REVIEW ARTICLE

SALINE WATER IRRIGATION USING DRIP IRRIGATION

Narender Kumar[1], Ashish Kumar[1]*, Amandeep Singh[1], Ajay Kumar[1], Aman Mor[1] and Satish Manda[2]

[1]College of Agricultural Engineering & Technology, CCS Haryana Agricultural University, Hisar, Haryana, India
[2]Maharana Pratap Horticultural University, Karnal, Haryana, India
Email: kamboashish@gmail.com

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Abstract: Good quality water is very limited constraint available on the earth for the agriculture production. With this limited resource, it is very impossible to get food security for world population. Saline water irrigation resources are very much available on the earth and can be used as irrigation. Without proper management, saline water irrigation built the salt in the agriculture field. Saline water irrigation with the use of drip irrigation system can be a solution for crop production. Cultivars of different varieties also gave a good response with saline water. Under shallow water condition, saline water irrigation with drip irrigation provide good soil environment and produce yield. Draught condition is very prevalent and occurs frequently from the previous decade and crop production is also stunted. Review is done from the previous research under various condition of saline water irrigation. Here, number of works done by researcher shows that even with saline water healthy yield of crop production can be obtained.

Keywords: Saline water, Drip irrigation, Crop production, Draught condition, Management practices

INTRODUCTION

Irrigation is essential for crop production in arid and semi-arid regions. However, it is being felt that the irrigated agriculture is facing the problem of water scarcity. Not enough water of good quality is available to irrigate whole of cropped area of our country. Over the years, several methods of on farm water application have been developed and tested. Broad categories of on farm water application method include surface methods subsurface methods (Davis, 1967) and pressurized (micro and sprinkler) irrigation methods (Keller and Bliesner, 1990). Among different method of water application, drip irrigation is considered as one the most efficient method of water application under saline water conditions. As a result, drip irrigation is being promoted as a solution to the problems of irrigation water scarcity and irrigation water quality. Several studies have successfully demonstrated the capability of drip irrigation to achieve higher crop production than traditional irrigation systems while using less water and saline quality water. Water saving in drip irrigation method is due mainly to the controlled application of water in limited part of the total field, as compared to surface and sprinkler irrigation methods. Drip irrigation only partly wets the soil root zone. This may be as low as 30 % of the volume of soil wetted by the other methods. In the current water crisis situation, sufficiently available fresh water recourses are becoming the binding constraint for food production. Therefore, it is imperative to use saline quality water for irrigation. However, it is important to know that development of excess soil salinity in the root zone, as result of use of saline water, may also inhibit normal crop growth and development (Kelley, 1951). Drip irrigation is also considered a suitable option to utilize marginal quality water for crop production due to movement of salt away from effective root zone. Irrigation with poor quality groundwater, if feasible, can reduce the demand of fresh water for irrigation, can help reduce volume of drainage effluents, and may help to check rise of saline groundwater table thereby reducing the risk of secondary soil salinization in affected areas.

Irrigation using saline water

Type of soil is the main constraint to use the saline water irrigation. Experiment conducted by Katerji *et al.* (1998) studied the response of tomatoes to different salinity level of irrigation water (0.9, 2.3 and 3.6 dS/m) in loam and clay soil. As the salinity of irrigation water increased fruit weight, number of fruits per plant and average fruit weight decreased in loam and clay soil. Maximum water use efficiency was observed with the use of fresh water in both loamy soil (8.65 kg/m^3) and clay soil (7.96 kg/m^3). Evapotranspiration rate is also reducing with irrigation with saline water irrigation (Minhas *et al.*, 2020). Evapotranspiration (708 mm) was observed from loam soil irrigated with fresh water (0.9 dS/m) and evapotranspiration (523 mm) was observed from clay soil irrigated with saline water (3.6 dS/m) during crop period of tomato crop (Katerji *et al.*, 1998). Fruit yield and number of fruits is more on the fresh water irrigation than the saline water irrigation (Malash *et al.*, 2005). Fruit yield (6.12 kg/m^2), number of fruits per plant (48.0) and average fruit weight (36.0 g) of tomatoes was observed in irrigation with fresh water (0.9 dS/m) as compare to saline water (2.3 and 3.6 dS/m) (Katerji *et al.*, 1998).
Irrigation with good quality water enhances the yield and but saline water enhances quality of fruits (El-

*Corresponding Author

moggy *et al*., 2018). A field experiment was conducted by Kadam and Patel (2001) to determine the effect of saline water through drip irrigation system on yield and quality of tomato. Maximum tomato yield (39.33 t/ha) was observed with good quality water (EC = 0.21 dS/m) and minimum tomato yield (29.90 t/ha) was observed with saline water (EC= 5.0 dS/m). Acidity (0.51 to 0.69 %), total soluble solid (4.20 to 5.22 %) and lycopene contents (1.65 to 2.47 mg/100g) of tomato increased with increase in salinity of water but the pH of fruit juice (5.22 to 5.08) decreased with increased water salinity (Kadam and Patel, 2001). Boamah *et al*. (2011) studied the effect of salinity level of irrigation with pond (0.25 dS/m), well (0.07 ds/m) and tap (0.02 ds/m) water on tomato crop. Flowering and yield of tomato was high with crops treated with well water (45.2 %; 99.1 kg/ha) followed by the pond (27.7 %; 43.8 kg/ha) and tap water (27.1%; 27.3 kg/ha). There was a significant difference in yield between well, pond and tap irrigation water. Soomro *et al*. (2012) studied the effects of good quality water (0.5 dS/m) and marginal quality groundwater (2.9 dS/m) on crop yield and water use efficiency in Okra. Higher crop yield and higher water use efficiency (18.90 t/ha and 2.7 kg/m^3) were recorded under fresh water over ground water (16.96 t/ha and 2.4 kg/m^3) respectively. WUE was more in fresh water (2.7 kg/m^3) and less in marginally quality water (2.4 kg/m^3). Plant height and girth was more in fresh water (91.2 cm and 4.8 cm) than marginally quality water (89.9 cm and 4.2 cm).

Cultivars grown in saline water irrigation

Cultivars under green house with saline water irrigation also show various yield and growth (Ahmadi and Ardekani, 2006). Two tomato cultivars (Daniela and Moneymaker) were taken by Romero-Aranda *et al*. (2001) to conducted experiment with saline water (0, 35 and 70 mM NaCl) irrigation. Irrigation with fresh water (0 mM NaCl) on Daniela cultivar shows maximum dry weight (30.2 g) maximum height (143 cm) and maximum number of leaves (17) as compare to saline water irrigation. Moneymaker cultivars also show the good response with fresh water (0 mM NaCl). Maximum height (116 cm) and maximum number of leaves (17) as compare to saline water irrigation. Incrocci *et al*. (2006) conducted experiment in the spring of 2002 and 2004 with tomato plants grown in glasshouse in pots filled with peat-perlite substrate (soil less culture). Irrigation was applied by conventional drip irrigation (D) or by sub-irrigation (S) methods. Plants were fed with nutrient solution. Nutrient solution was replaced, when electrical conductivity of water exceeded 6.0 dS/m. Leaf area index was higher in D (4.25) than S (4.01). There was no significant difference in fruit yield in D (10.9 kg/m^2) and S (10.6 kg/m^2) irrigation methods. Al-Busaidi *et al*. (2010) conducted a pot experiment to study the response of saline water on different varieties of tomato (4, 22, 38, 46 & 54). Salinity water used included fresh water, 3 dS/m and 6 dS/m. With high salinity water (6 dS/m) varieties number 38 and 46 gave relatively higher values for fruits number and weight (33, 17 and 555.2 g, 344 g). Fresh water showed good result of plant height, leaf area, fruit weight for each variety. In 3 dS/m water, variety 4 and 46 give maximum plant height (169.3 cm). However maximum number of fruit (36) was in variety 38. Variety 38 gave good result in each treatment of saline water and fresh water. Variety number 38 showed an optimistic response to saline irrigation by producing more yield.

Management practice also play an important role for growing crop under saline water irrigation. Without management practice loss of crop, fertilizer and soil structure can be occurred. Gawad *et al*. (2005) conducted experiments on different tomato varieties irrigated with saline water with various irrigation management practices during 1999-2002. First growing season (1999) experiments showed a significance difference between yield of hybrid varieties (Sunrise and Sun hybrid) and local varieties (Homs, Kamal, Hama, Deir, Mora, Dara, Aleppo and Raqqa) with three qualities (0.6, 6.0 and 9.0 dS/m) of water. Higher yield was obtained with 0.6 dS/m water in each variety as compare to 6.0 and 9.0 dS/m water. Drip irrigation provide higher water use efficiency, thus save a healthy amount of water as compare to furrow irrigation (Hanson and May, 2004). Tomato yield under drip irrigation gave higher yield than traditional furrow method with all six water qualities (0.6, 2.3, 4.0, 6.0, 7.5 and 9.0 dS/m) (Gawad *et al*., 2005).

Gawad *et al* ,2005 conducted another experiment in 2000 high salinity tolerance tomato variety (Floradade) with two irrigation management practices (continuous and alternating), two irrigation methods (drip and furrow) and six irrigation water salinity (0.6, 2.3, 4.0, 6.0, 7.5 and 9.0 dS/m). Fresh water (0.6 dS/m) gave significantly higher yield in each treatment as compared to other treatments. Maximum yield was obtained with irrigation water (0.6 dS/m) with alternate drip irrigation. Tomato yield decreased significantly with increased salinity of irrigation water. In third growing season (2002), field experiment was conducted on hybrid tomato variety (Floradade) with two irrigation management practices (continuous and alternating), two irrigation methods (drip and furrow) and four water qualities (~1.24, ~3.63, ~5.55 and ~7.54 dS/m). Furrow irrigation used about 60 % more water than drip irrigation while yield obtained under drip irrigation was significantly higher than that under furrow irrigation. Reina-Sanchez *et al*. (2005) studied the effect of saline water (1.9, 4.7, 7.1 and 9.1 dS/m) on four cultivars (L1, L5, L9 and Floradade) of tomato under greenhouse. Yield decreased with increasing salinity of irrigation water. Average yield reduction for the four cultivars was 295 g/dS/m. Maximum fruit yield for Floradade, L1, L5, L9 (2789, 3310, 3432 and 3170 g/plant) was observed in irrigation with 1.9 dS/m water and minimum yield (882, 1043, 1343 and 815 g/plant) for the respective cultivars was observed for irrigation with saline water (9.1 dS/m) irrigation.

Saline water irrigation under shallow water condition

Drip irrigation promises the saving of huge amount of water (Venot *et al*., 2014). Irrigation with saline water develops the salt in the field which diminish structure of the soil (Asfaw *et al*., 2018). Under shallow water condition, controlled application of water with drip irrigation provides good rootzone environment and resulting to good yield (Ghrab *et al*., 2013). Watermelon was grown by Tingwu *et al*. (2003) by using saline water through drip irrigation under shallow water table condition. Irrigation water was applied through drip irrigation equivalent to 30%, 60%, and 90% of evaporation from Chinese evaporation pan. Highest yield (50.4 t/ha) was observed with irrigation scheduled at 60% of pan evaporation and least yield (39.4 t/ha) was observed with irrigation scheduled at 90% of pan evaporation. Optimum irrigation is very important under saline water irrigation. Irrigation scheduled at 30% of pan evaporation resulted into significantly higher salt accumulation as compare to 60% and 90% of pan evaporation. Lower yield of watermelon under 90 % and 30 % pan evaporation treatment was attributed to poor aeration and soil nutrient leaching. The quality of watermelon also improved under drip irrigation with best quality under 60 % irrigation treatments (Tingwu *et al*. 2003).

Saline water irrigation in draught condition

Drought and Salinity are the most common environmental factors that stunted plant growth and yield in agricultural crops (Khan *et al*., 2017). Approximately 40% of the world's available land is affected by draught and climate change and weather pattern may lead to extreme temperatures is predicted to cause severe prolonged drought in some areas (Zhang *et al*., 2014). Research conducted by Maggio *et al*. (2005) to study the effect of drought and salinity stress on cabbage. Irrigation treatment consisted of non-irrigated control (NIC), non-salinized control (NSC, ECw = 0.5 dS/m) and two levels of irrigation water salinity (ECw of 4.4 & 8.5 dS/m). Drought stress decreased the total head yield from 50.5 t/ha (NSC) to 17.5 t/ha (NIC). The reduced yield was mainly due to reduced head size rather than head number

Saline water irrigation in sub humid condition

Generally, practice in the highly vulnerable semiarid zone consists of copying the same practices of more humid zones. In humid and sub-humid areas water availability is sufficient to allow sprinkler irrigation, which together with the seasonal rainfall is enough to leach the excess salts. Little attention, however, is paid to the vulnerability of groundwater resources. In sub humid region, practices should be done to consider the groundwater availability. A experiment was conducted by Wan *et al*. (2007) to studied the effect of drip irrigation with saline water on tomato yield and water use in sub-humid area of China. Six treatments of irrigation water with average salinity level of 1.1, 2.2, 2.9, 3.5, 4.2 and 4.9 dS/m were designed. Saline water application initiated about 30 day after transplant. Prior to treatment initiation only fresh water was applied. Irrigation was applied only when the soil metric potential at 0.2 m depth reduced to -20 kpa. When saline water was applied, surplus water was added to provide a leaching fraction. As noted earlier, water was applied, when soil matric potential reached -20 kpa, the number and total depth of irrigation decreased as salinity level of irrigation water increased. Results showed that different salinity level (1.1 to 4.9 dS/m) of irrigation water had no effect on tomato yield under suitable management strategies. Best management strategies included 4.2 dS/m water with drip irrigation system.

Conjunctive use of saline water

The conjunctive use of good quality water and saline water cannot only solve the problem of water shortages but also improves the water use efficiency and regional environment of irrigated areas (Liu *et al*., 2013). Conjunctive use is also necessary because availability of one source of water over time and space may not be sufficient in quantity/quality to fulfill the entire crop water demand (Harmancioglu *et al*., 2013). Conjunctive water use reduces risks associated with uncertain fresh water supplies and their fluctuation and plays an important hydrologic–economic role in irrigation. Malash *et al*. (2008) conducted experiment with two water management strategies i.e., cyclic and mixed supply of fresh and saline water through drip and furrow method. Saline water above 3 dS/m reduced plant height, leaf area, dry matter and fruit weight. Maximum plant height (93.4 cm), leaf area (1.29 cm^2), dry matter (187.4 g/plant) and yield (86.30 t/ha) was obtained in 2.0 dS/m blended water with drip irrigation system. Maximum WUE (77.29 kg/m^3) was recorded in 2.0 dS/m blended water by drip irrigation. Drip irrigation system showed the advantage over the furrow irrigation system with blended and cyclic fresh and saline water.

Saline water irrigation with different discharge rate

Drip irrigation offers a large degree of control over water application, enabling accurate application of irrigation amounts according to crop water requirement. By managing drip discharge rate during saline water irrigation can minimise loss and control salinity developed by irrigation water. Further, advantage of applying controlled discharge nutrients directly into the plant root zone with minimum leaching effect. Nangare *et al*. (2013) studied the response of different ratio of fresh water (EC=0.38 dS/m) and saline water (EC=19.5 dS/m) and discharge rate (1.2, 2.4 and 4.2 lph) of drip on yield and quality of tomatoes crop at different IW/CPE ratio (0.6, 0.8, and 1.0). Maximum plant yield (3.91 kg/plant) was recorded with fresh water irrigation at IW/CPE ratio 1 with drip discharge rate 2.4 lph. While 50% saline water mixing in irrigation reduced the tomato yield (2.39 kg/plant) with IW/CPE ratio 0.6 and drip discharge 4.2 lph. Maximum plant height (77.8 cm) was recorded under fresh water irrigation with drip discharge 4.2 lph. Maximum WUE (1.56 t/ha-cm) was recorded in fresh water irrigation with drip discharge 2.4 lph having IW/CPE ratio 1. The quality of tomato was observed inferior in saline water treatment compared to fresh water treatment.

CONCLUSION

From the studied papers, it is concluded that saline water is an essential resource in arid areas and areas with poor quality groundwater resources. Use of poor-quality water poses serious loss in yield and plant growth. Conjunctive use of water increased the irrigation water use efficiency with a slight reduction in crop yield compared to constant use of saline water for irrigation. Drip irrigation is suitable to use for irrigation with saline water, since it minimises salt accumulation in the soil, leaves are not subject to leaf burn, and peaks in salt concentrations are avoided. Drip irrigation forms a wetting front that reduces the salinity around the root and hence optimising the conditions suitable for growth. The cost of sustaining crop production using saline water is up-and-down according to resource availability, economic and social preferences.

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