RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 7 | Issue 1 | April, 2014 | 165–171

Effect of different levels of drip and surface irrigation methods on potassium distribution in the rhizosphere of beetroot crop under saline vertisols

SUBHAS BALAGANVI, M.V. RANGHASWAMI, P. BALAKRISHNAN AND S.B. SALIMATH

Received : 04.01.2014; **Revised :** 22.02.2014; **Accepted :** 04.03.2014

See end of the Paper for authors' affiliation

Correspondence to :

SUBHAS BALAGANVI
Department of Agricultural Engineering, College of Agriculture, Hanumanamatti, HAVERI (KARNATAKA) INDIA
Email : subhasuasd@rediffmail.com

ABSTRACT : A study was conducted at the Agricultural Research Station, Gangavati, in northern Karnataka, India during *Rabi/*summer, 2007-'08 and 2008-'09 with beetroot (*Beta vulgaris)* as the test crop in saline vertisol. During both the year and irrespective of the soil salinity levels slightly higher potassium was observed at 15 cm away from the dripper point compared to either at the dripper point or distances beyond 15 cm from the dripper point. The magnitude of available nutrients decreased vertically with increase in soil depth. The drip irrigation scheduled at 1.2 ET resulted in the maximum tuber yields of 19.43 and 18.91 t ha^{-1} during 2007-'08 and 2008-'09, respectively. Among the salinity levels, the highest tuber yield of 18.23 and 17.89 t ha^{-1} were recorded in salinity level-I, respectively. Whereas among the surface irrigation levels, irrigation at 1.2 ET recorded the highest tuber yields of 12.2 and 11.84 t ha^{-1}, respectively.

KEY WORDS : Drip, Surface irrigation, Vegetable, Beetroot, Soil salinity, Potassium distribution

HOW TO CITE THIS PAPER : Balaganvi, Subhas, Ranghaswami, M.V., Balakrishnan, P. and Salimath, S.B. (2014). Effect of different levels of drip and surface irrigation methods on Potassium distribution in the rhizosphere of Beetroot crop under saline vertisols. *Internat. J. Agric. Engg.,* **7**(1) : 165-171.

Waterlogging and salinity are global phenomena that affect the agricultural economy considerably. The salt-affected soils are distributed in more than hundred countries especially in arid and semi-arid regions to the extent of about 95.5 M ha and it was estimated that the world as a whole is losing at least 3 ha of fertile land every minute due to salinisation/sodification (Siyal *et al*., 2002). Though India has made phenomenal irrigation development during the post-independence period, the performance of most of the major and medium irrigation projects is highly disappointing due to various factors. Particularly the twin menacing problems of waterlogging and salinity have become a major concern as they pose serious questions on capital investment and cause environmental problems. The salt-affected soils form sizable area in India and according to one estimate an area of 6.73 M ha has been salt-affected in the country (Sharma *et al.*, 2006). The problems being dynamic in nature are developing at rapid pace. Unless, these problems are addressed and solutions are evolved for prevention of the same and reclamation/management of the already affected areas, the performance of the projects, agriculture productivity and production would continue to pose serious concern.

Projections are that India will need to produce 367 M t of food grains by 2025 and 581 M t by 2050 to achieve marginal self-sufficiency. There is no scope to expand the net sown area. Maintenance of self-sufficiency would require increasing the cropping intensity and putting more area under irrigation. The gross area under irrigation would nearly double from the existing 79 M ha requiring 780 BCM of water by 2025, which may be unsustainable. By increasing the cropping intensity to 157 per cent by 2050, the gross cropped area will increase to 223 M ha by 2050 from the existing 193 M ha. However, the target of 223 M ha may not be easy considering increasing land requirements by other sectors including rapid urbanisation. With India's ultimate irrigation potential assessed at 140 M ha, it is projected that 48 per cent of the gross cropped area, *i.e.* nearly 104 M ha will be under irrigation by 2025, which will increase to 60 per cent, *i.e.* nearly 134 M ha by 2050. Irrigation will continue to be the predominant end use, even though its share is projected to reduce marginally from 95.1 per cent in 2001-'02 to 94.5 per cent in 2025 and 93.8 per cent in 2050.

The dynamic processes of waterlogging, salinisation and sodification in many irrigated command areas of the arid and semi-arid regions render the lands degraded, thereby causing decline in agricultural production. Accumulation of excess soluble salts as in case of saline soil influences crop production through changes in proportions of exchangeable anions, cations, the physical properties and the effects of osmotic and specific ion toxicity, etc. However, such saline soils can be managed to prolong field productivity with proper management of soil moisture, efficient irrigation systems, local drainage and the right choice of crops so that the adverse effect of salinity on crops can be minimised and hence the cropping intensity and yield would increase considerably and also the lands can be cultivated on sustainable basis. The recent advances in irrigation techniques involving efficient use of water through micro irrigation systems hold a key to arrest further increase in waterlogging and salinisation and also can improve the economy of the farmers especially in the tail-ends of commands through increased farm produce. With these issues in view, the present investigation was undertaken with beetroot (*Beta vulgaris)* to study the effect of different methods and levels of irrigation on potassium distribution and yield of beetroot under saline vertisols.

■ METHODOLOGY

Experimental site:

The experiment to find out the effect of different levels and methods of irrigation on performance of beetroot was conducted at the salinity block of the Agricultural Research Station (ARS), Gangavathi, which is situated in the north-eastern dry zone *i.e.* zone-3 of region–II of Karnataka State, India and the location corresponds to 15°15'40" North latitude and 76° 31' 45" East longitude at an altitude of 419 m above the mean sea level. The site selected for the conduct of experiment was found to have wide range of soil salinity. Separate soil samples from 0-60 cm depth were taken to classify the experimental site into three salinity (EC, dS m^{-1}, 1:2.5 soil water extract) level blocks and divided accordingly. The soil of the experimental site is clay belonging to Noyyal series.

Treatment details:

The treatment consisted of three salinity levels in main plots and eight irrigation regimes in sub-plots as follows. The experiment was laid out in strip plot design with three replications.

Main plot : Salinity levels (Three) - S		
S_1	:	Salinity level – I (EC = 1.3 dS m^{-1})
S_2	:	Salinity level – II (EC = 2.7 dS m^{-1})
S_3	:	Salinity level – III (EC = 4.3 dS m^{-1})

Sub-plots : Irrigation levels (Eight) - I		
I_1	:	Drip irrigation at 0.6 ET
I_2	:	Drip irrigation at 0.8 ET
I_3	:	Drip irrigation at 1.0 ET
I_4	:	Drip irrigation at 1.2 ET
I_5	:	Drip irrigation at 1.4 ET
I_6	:	Surface irrigation at 0.8 ET
I_7	:	Surface irrigation at 1.0 ET
I_8	:	Surface irrigation at 1.2 ET

Lay-out of drip irrigation system:

Irrigation water was pumped through 3 hp motor and conveyed to the main line of 75 mm OD PVC pipes after passing through sand and screen filters. From the main pipes, sub-mains of 63 mm OD PVC pipes were drawn. From the sub main, laterals of 12 mm LLDPE pipes were installed at an interval of 1.20 m. Each lateral was provided with individual tap control for imposing irrigation. Along the laterals, pressure compensating drippers of 4 Lph, were fixed at a spacing of 60 cm. One lateral was used for four rows of beetroot crop. Sub-mains and laterals were closed at the end with end cap. After installation, trial run was conducted to assess mean dripper discharge and uniformity co-efficient. During the irrigation period an average uniformity co-efficient of 95 per cent was observed. This was taken into account for fixing the irrigation water application time.

Irrigation schedule

Good quality water was used for irrigation (EC = 0.34 dS m^{1} and pH = 7.64). Irrigation was scheduled based on climatological approachand the daily evapotranspiration (ET) rate of beetroot was estimated using the following equation

ET = Ep x Kp x Kc

where,

ET = evapotranspiration, mm

Ep = pan evaporation, mm

Kp = pan co-efficient

Kc = crop co-efficient.

Quantity of water required to be applied per day per plant for 100 per cent ET in case of drip irrigation was computed using the following equation:

Q = ET x A x B

where,

Q = quantity of water required per day per plant, L

A = gross area per plant, m^2

= plant to plant distance, m x row to row distance, m

B = amount of area covered with foliage fraction (100 %, Tiwari *et al.*, 2003).

From the above equation, irrigation water required to meet 100 per cent crop evapotranspiration (ET) was determined, followed by 0.6, 0.8, 1.2 and 1.4 ET values. Accordingly, the irrigation was given every 48 hours.

Fertiliser application for surface irrigation:

For the experimental plot, recommended dose of inorganic fertilisers were applied manually. The fertiliser sources for supplying NPK were urea (46%N), single superphosphate (16%P_2O_5) and muriate of potash (60%K_2O), respectively. The details of split application of fertilisers are given below :

Basal	Top dressing
50% N	50% N – on 30th day
100% P_2O_5	-
100% K_2O	-

Potassium distribution:

To determine the potassium distribution, the profile soil samples were drawn using screw auger from all the treatments at 0-15, 15-30, 30-45 and 45-60 cm depths vertically downward for surface irrigation. In case of drip irrigation, soil samples were collected at a radial distance of 0, 15, 30, 45 and 60 cm from the emitter at 0-15, 15-30, 30-45 and 45-60 cm depths vertically downward from the surface.

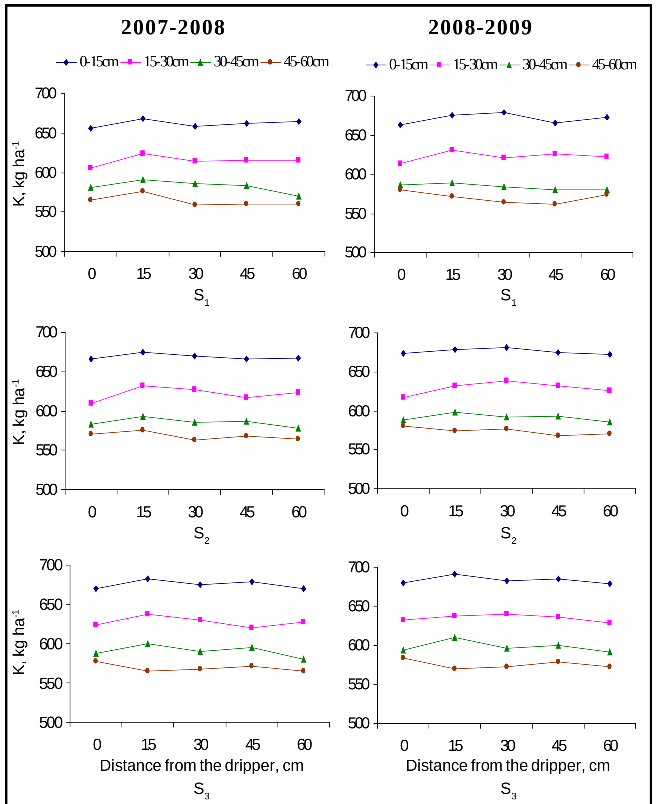

Fig. 1 : Potassium (K, kg ha^{-1}) distribution as influenced by drip irrigation at 0.6 ET with different salinity levels

RESULTS AND DISCUSSION

The maximum available potassium (K) of 667.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 558.5 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm away from dripper point during 2007-'08 in drip irrigation with the irrigation level of 0.6 ET (Fig. 1) under the salinity level-I. Similarly, the highest available K of 675.2 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and lowest K of 561.3 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 45 cm away from dripper point during 2008-'09. In the salinity level-II, the maximum available K of 674.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 563.5 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm away from dripper point during 2007-'08. During 2008-'09 the highest available K, of 678.2 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontally away from the dripper point and lowest K of 567.5 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 45 cm from dripper point. Similarly, the maximum available K of 683 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper and minimum available K of 565 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm from dripper point during 2007-'08 under the salinity level-III. During 2008-'09, the highest K of 691.2 kg ha^{-1} at a horizontal distance of 15 cm in the soil profile of 0-15 cm depth and lowest available K of 570.5 kg ha^{-1} in the soil profile of 45-60 cm at a horizontal distance of 15 cm away from dripper were recorded.

In case of irrigation level of 0.8 ET (Fig. 2) under the salinity level-I, the maximum available K of 662.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 560 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm away from dripper point during 2007-'08 . Similarly, the highest available K of 669.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and lowest K of 560 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 15 cm away from dripper point during 2008-'09. In the salinity level-II, the maximum available K of 675 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 563 kg ha^{-1} in the

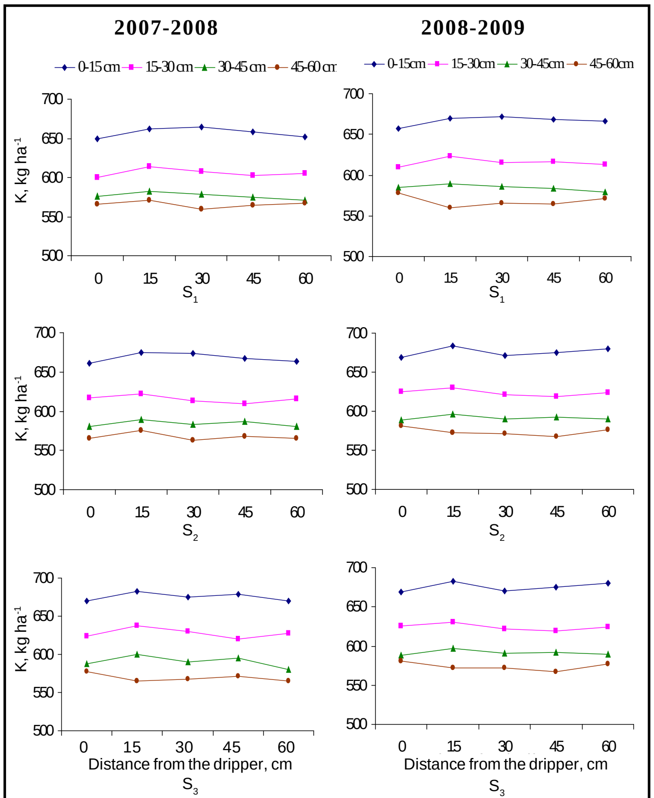

Fig. 2 : Potassium (K, kg ha^{-1}) distribution as influenced by drip irrigation at 0.8 ET with different salinity levels

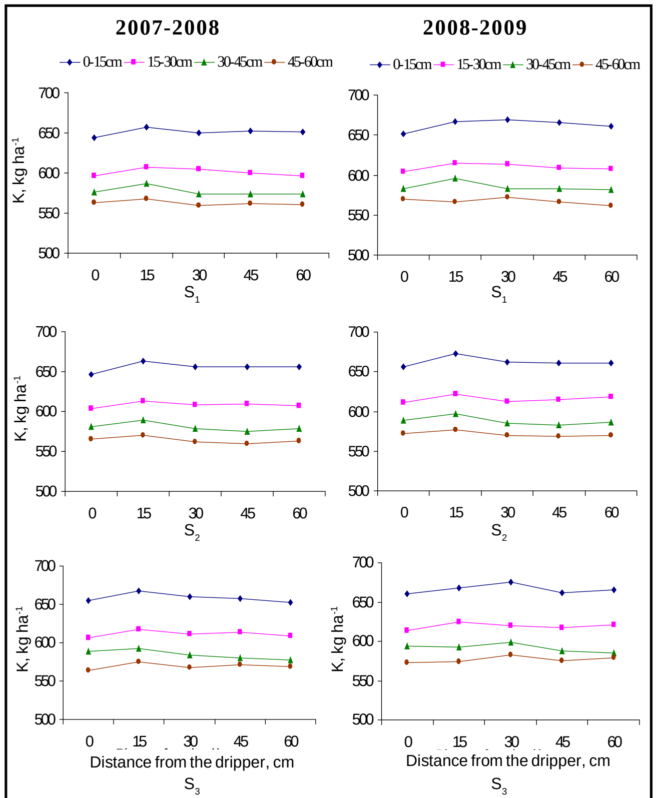

Fig. 3 : Potassium (K, kg ha^{-1}) distribution as influenced by drip irrigation at 1.0 ET with different salinity levels

soil profile of 45-60 cm depth at a horizontal distance of 30 cm away from dripper point during 2007-'08. During 2008-'09 the highest available K, of 683.2 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontally away from the dripper point and lowest K of 567.5 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 45 cm from dripper point. Similarly, the maximum available K of 680.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper and minimum available K of 567 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm from dripper point during 2007-'08 under the salinity level-III. During 2008-'09, the highest K of 687.3 kg ha^{-1} at a horizontal distance of 15 cm in the soil profile of 0-15 cm depth and lowest available K of 573.6 kg ha^{-1} in the soil profile of 45-60 cm at a horizontal distance of 15 cm away from dripper were recorded.

Under the irrigation level of 1.0 ET (Fig. 3) in the salinity level-I, the maximum available K of 657.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 560 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm away from dripper point during 2007-'08 . Similarly, the highest available K, of 666.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and lowest K of 561.5 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 60 cm away from dripper point during 2008-'09. In the salinity level-II, the maximum available K of 663.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 560 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 45 cm away from dripper point during 2007-'08. During 2008-'09 the highest available K, of 672.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontally away from the dripper point and lowest K of 568.2 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 45 cm from dripper point. Similarly, the maximum available K of 667.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper and minimum available K of 564 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm from dripper point during 2007-'08 under the salinity level-III. During 2008-'09, the highest K of 668.5 kg ha^{-1} at a horizontal distance of 15 cm in the soil profile of 0-15 cm depth and lowest available K of 572.5 kg ha^{-1} in the soil profile of 45-60 cm bellow dripper were recorded.

In case of irrigation level of 1.2 ET (Fig. 4) under the salinity level-I, the maximum available K of 648 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 558 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point during 2007-'08 . Similarly, the highest available K of 655.3 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and lowest K of 560.6 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 15 cm away from dripper point during 2008-'09. In the salinity level-II, the maximum available K of 657.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 560.5 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point during 2007-'08. During 2008-'09 the highest available K, of 6588.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontally away from the dripper point and lowest K of 565.3 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 15 cm from dripper point. Similarly, the maximum available K of 661.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper and minimum available K of 563.5 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point during 2007-'08 under the salinity level-III. During 2008-'09, the highest K of 669.5 kg ha^{-1} at a horizontal distance of 15 cm in the soil profile of 0-15 cm depth and lowest available K of 570.4 kg ha^{-1} in the soil profile of 45-60 cm at a horizontal distance of 15 cm away from dripper were recorded.

Similarly in drip irrigation at 1.4 ET (Fig. 5) in the salinity level-I, maximum available K of 656.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 560 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point during 2007-'08. Similarly, the highest available K, of 663.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and lowest K of 560 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 15 cm away from dripper point during 2008-'09. In the salinity level-II, the maximum available K of 661.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper point and minimum available K of 560 kg ha^{-1} in the soil profile of 45-60 cm bellow dripper point

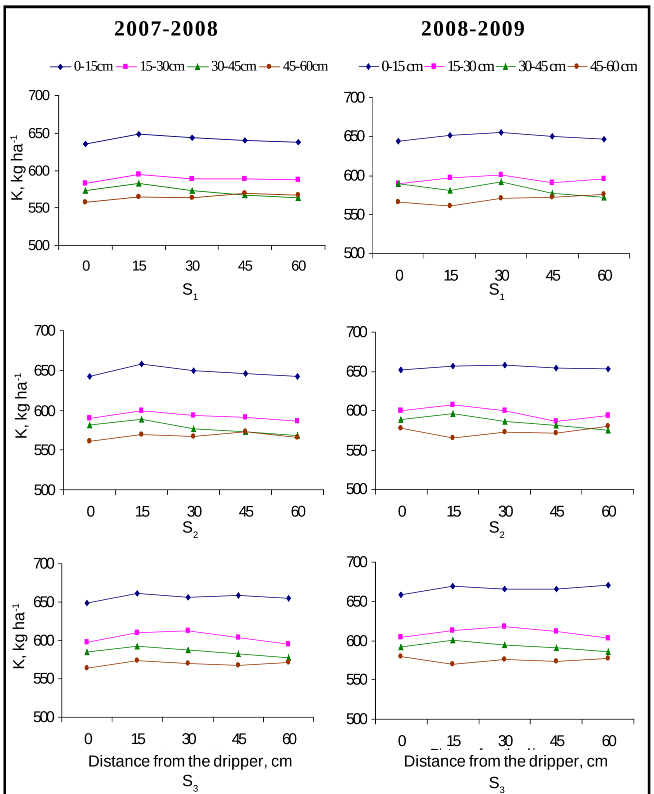

Fig. 4 : Potassium (K, kg ha^{-1}) distribution as influenced by drip irrigation at 1.2 ET with different salinity levels

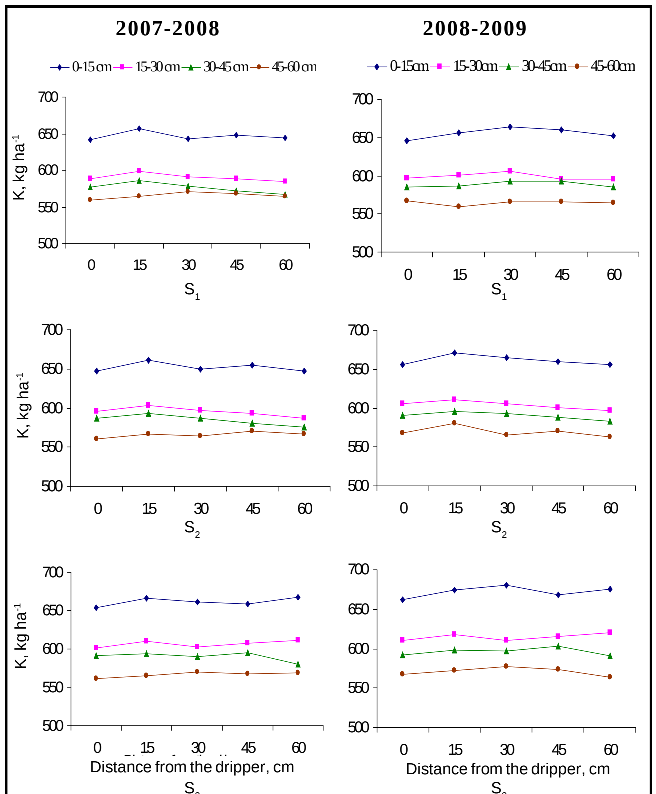

Fig. 5 : Potassium (K, kg ha^{-1}) distribution as influenced by drip irrigation at 1.4ET with different salinity levels

during 2007-'08. During 2008-'09 the highest available K, of 670.5 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontally away from the dripper point and lowest K of 562.5 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 60 cm from dripper point. Similarly, the maximum available K of 666 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 15 cm horizontal distance away from the dripper and minimum available K of 561 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point during 2007-'08 under the salinity level-III. During 2008-'09, the highest K of 680.5 kg ha^{-1} at a horizontal distance of 15 cm in the soil profile of 0-15 cm depth and lowest available K of 563.5 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 60 cm from dripper point were recorded.

Under surface irrigation irrespective al salinity levels, highest K was observed in the soil profile of 0-15 cm depth which, decreased at the lower depths and lowest K was observed in the soil profile of 45-60 cm, depth during both the years of study (Fig. 6).

The above discussion reveals that irrespective of the irrigation and soil salinity levels, the highest available potassium was concentrated in 0 – 15 cm of soil layer .The available potassium decreased with increase in soil depth. These results are in agreement with the findings of Singh *et al*. (2002).

The drip irrigation scheduled at 1.2 ET resulted in the maximum tuber yield of 19.43 and 18.91 t ha^{-1} during 2007-'08 and 2008-'09 (Table 1), respectively. Among the salinity levels, the highest tuber yield of 18.23 and 17.89 t ha^{-1} was recorded in salinity level-I. Whereas among the surface irrigation levels, irrigation at 1.2 ET recorded the highest tuber yield of 12.2 and 11.84 t ha^{-1}. The tuber yield reduced as the salinity increased. The reduction was to the extent of 12 per cent in salinity level-II and 39.7 per cent in salinity level-III as compared to the tuber yield obtained in salinity level-I during 2007-'08 and similarly, the same were 12.8 per cent and 41.3 per cent during 2008-'09. Among all the irrigation levels under both the drip and the surface irrigation methods, 1.2 ET performed better under all the three salinity levels. Similar results were obtained by Rajak *et al.* (2006), Tripathi *et al.* (2010) and Reddy *et al.* (2011). With the foregone discussions, it may be concluded that, adoption of drip irrigation for hybrid

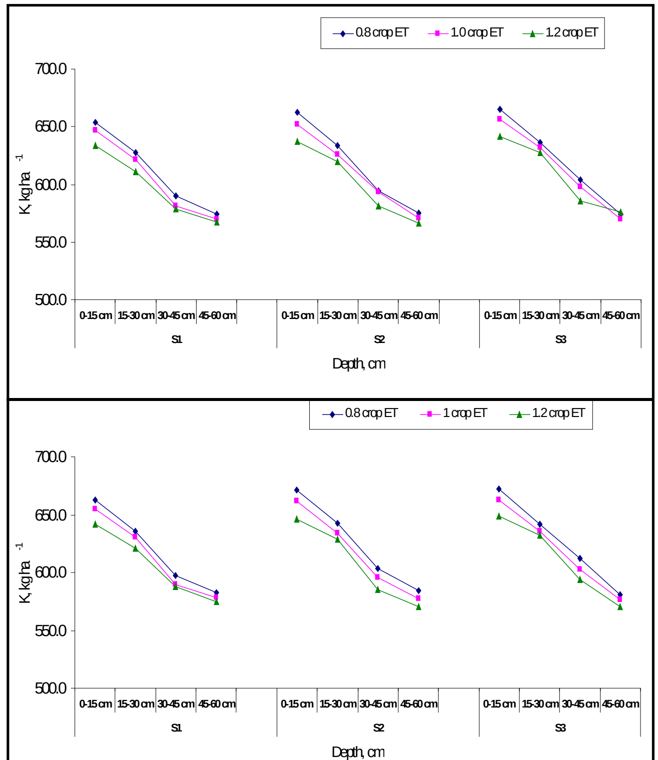

Fig. 6 : Potassium (K, kg ha^{-1}) distribution as influenced by levels of surface irrigation with different salinity levels

Table 1 : Effect of different levels of drip irrigation and surface irrigation on tuber yield, t ha^{-1}

Irrigation levels	2007-'08			Mean	2008-'09			Mean
	Salinity levels				Salinity levels			
	S_1	S_2	S_3		S_1	S_2	S_3	
I_1	19.02	16.53	11.20	15.58	18.47	15.77	10.42	14.89
I_2	20.25	17.58	12.31	16.71	19.77	17.03	11.70	16.16
I_3	21.47	18.80	13.67	17.98	21.02	18.31	13.12	17.48
I_4	22.69	20.42	15.19	19.43	22.25	19.91	14.56	18.91
I_5	21.79	19.12	13.92	18.28	21.28	18.63	13.39	17.77
I_6	12.79	11.05	6.10	9.98	12.42	10.66	5.73	9.60
I_7	13.83	12.09	7.18	11.04	13.34	11.70	6.82	10.62
I_8	14.76	13.19	8.64	12.20	14.54	12.77	8.22	11.84
Mean	18.23	16.04	11.00		17.89	15.60	10.50	
C.D. (P=0.05)	S	I	I X S		S	I	I X S	
	0.33	0.71	NS		0.4	0.8	NS	

S- Salinity levels I- Irrigation levels NS=Non-significant beetroot is a viable proposition for cultivation in salt-affected soils for greater yield with less amount of water.

Authors' affiliations:

M.V. RANGHASWAMI, Department of Soil and Water Conservation Engineering, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

P. BALAKRISHNAN, A.S. College of Agricultural Engineering, University of Agricultural Sciences, RAICHUR (KARNATAKA) INDIA

P. BALAKRISHNAN, Krishi Vigyan Kendra, Hiriyur, CHITRADURGA (KARNATAKA) INDIA

REFERENCES

Rajak, Daleshwar, Manjunatha, M.V., Rajakumar, G.R., Hebbara, M. and Minhas, P.S. (2006). Comparative effects of drip irrigation and furrow irrigation on the yield and water productivity of cotton (*Gossypium hirsutum* L) in saline and waterlogged vertisols. *Agric. Water Mgmt.,* **83** (1-2) : 30-36.

Reddy, Mallikarjun, Ayyanagowdar, M.S., Nemichandrappa, M., Momin, Umarfarooque, Sirajuddin, Horaginamani, M. and Ravichandran, M. (2011). Influence of drip irrigation methods on growth and yield of onion at Raichur region. *Indian J. Natural Sci.,* **8** (2): 580-587.

Sharma, R.C., Singh, Ranbir, Singh, Y.P. and Singh, Gurubachan (2006). Sodic soils of shivrin experimental farm: Site characteristics, reclaimability and use potential for different land uses. Central Soil Salinity Research Institute Bulletin 1/2006, pp. 1-32, Karnal, India.

Singh, A.K., Chakraborty, D., Mishra, P. and Singh, D.K. (2002). Nitrogen and potassium dynamics in fertigation systems.17th WCSS, 14-21 August 2002, Thailand.

Siyal, A.A., Siyal, A.G.. and Abro, Z.A. (2002). Salt-affected soils, their identification and reclaimation. *Pakistan J. Appl. Sci.,* **2** (5): 537-540.

Tiwari, K.N., Singh, Ajay and Mal, P.K. (2003). Effect of drip irrigation on yield of cabbage (*Brassica oleracea* L.var. capitata) under mulch and non-mulch conditions. *Agric. Water Mgmt.,* **58** (1) : 19-28.

Tripathi, P.C., Sankar, V. and Lawande, K.E. (2010). Influence of micro-irrigation methods on growth, yield and storage of *Rabi* onion. *Indian J. Hort*., **67**(1) : 61-65.