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A Review on Drip Irrigation using Saline Irrigation Water in Potato (*Solanum tuberosum L.*)

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Abstract—*Competitive development in industry and agricultural sector has drastically curtailed the availability of fresh water for agriculture. As per the estimates of FAO, 250 million hectares of irrigated land in the world show salinization problems, and 10 million hectares are abandoned annually due to salinity problems. About 41-84 per cent of groundwater of North-West India is brackish in nature. In Punjab, 42 per cent of the ground water is poor in quality, out of which 69 per cent are sodic, 25 per cent are saline and 6 per cent are saline-sodic. Thus it is necessary to use saline water for agricultural irrigation if appropriate crop, soil, and water management strategies are applied. Maas and Hoffman (1977) showed that the response of any crop to salinity is a characteristic of environmental conditions and irrigation methods. Drip irrigation has the potential to increase/sustain crop yields with less irrigation water, and under saline conditions it provides favourable conditions in the root zone as compared to conventional irrigation systems even in some of the sensitive vegetable crops. Drip irrigation in potato crop shows higher weight of the tuber in contrast to furrow irrigation under same salinity levels of irrigation water. Irrigating solanaceous crop with medium and high RSC sodic water under drip irrigation can lead to higher yields than furrow irrigation with better moisture conditions and less deterioration of soil properties.*

1. INTRODUCTION

Potato (*Solanum tuberosum L.*) is the third most important food crop in the world after rice and wheat. The reports of International Potato Centre (2014) states India as the second largest producer of potato after China. In India, UP leads in production of potato with 13.3 million tonnes with an acreage of 5,48,000ha. It is the major export crop of Punjab with an acreage of 87,240 ha and production of 2.2 million tonnes. Potato is a herbaceous plant which grows to a height of 100 cm. It prefers well drained sandy loam soil for its growth. Potato is largely grown in cooler regions where mean temperature does not normally exceed 18 degrees Celsius. Conventionally the crop is grown through vegetative reproduction of its tuber. Previous researches by Kaur *et al* (2005) shows the yield and quality of potato were improved through drip irrigation.

1.1. Fresh Water availability for crop production

According to Qadir and Oster (2004) the competition in present days for fresh water in the development of urbanization, industry and agriculture causes the reduction in availability of fresh water for irrigation. As per the estimates of FAO, 250 million hectares of irrigated land in the world show salinization problems and 10 million hectares are abandoned annually due to salinity problems. The north western part of India is affected by the problems of salinity or sodicity to the extent that 41-84% of the groundwater resources of the region are brackish in nature. In Punjab, out of the 42% poor quality water, 69% are sodic, 25% are saline and 6% are saline-sodic. Improper management of poor quality waters, without careful regard to their salinity and ionic composition of the irrigation water poses grave risks to soil conditions and the environment (Minhas and Gupta 1992, Minhas and Bajwa 2001 and Choudhary *et al* 2004). Thus it is necessary to follow appropriate crop, soil, and water management strategies for using saline water for agricultural irrigation (Shalhevet 1994). In fact large amount of saline water resources in the world may be good supplement to inadequate good quality surface water resources for irrigation.

1.2. Drip Irrigation: A boon for saline groundwater areas

Drip Irrigation has proved to be a success over furrow or flood irrigation in terms of water and increased yield (Thuy *et al* 2011). Edoga and Edoga (2006) have reported that with drip irrigation, the soil is maintained continuously in a condition which is highly favourable to the crop growth. Deficit irrigation provides a means of reducing water consumption while minimizing salt build up and thereby adverse effects on yield of crops (Rimon 1976). If saline water is used through conventional methodsof irrigation, salt accumulation occurs in the soil which can be harmful to plants (Driessen 2008). Application of water in the vicinity of root through drippers provides better soil moisture regime in the root zone and thus lowering the salinity under drip irrigation than under furrow irrigation (Saggu and Kaushal 1990).

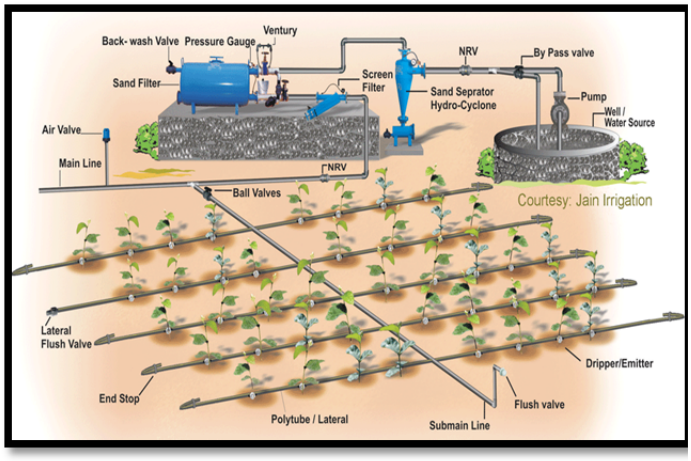

Fig. 1: Schematic layout of drip irrigation system (Source:Jain Irrigation Systems Ltd., Jalgaon)

2. DRIP IRRIGATION AND CONCEPT OF WETTING FRONT

Drip irrigation is a micro-irrigation in which the rate of water application is very low and drop by drop. The pressure of drip irrigation system in potato should be around 1.1-1.2 kgcm^{-2}. Drip irrigation or trickle irrigation is an efficient irrigation method which is becoming popular in areas of water scarcity and poor quality irrigation water.

2.1. Components of drip irrigation systems

The pumped water flows through valves, filters, mainlines, sub-mains or manifold lines and laterals before being applied to plants (Fig. 1). The dripper is a water emitting component that allows water to flow drop by drop or continuously.

Presence of air in the pipeline causes hindrance to the water flow. Air release valves help in overcoming this problem. Pressure regulating valves are helpful to regulate pressure of 1.1 to 1.2 kg cm^{-2} in potato crop. Sand filters in the system helps in primary filtration of irrigation water. Solid impurities like fine sand and dust are removed by passing the irrigation water through screen filters. Fertilizer application in drip is done by using water soluble fertilizers, applied by fertigation through fertigation tank.

2.2. Wetting front concept

Drip irrigation has the potential to increase/sustain crop yields with less irrigation water, and under saline conditions it provides favourable conditions in the root zone as compared to conventional irrigation systems even in some of the sensitive vegetable crops (Hanson and May 2011). Wetting front is the bell shaped outline or a boundary formed in saline areas away from the root zone. This is formed due to the movement of water drop by drop from root zone to away from the root zone areas. Salt accumulates at the boundary of the wetting front. This helps the roots to overcome the osmotic and toxic effects of salts and hence proper nutrient and water uptake by plants.

The wetting front formed in coarse texture will be elongated and deep due to higher infiltration (Fig. 2A), and more circular in clayey soil (Fig. 2B).

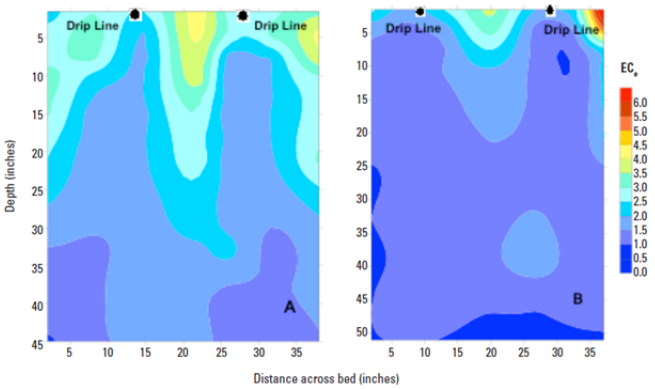

Fig. 2: Wetting front formed in soil irrigated with saline water (A.) Coarse texture (B.) Fine texture (Grattan 2003)

3. DRIP IRRIGATION USING SALINE IRRIGATION WATER

The indiscriminate use of poor quality irrigation water in the arid and semi-arid parts of India poses serious threat to soil health and to the sustainability of natural resources and the environment (Minhas and Bajwa 2001). Hoffmen *et al* (1986) reported, when saline water is skilfully used for irrigation, it can benefit the agricultural production of crops. Its utility for cultivation of crops offers several additional benefits. Re-use instead of disposal of large amounts of saline water during the entire year reduces the environmental risk of groundwater deterioration (Oron 1993). A premium market price for the fruit and vegetable produce, because of a high content of total soluble solids and an extended shelf life, resulted from the plants adaptation to the stressful growing conditions according to the reports of Mizrahi and Pasternak (1985). Irrigation with brackish water for irrigation through conventional method is associated with salt accumulation in the soil, which poses harm to plant growth that adversely influences crop yields. The effects of soil on physiological process result from lowering of soil water potential and the toxicity of specific ions. Bresler *et al* (1982) reported on this basis that non-toxic highly saline water has an agricultural significance.

Dryland cultivation of potato (*Solanum tuberosum L.*) is expanding worldwide (Scott 1997). Potato is a classic summer crop of temperate climate regions. According to Ewing and Struik (1992) low temperatures and short photoperiods restrict shoot growth and promote the onset and growth of tubers. Reports of Maas and Hoffman (1977) shows, in terms of relative yield (percentage of yield under non-saline conditions), the response of any crop to salinity is characteristic of environmental conditions (e.g. soil properties and weather) and agricultural methods (e.g. irrigation methods). The authors have classified potato as a moderately

salt-sensitive crop and define a relatively lower soil salinity (EC) threshold value of 1.7dSm^{-1}, for this crop above which the relative yield decreases by 12% per 1 dSm^{-1} increase in EC, based on experiments by Bernstein *et al* (1951) on a loamy soil under flood irrigation. Bernstein L and Francois L E (1973) recognized, as potato being sensitive to water stress include high and nearly constant soil water potential along with a high soil oxygen diffusion rate as ideal conditions for its growth. Bajwa M S and Choudhary O P (1996) reported, under temperate summer conditions and saline water irrigation, yield of potato are unaffected by soil salinities as high as 3.5-7.6dSm^{-1}. Wang *et al* (2006) stated in their experiments that potato evapotranspiration is small due to the very short growing period for potatoes. Epstein and Grant (1973) specified that potato plants exhibit water stress when the soil water potential drops below -25kPa.

As per the reports given by Shainberg and Singer (1990), irrigation with saline water can be problematic because of the enhanced salinization due to poorly structured soils with low infiltration capacity. Saggu and Kaushal (1990) recommended that these problems can be overcome in part by growing the crop on deep sandy soils as it drains rapidly and retains little salt. Pasternak (1987) informed unlike flood irrigation, drip irrigation leaches salt away from rhizosphere and maintains a low soil moisture tension. Kang (2004) stated that the low rate and high frequent irrigation applications of drip irrigation system, over a long period of time, can maintain high soil matric potential in root zone, compensating for the decrease of osmotic potential introduced by the saline water irrigation, and constant high water potential can be maintained for the crop growth. Minhas (1996) regarded drip system as the most advantageous method for applying saline water to crops and also for maintaining well aerated conditions in the soil.

4. ADVANTAGES OF DRIP IRRIGATION OVER FURROW IRRIGATION

In India, furrow irrigation is widely used in potato production. Drip irrigation is not efficiently and effectively used in the country due to its higher cost of installation (Nagaz 1991). However it was observed by Nagaz *et al* (2008) that furrow irrigation showed relatively higher value of hydraulic conductivity during the initial stages, than the drip irrigation principally because of high fraction of the soil surface wetted by irrigation. However that causes more evaporation under furrow irrigation. The authors also observed the reason for the higher salinity obtained for furrow method than drip method was attributed to evaporation of ridge soil during the periods between the respective irrigations and since irrigation applied by furrows are expected to do little leaching of the ridge soil. However, Saggu and Kaushal (2008) recommended that the application of water in the vicinity of root through drippers provides better soil moisture in the root zone and thus lowering the salinity under drip irrigation than for furrow irrigation. Cetin and Bilgel (2002) specified the 11% increase in yield in drip irrigation than in furrow irrigation is attributable to the application of irrigation water in the vicinity of root zone. Erdem *et al* (2006) stated the higher water use efficiency in case of drip irrigation treatment due to higher yield accompanied by saving of irrigation water as compared to furrow method of irrigation.

5. CONCLUSION

Saline water is an important resource in arid areas and areas with poor quality groundwater resources. Use of poor quality water poses serious loss in yield and plant growth. Potato is one of the most important crop which can tolerate salinity of irrigation water upto a threshold value of 2.5 dSm^{-1}. In such areas drip irrigation proves to be a boon for tuber formation. In traditional furrow irrigation method tuber numbers and yield widely gets affected due to osmotic effects by the salts in the rooting zone. Drip irrigation forms a wetting front that reduces the salinity around the root and hence optimising the conditions suitable for growth. Cost of sustaining crop production using saline water is variable according to resource availability, economy and social preferences.

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