

Effect of Irrigation Scheduling on Moisture and Salt Distribution and Growth of Kagji Lime under Drip Irrigation in Arid Rajasthan

R.K. Beniwal, M.L. Soni, N.D. Yadava, Chander Prakash and H.S. Talwar

Central Arid Zone Research Institute, Regional Research Station, Bikaner 334 004, India

Abstract: A field experiment was conducted in an Aridisol on Kagji lime (*Citrus aurantifolia*) plants during 2001-2002 to study the effect of drip irrigation levels (Evapotranspiration coefficient (ETc) = 1.00, 0.70 and 0.40) on spatial distribution of soil moisture, salts and plant growth. The results revealed that soil moisture decreased laterally, but increased vertically at each irrigation level. Comparatively lower soil moisture was recorded in surface soil layers during summer months. Minimum salt content was observed near the emitters and it increased laterally. Salt spreading was more in 1.00 ETc with maximum value near periphery of the wetted zone. At each lateral distance, higher salt concentration was observed at surface soil layers as compared to lower depths. Canopy diameter, number of branches and relative increase in girth were significantly affected by irrigation levels showing minimum values at 0.40 ETc. Irrigation at 0.70 ETc levels was better over 1.00 and 0.40 in terms of increasing plant growth and saving water.

Key words: Drip irrigation, growth, irrigation scheduling, Kagji lime, moisture, salt distribution

The Indian hot arid zone covers about 10% (31.7 m ha) of the country's geographical area. It is characterized by high temperature, low and erratic rainfall, high potential evapotranspiration, low relative humidity and high wind velocity. Water is the scarest commodity limiting the agricultural production of this ecosystem. The prevailing soil and climatic conditions of this zone are not congenial for the surface irrigation system. Studies conducted by Water and Power Commission have shown that 71% of irrigation water is lost during conveyance and actual utilization is only 29%. Considering the climate, soil and water resources, the arid ecosystem is more suitable for the plantations of fruit and other multipurpose trees (MPTs). Citrus plants, well adapted to arid and semi-arid ecosystems, are

commonly grown with surface irrigation, which results in sizeable water loss, and reduced water-use efficiency. Drip irrigation, discharging the water in root zone of the plant, results in efficient utilization of water (Shirgure *et al.*, 2001). It economizes the water use and can double the irrigated area with the same quantity of available water. Drip irrigation can solve the problem of water shortage, increase the productivity and bring more income to the farming community (Sivanappan, 1998). It can be a promising technology in the desert having undulating topography, poor soil water retention capacity and lack of good quality ground water. Limited information is available on the growth of citrus under drip irrigation in arid ecosystem. The present investigation was, therefore, conducted to study the spatial distribution

of moisture, salts in soils and growth of citrus in an Aridisol at different levels of irrigation through drip irrigation system.

Materials and Methods

A field experiment was conducted on citrus plants under drip irrigation from September 2001 to August 2002 at the experimental farm of Central Arid Zone Research Institute, Regional Research Station, Bikaner. The climatic condition of the area is hyper aridic with low rainfall, high temperature and high evaporation. The rainfall received during the study period was only 35.3 mm, which was eight times less than the average annual rainfall of 275 mm for the region. Daily pan evaporation ranged from 3.02 mm day⁻¹ in December to 14.66 mm day⁻¹ in the month of May. In none of the months rainfall exceeded pan evaporation. The soil characteristics of different depths upto 120 cm, were determined by standard methods (Jackson, 1967). The soil of the experimental site was loamy sand in texture having low soil organic carbon (0.14% in 0-15 cm surface soil). The pH of the soil was alkaline with 0.5% CaCO₃ at surface horizon which increased with depth. The water retention at 1/3 bar was 9.5% in surface 0-15 cm soil and increased with depth. One-year-old *Citrus* saplings were transplanted at a distance of 5 x 5 m in pits filled with FYM and recommended dose of NPK for citrus. The treatments were replicated six times in a randomized block design. Initially uniform irrigation was provided to all the plants during establishment period from September to November 2001. From December 2001, the plants were irrigated every third day with drip on the basis of

Table 1. Irrigation water applied to Citrus through drip (2001-2002)

Month	Irrigation water applied (L plant ⁻¹)		
	I ₁	I ₂	I ₃
September	154.0	154.0	154.0
October	132.0	132.0	132.0
November	91.0	91.0	91.0
December	59.8	41.8	23.9
January	75.2	52.6	30.1
February	87.2	61.0	34.9
March	154.3	108.0	61.7
April	146.5	102.5	58.6
May	163.8	114.7	65.5
June	181.8	127.2	72.7
July	184.6	129.2	73.8
August	187.0	130.9	74.8

evapotranspiration value with three levels of irrigation viz. I₁ = 1.00 ETC (Evapotranspiration coefficient), I₂ = 0.70 ETC and I₃ = 0.40 ETC. Water was applied with the help of button type drippers having discharge capacity of 4 L h⁻¹ placed at a distance of 10 cm from tree trunk. The water applied in different treatments is presented in Table 1.

One-meter long access tubes were installed at 20 and 40 cm distance from the tree trunk to monitor the soil moisture. Soil moisture distribution at 20 and 40 cm lateral distance from drippers and vertically at 0-15, 15-30, 30-45 and 45-60 cm depths were recorded with the help of TDR meter (Model Trime-FM) before each irrigation. Soil samples were collected to determine salt content during June 2002 (prior to normal rainfall months) at 20, 40 and 60 cm from emitters laterally and 0-15, 15-30, 30-45 and 45-60 cm depth vertically. Salt concentration was determined in 1:2 soil water suspensions

by conductivity meter (Richards, 1954). Data on canopy diameter, number of branches, height and girth were also recorded.

Results and Discussion

The soil moisture in the profile increased with increasing irrigation levels (Fig. 1). In general, moisture content was higher near the drippers and it decreased with increasing horizontal distance from emitters at each level of irrigation. A decrease in soil moisture content with increasing distance from the dripper was also recorded by several workers (Bhardwaj *et al.*, 1995; Bharambe *et al.*, 2002). Regarding vertical

distribution, moisture content was lower at the surface and increased with increase in depth. Relatively higher increase in soil moisture was observed between 15-30 cm depth and thereafter it showed uniform increase up to 60 cm. These results are in contradiction to the earlier findings of Bharambe *et al.* (2001) who reported a decrease in soil moisture with depth. Perhaps in Vertisols low transmission restricted the applied water in upper soil layers. In our case, the soils were light in texture having high infiltration rate. Further, the sub-soil was heavier with relatively higher water holding capacity than surface soil. Drip maintained the soil moisture above field capacity under higher rate (I_1 and I_2) of

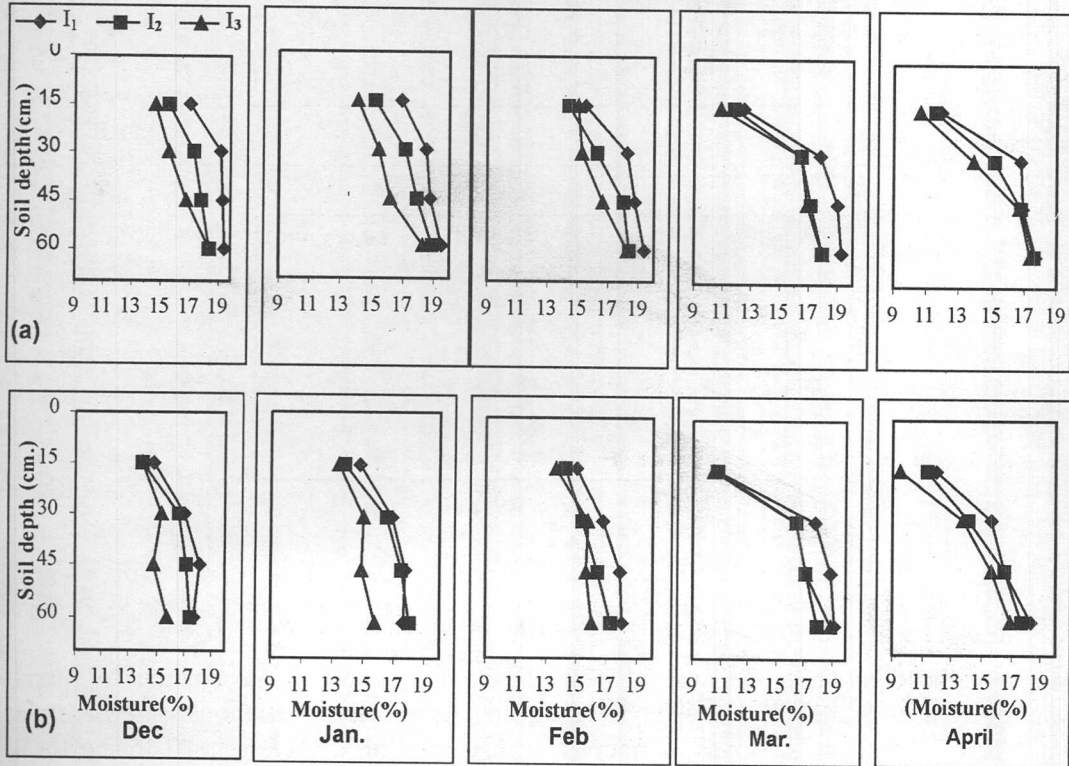


Fig. 1. Spatial distribution of volumetric soil moisture content at (a) 20 cm lateral (b) 40 cm lateral and at 15, 30, 45 and 60 cm depth.

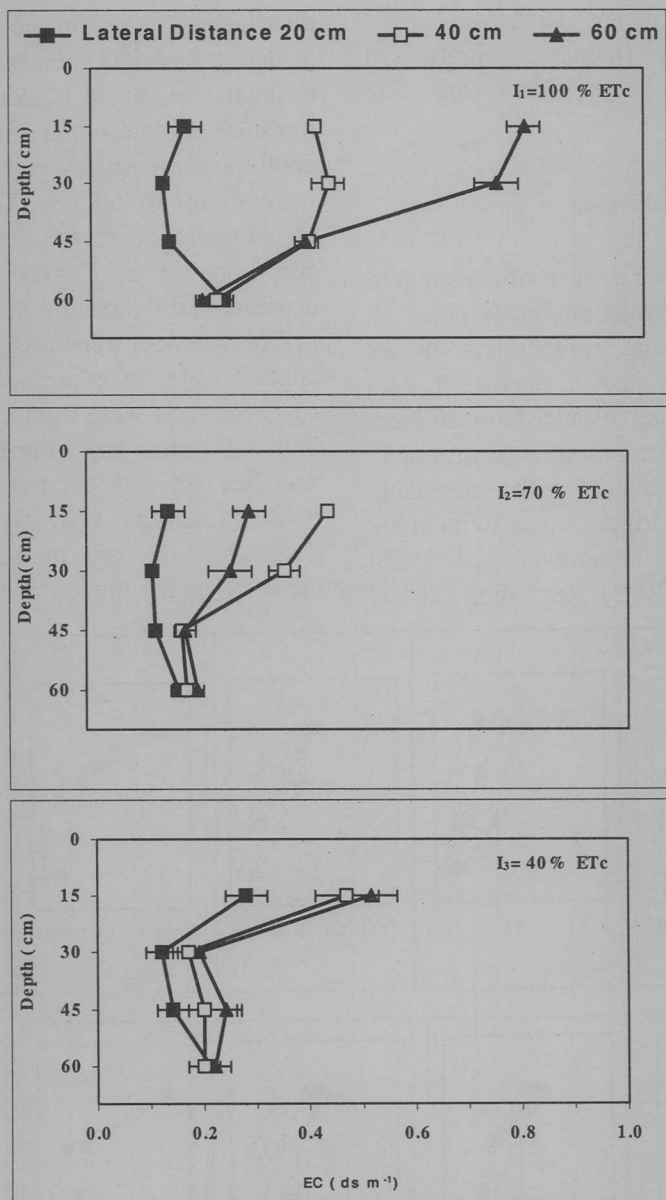


Fig. 2. Effect of different levels of irrigation on Spatial distribution of salt.

water application while moisture content was over 50% availability level at lower rate (I₃). Data on seasonal variations revealed that higher soil moisture was recorded in December, January and

February months as compared to March and April. These variations were observed mainly in surface layers, i.e. 0-15 and 15-30 cm depths due to high evaporation during warmer months.

Table 2. Effect of irrigation levels on number of branches, canopy diameter and relative increase in height and girth

Treatments	No. of branches after 1 year	Canopy diameter (cm) after 1 year	Relative increase in girth (%) (May-Sept. 2002)	Relative increase in height (%) (May-Sept. 2002)
I ₁	15.7	90.6	41.95	20.96
I ₂	15.0	84.3	43.75	23.80
I ₃	10.3	73.3	19.65	21.65
CD (0.05)	1.99	7.23	-	-

Spatial distribution of salts as affected by different levels of irrigation have been shown in Fig. 2. Minimum salinity was observed below the emitters at 20 cm lateral spacing in all treatments due to the continuous movement of salts away from the emitters with the waterfront. The movement of salts at each irrigation level was mainly observed laterally at soil surfaces (0-15 and 15-30 cm depth), as water evaporated leaving dissolved salts in the upper layers of soil. Larger spread of salts was observed in I₁ treatment as compared to I₂ and I₃ treatments. Small quantity of water applied at shorter intervals, as in the case of I₂ and I₃ treatments decreased the size of wetted front and resulted in increased accumulation of salts near the root system.

Relative increase in height was almost same at all irrigation levels with maximum at I₂ irrigation level (Table 2). However, number of branches, canopy diameter and relative increase in girth were affected by irrigation levels. Significantly more number of branches and relative increase in girth was observed in I₁ and I₂ as compared to I₃ treatment. Average number of branches after 1 year was 15.7, 15.0 and 10.3 in I₁, I₂ and I₃ treatments, respectively. An increase of 41.9 and 43.7% stem girth was observed at I₁ and I₂ irrigation levels as

compared to 19.6% in I₃ irrigation level. Relative increase in girth and number of branches was comparable in I₁ and I₂ treatments. After one year, the overall effect of irrigation levels on canopy diameter was in the order I₁ I₂ I₃. The corresponding values for canopy diameter were 90.6, 84.3 and 73.3 cm for I₁, I₂ and I₃ treatments, respectively. Therefore, it may be concluded that irrigation at 0.70 ETc level is better over 1.0 and 0.40 ETc levels in terms of increasing plant growth and saving water.

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