 | SAR | - | 0.87 | 14.10 | 19.64 |
| 8 | $Cl : SO_4$ | - | 1.16 | 2.88 | 2.74 |
| 9 | Mg : Ca | - | 1.12 | 3.0 | 2.8 |

Table 2: Effect of different salinity levels of irrigation water on yield and yield attributes of okra under drip and flood irrigation

| Treatments | Okra yield (t/ha) | | | | Plant Height (cm) | | | | No. of Fruits/plant | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | Mean | 2006 | 2007 | 2008 | Mean | 2006 | 2007 | 2008 | Mean |
| Irrigation Methods | | | | | | | | | | | | |
| $M_1$ - Drip | 3.19 | 4.96 | 3.76 | 3.97 | 61.63 | 68.77 | 75.43 | 68.61 | 16.13 | 20.73 | 20.20 | 19.02 |
| $M_2$ - Flood | 1.62 | 3.76 | 2.54 | 2.64 | 49.83 | 58.63 | 64.67 | 57.71 | 13.43 | 16.10 | 13.87 | 14.47 |
| SEm ± | 0.10 | 0.16 | 0.16 | 0.08 | 1.26 | 1.43 | 1.63 | 0.83 | 0.44 | 0.69 | 0.96 | 0.42 |
| CD at 5% | 0.32 | 0.49 | 0.51 | 0.24 | 3.97 | 4.49 | 5.12 | 2.41 | 1.40 | 2.18 | 3.02 | 1.22 |
| Salinity Levels ($dSm^{-1}$) | | | | | | | | | | | | |
| $S_1$ - 0.25 | 2.53 | 4.59 | 3.62 | 3.58 | 61.10 | 68.20 | 71.30 | 66.87 | 15.75 | 19.90 | 17.50 | 17.72 |
| $S_2$ - 3.0 | 2.82 | 5.09 | 3.58 | 3.83 | 60.20 | 68.80 | 75.15 | 68.05 | 16.10 | 19.45 | 19.80 | 18.45 |
| $S_3$ - 6.0 | 1.87 | 3.41 | 2.25 | 2.51 | 45.90 | 54.10 | 63.70 | 54.57 | 12.50 | 15.90 | 13.80 | 14.07 |
| SEm ± | 0.12 | 0.19 | 0.20 | 0.10 | 1.54 | 1.75 | 1.99 | 1.02 | 0.54 | 0.85 | 1.17 | 0.52 |
| CD at 5% | 0.39 | 0.60 | 0.63 | 0.29 | 4.87 | 5.50 | 6.28 | 2.95 | 1.71 | 2.68 | 3.70 | 1.49 |

Table 3: Interactive effect of methods of irrigation and salinity of water on Okra yield (t/ha) on pooled basis (three years)

| Treatment | Irrigation Methods | |
|---|---|---|
| Salinity Levels ($dSm^{-1}$) | Drip ($M_1$) | Flood ($M_2$) |
| $S_1$ - 0.25 | 4.14 | 3.01 |
| $S_2$ - 3.0 | 4.79 | 2.87 |
| $S_3$ - 6.0 | 2.98 | 2.04 |
| | S.Em. ± | C.D. (5%) |
| Method | 0.08 | 0.24 |
| Salinity | 0.10 | 0.29 |
| M x S | 0.14 | 0.41 |

Table 4: Water Use (mm) and WUE (Kg/ ha /cm) through drip and flood method (Average of three years)

| Treatments | Water Use (mm) | | | | WUE (Kg/ ha-cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | Mean | 2006 | 2007 | 2008 | Mean |
| Drip method ECiw ($dSm^{-1}$) | | | | | | | | |
| 0.25 | 583 | 641 | 566 | 597 | 57.6 | 76.7 | 73.3 | 69.2 |
| 3.0 | 566 | 611 | 543 | 574 | 66.8 | 101.1 | 81.8 | 83.2 |
| 6.0 | 596 | 652 | 586 | 611 | 41.1 | 58.1 | 45.9 | 48.4 |
| Average | 581 | 634 | 565 | 594 | 55.2 | 78.6 | 67.0 | 66.9 |
| Flood method ECiw ($dSm^{-1}$) | | | | | | | | |
| 0.25 | 760 | 810 | 745 | 771 | 22.4 | 52.6 | 41.3 | 38.8 |
| 3.0 | 790 | 835 | 760 | 795 | 23.8 | 47.9 | 35.8 | 35.8 |
| 6.0 | 775 | 790 | 787 | 784 | 16.6 | 38.2 | 23.0 | 25.9 |
| Average | 775 | 812 | 764 | 783 | 20.9 | 46.2 | 33.4 | 33.5 |

Table 5: Salinity (ECe) build -up in the soil profile with saline water irrigation through drip system after harvesting of okra

| Distance from emitter (cm) | Soil depth (cm) | ECiw ($dSm^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Drip | | | Flood | | |
| | | 0.25 | 3.0 | 6.0 | 0.25 | 3.0 | 6.0 |
| 0 cm distance from emitter (Just below emitter) | 0 15 | 0.45 | 0.94 | 1.30 | 0.53 | 1.21 | 1.63 |
| | 15 30 | 0.51 | 1.39 | 1.69 | 0.62 | 1.59 | 2.17 |
| | 30 - 45 | 0.53 | 1.56 | 2.11 | 0.71 | 1.80 | 2.90 |
| 15 cm distance from emitter | 0 15 | 0.58 | 1.08 | 1.83 | | | |
| | 15 30 | 0.63 | 1.51 | 2.07 | | | |
| | 30 - 45 | 0.67 | 1.71 | 2.34 | | | |
| 30 cm distance from emitter | 0 15 | 0.60 | 1.39 | 2.39 | | | |
| | 15 30 | 0.58 | 1.84 | 2.63 | | | |
| | 30 - 45 | 0.70 | 1.85 | 2.71 | | | |

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