THE EFFECT OF SALINE WATER UNDER SUBSURFACE DRIP IRRIGATION ON COTTON

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ABSTRACT

Water is the most vital input in agriculture and has made a significant contribution in providing stability of food grain production. With increasing demand for water in non-agriculture sectors and continuously increasing pressure on water resources, good quality water and its availability for irrigation are becoming a serious concern. One of the most common water quality concerns for irrigated agriculture is its salinity. Efficient management of saline water depends on soil properties, climate, water quality, choice of crop and crop rotation and farm water management capabilities. Surface and subsurface drip irrigation (SDI) can be very effective in achieving higher irrigation application efficiency and water distribution uniformity. Besides keeping the foliage dry during irrigation, light and frequent water application can result in a small wetted zone with a possibility of dilution for leaching of salt. In order to study the effect of saline water under subsurface drip irrigation on yield and yield components of cotton, an experiment was conducted at Precision Farming Development Center, Water Technology Center, Indian Agricultural Research Institute (IARI), New Delhi with loamy soil. Experimental design was strip split plot with 3 replications with 4 levels of saline water (EC_1= ground water (2-2.5 dS/m), EC_2= 5 dS/m, EC_3=8 dS/m and EC_4=11 dS/m) as main plot and 3 types of drip irrigation system (surface, subsurface at 15 cm depth and subsurface at 30 cm depth) as sub plot. The results showed that there was no significant difference on cotton yield among EC_1, EC_2 and EC_3, while EC_4 affected the cotton yield significantly. The yield decreased 37.3% with irrigation water having EC_4 as compared to the one with EC_1. The highest yield was recorded in EC_2 treatment which was 12.7%, 15.07% and 79.8% more than EC_1, EC_3 and EC_4 treatments, respectively. Treatment of EC_4 had lowest mean boll weight, earliness percentage and boll number per plant than in EC_1 and EC_2 treatments. Salinity of different levels had no significant difference on mean boll weight and earliness percentage but had significant difference on boll number per plant. Subsurface drip irrigation decreased yield, mean boll weight and boll number per plant than surface drip irrigation but increased earliness percentage.

Keywords: Subsurface drip irrigation, Drip irrigation, Saline water and Cotton

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1- INTRODUCTION

The food security coupled with the water security of the many developing nations is a cause of serious concern. The land irrigation is playing the world over a major role in increasing the food production. 8 Mha irrigated land in the year 1800 has increased to more than 230 Mha by the year 2000 and this irrigated area compared to 1500 Mha of dry land agriculture has produced nearly 40% of the world's food supplies. The contribution by irrigated agriculture to the world's total agricultural output is around 50% (Wolf and Hubener 1999). Under the present scenario, about 75 % of the irrigated land lies presently in the developing countries, but the natural resources base of the land and fresh water has been decreasing per capita with the fast rate of rise in population. The irrigation water availability could be enhanced through the scientific use of saline water, the recycling of drainage water and the reuse of wastewater (World Bank 1986, FAO 1992,). The concept for the use of saline water for irrigation to increase food production has been advocated by many research scientists, organizations, institutions and authorities for the last more than five decades. The considerable amounts of poor quality waters are available in many countries of the Asia and African continents, Australia, North and South America and the dry land areas of Europe.

Efficient management of saline water depends on soil properties, climate, water quality, choice of crop and crop rotation, irrigation and farm management capabilities. In India 32−84% of the ground water in different states are either saline or alkali due to the continental monsoonal climate. The basic principles of saline water management need some adaptation, e.g. providing for a leaching requirement in appropriate manner. (Minhas, 1996).

Where foliar damage by salt in irrigation water is concern, irrigation methods that do not wet plant leaves can be beneficial. Subsurface drip irrigation (SDI) can be very effective in achieving higher irrigation application efficiency and water distribution uniformity. Light and frequent irrigation application can result in a small wetted zone with a possibility of dilution for leaching of salt.

In subsurface drip irrigation, small amount of water is applied to the soil through the drippers placed below the soil surface with discharge rates same as surface drip irrigation. Subsurface drip irrigation helps reduce the evaporation loss, causes very little interference with cultivation or cultural practices and possibly increases longevity of laterals and drippers, increases water use efficiency, saves labor, water saving up to 30-70%. It can be used in hilly regions and on saline or alkali soils (Mane *et al*, 2008).

Volkan-levy *et al.* (1998) studied the effect of the amount of water and its salinity level on the yield of Pima cotton. The water salinity ranged from 2 to 7.5 dS/ m and the seasonal water application ranged from 30.0 to 68.0 cm by sprinkler system. With water amounts of up to 50.0 cm (42% of Class A evaporation), an increase in water salinity caused a reduction in the seed cotton yield and the salinity threshold increased with an increasing amount of water. The maximum yield of seed cotton (about 5000 kg/ ha) was obtained with a water application of 50 cm and water salinity between 4 to 5 dS/ m. Whitaker *et al.* (2008) compared soil water, water use, crop maturity and lint yield of cotton grown with subsurface drip (SSD) to cotton grown with overhead irrigation. Three experiments were conducted at two Georgia locations and treatments consisted of overhead irrigated, no irrigated, SSD matched to overhead irrigation rates (SSD Matched), and SSD based on soil water (SSD Fed). Cotton maturity was affected by irrigation treatment as non irrigated cotton matured earliest, whereas overhead irrigated cotton matured latest. Subsurface drip irrigated cotton produced similar or higher lint yields than overhead irrigated cotton. Water use efficiency (WUE) of cotton SSD irrigated was 23 and 15% higher than overhead-irrigated cotton in two experiments.

Ayars *et al.* (1995) compared conventional surface drip systems, concentration of salts on or near the surface causing germination and other problems that reduced under properly designed and managed SDI systems. However, salinity may still be a problem with SDI in arid and semi-arid areas since any leaching above the tubing occurs only as the result of rain. Thus, salts tend to accumulate in this area during the season as the plants extract water and leave the salts behind. High salt concentrations exceeding 10 dS/m have been found in the top 6-10 cm of the soil profile. Salinity distribution measurements have shown that salts moved to below the plant row when the laterals were placed under the furrows rather than under the beds. Mantell *et al.* (1985) in the Negev determined the effect of four levels of water quality (Ec=1.0, 3.2, 5.4 and 7.3 dS/m) using the drip method in combination with three soil amendment treatments (gypsum spread on the soil surface along the drip laterals after planting, injection of H_2SO_4 into the water during each irrigation, and a control) on plant response, salt distribution in the soil profile, and soil sodification processes. Salinity did not reduce yields even at the highest level, in spite of sodium and chloride accumulation. The highest seed cotton yield (6.4 t/ha) was obtained with the local well water (Ec =3.2 dS/m), indicating an optimal response to salinity.

2- MATERIALS AND METHODS

The experiment was conducted at Precision Farming Development Center, Water Technology Center, Indian Agricultural Research Institute (IARI), New Delhi. Experimental design was strip split plot with 3 replications at 4 levels of saline water (EC_1= 2 dS/m, ground water, EC_2= 5 dS/m, EC_3=8 dS/m and EC_4=11 dS/m) as main plot and 3 types of drip irrigation system (surface, subsurface at 15 cm depth and subsurface at 30 cm depth) as sub plot. Distances between drippers and laterals were 60 cm and 90 cm, respectively. Average rainfall was 595,mm that 86% of rain (515mm) was during boll formation and boll developing in July, August and September months (Figure 1).

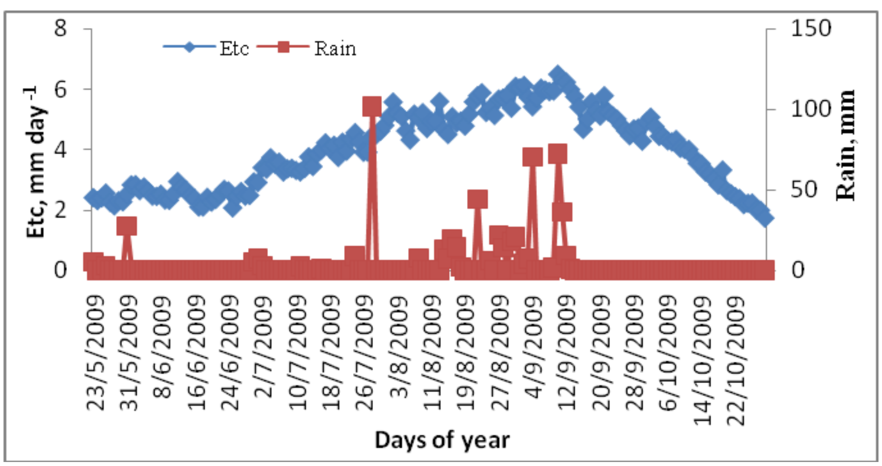

Figure 1. Rainfall and water reqirement during crop season in 2009 year

The mean annual temperature was 24°C with June being the hottest month (mean maximum temperature is about 45°C) and January as the coldest (mean minimum temperature is 7°C). The mean annual rainfall based on 100 years record (1901-2000) was 710 mm. About 80 per cent of the annual rainfall is received during monsoon (June–September) and the rest in winter, with occasional summer rain accompanied by hail storms.

Before sowing, soil samples were collected for measuring the soil physical and chemical properties and for estimating the fertilizer requirements. Soil texture was loam, EC= 0.5 dS/m, pH=8.1, volumetric moisture at field capacity 25% and at wilting point 9%.

Fertilizers of NPK were applied by drip system (fertigation) in 8 split doses at the rate of 120 kg/ha nitrogen, 70 kg/ha potassium and 70 kg/ha phosphorus. Other cultural practices were kept same in all treatments. Cotton variety of RCH134 was planted at plant to plant distance of 60 cm and row to row distance of 90 cm.

Every sub plot had 8.4 m long four rows of crop. Irrigation scheduling was conducted based on meteorological data. ETo (Figure 1) was calculated using meteorological data and multiplying it by Kc (crop coefficient) at different growth stages (ETc=ETo*Kc). Irrigation frequency was kept every alternate day for all treatments. NaCl and $CaCl_2$ were mixed with fresh water in 1:1 ratio to prepare different salinity waters for different treatments. Salinity of irrigation water was measured by portable EC meter.

Cotton harvesting was done during two times for determining earliness percentage. Mean boll weight and number of bolls per plant were measured before the first harvesting from randomly selected 5 plants in every plot. The results were analyzed using Mstatc computer software.

3- RESULTS AND DISCUSSION

The results of effect of different saline water treatments and dripper depth on cotton yield, mean boll weight, earliness percentage and numbers of boll per plant are shown in Figures 2 to 5. There was no significant difference on cotton yield among EC_1, EC_2 and EC_3, while EC_4 affected the cotton yield significantly (Figure 2). The highest yield with 2397 kg/ha was obtained in EC_2 treatment which was 12.7%, 15.07% and 79.8% more than EC_1, EC_3 and EC_4 treatments, respectively. The lowest yield was recorded in EC_4 treatment with 37.3%, 43.9% and 36% lesser than in EC_1, EC_2 and EC_3 treatments, respectively. The similar results were reported by Volkan-levy *et al.* (1998) and Mantell *et al.* (1985) on cotton. This is due to increased osmotic pressure of soil solution leading to physiological dryness and accumulation of one or more elements that may hinder uptake of one or more nutrient elements. This may also occur because of poor air and water movement and low microbial activity in treatment with high saline water. There was no significant difference among dripper installation depths on cotton yield while subsurface drip irrigation with laterals placed at a depth of 30cm decreased cotton yield at the rate of 6.4% and 10.2% than subsurface drip irrigation with drip laterals at 15cm depth and surface drip irrigation treatments, respectively.

Different levels of salinity had no significant effect on mean boll weight and earliness percentage (Figures 3 and 4). Mean boll weight in EC_2 treatment was highest and in treatment EC_4 was lowest while mean boll weight in treatment EC_2 was 10.4% more than EC_4 treatment. Subsurface drip irrigation decreased mean boll weight but had no significant difference as compared with surface drip irrigation. Subsurface drip irrigation decreased yield, mean boll weight and boll number per plant than surface drip irrigation but increased earliness percentage. Dripper installation depth had not significant effect on earliness percentage but increased earliness percentage (Figure 3).

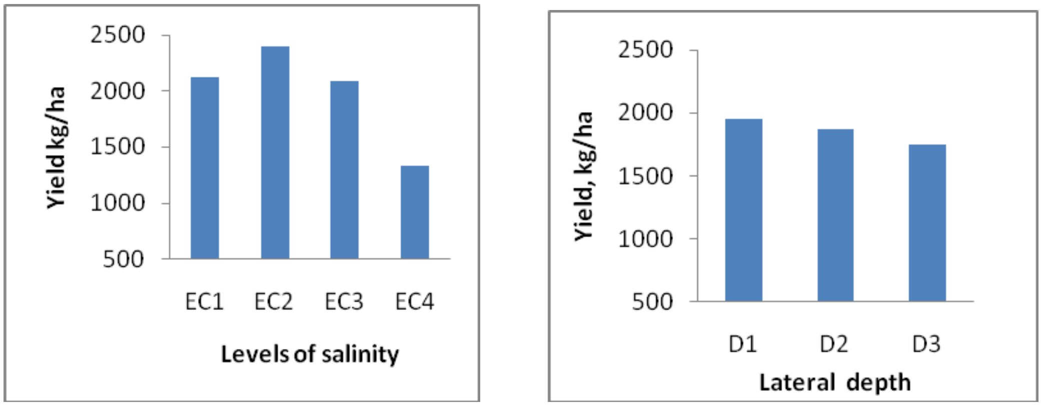

Figure 2 . The effect of different saline water and lateral depth on cotton yield

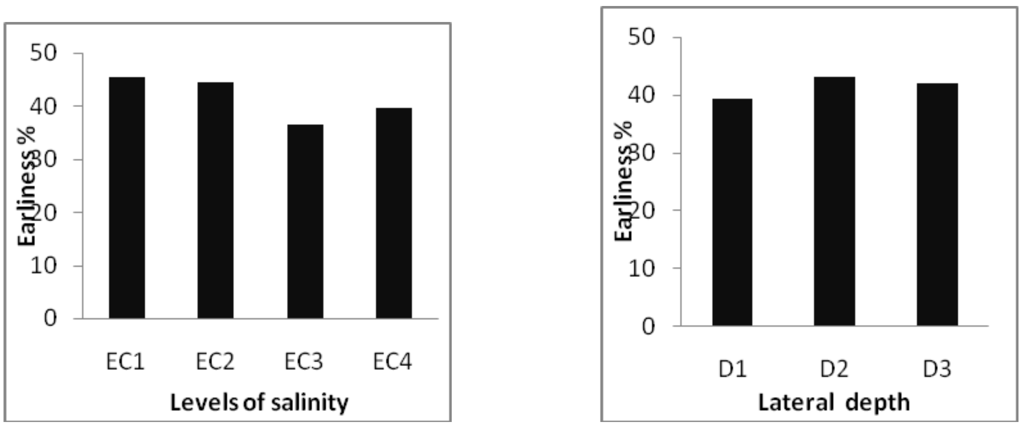

Figure 3 . The effect of different saline water and lateral depth on earliness percentage

The highest and lowest number of boll per plant was related to $EC_1$and EC_4 treatments. There was significant difference between $EC_1$and EC_4 treatments in view of numbers of boll per plant while EC_2 and EC_3 treatments had no significant difference. Subsurface drip irrigation with laterals placed at 15 cm depth increased numbers of boll per plant than surface drip irrigation however this difference was not statistically significant (Figure 5).
This is because of leaching of salt due to monsoon rainfall in New Delhi condition. Amount of rainfall during 2009 year was 595mm with 515mm (86%) received during boll formation and boll developing stages of cotton. Before monsoon, crop height in treatment EC_4 was noted less due to high salinity which ultimately resulted in reduction of yield and yield components. Cotton is considered tolerant to salinity but the crop had started showing salinity stress at salinity of 7.7 dS/m.

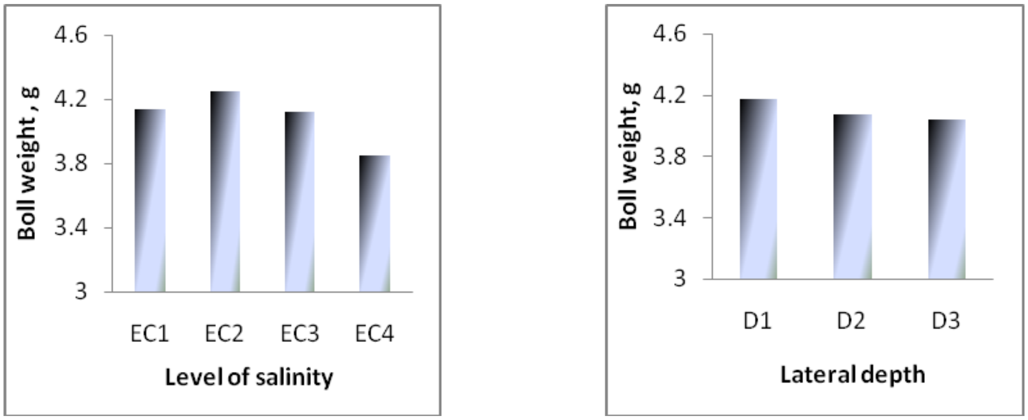

Figure 4 . The effect of different levels of saline water and lateral depth on mean boll weight

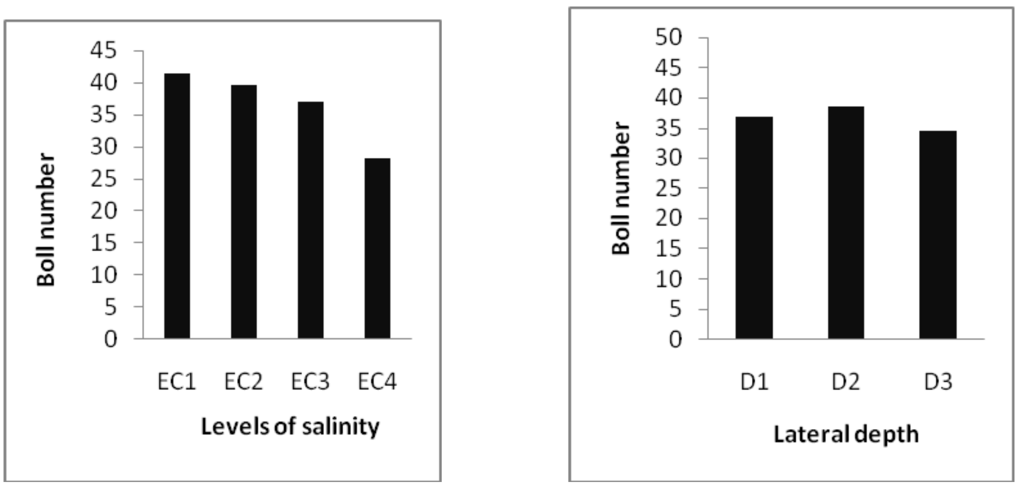

Figure 5 . The effect of different levels of saline water and lateral depth on boll number per plant

Amount of irrigation water in all treatment was 275.5 mm. Cotton was irrigated every other day and number of irrigations was 48. Irrigation water use efficiency was obtained by dividing yield by the water use. Highest and lowest water use efficiency was obtained in EC_2 and EC4 treatments 0.83 and 0.52 kg/m^3/ha, respectively. Water use efficiency in EC_4 treatment was 37, 44 and 36% lesser than in EC_1, EC_2 and EC_3 treatments, respectively. Different depths of placement of drip laterals had no significant effect on the water use efficiency. The results are shown in Figure 6.

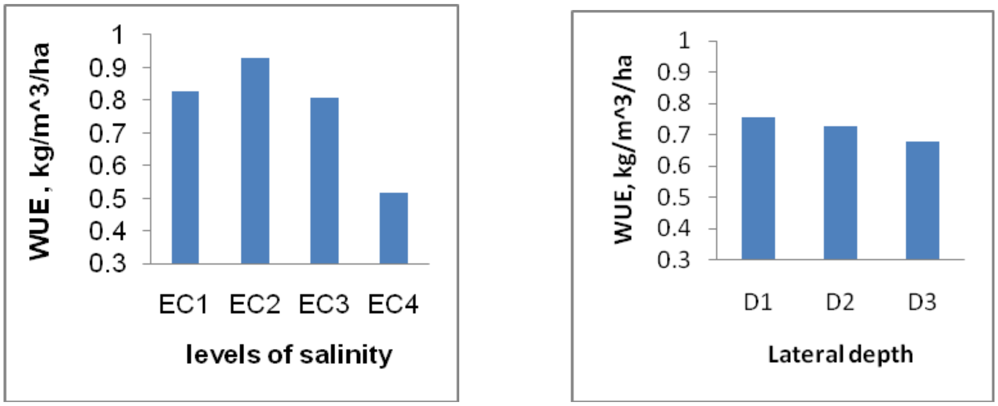

Figure 6 . The effect of different levels of saline water and lateral depth on irrigation water use efficiency

4- CONCLUSION

Cotton is considered as a crop tolerant to salinity. Saline water up to 7.7 dS/m did not have any significant effect on cotton yield while irrigation of cotton by saline water at the level of 11 dS/m decreased cotton yield significantly. Salinity at the levels of 5 and 11 dS/m resulted in highest and lowest cotton yields, respectively. The yield decreased 37.3% with irrigation water having EC_4 as compared to the one with EC_1.

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