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Salt dynamics as influenced by different levels of drip and surface irrigation methods in the rhizosphere of vegetable crop under salt affected vertisols

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■ ABSTRACT : A study was conducted at the Agricultural Research Station, Gangavati, University of Agricultural Sciences, Gangavathi in northern Karnataka, India during *Rabi/*summer, 2007-'08 and 2008-'09 with beetroot (*Beta vulgaris)* as the test crop in saline vertisol. At all levels of irrigation under drip system, the soil pH around the dripper decreased considerably from initial as compared to the same at distances away from the dripper. The upper parts of the soil profiles showed low concentration of salts depending on the applied quantity of water. The higher irrigation regimes recorded the lower soil pH as compared to the lower irrigation regimes. The study indicated that salt content at particular distance from the point of application decreased with increase in depth of applied water and it increased with distance from the same . 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 17.89t 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, Salt distribution, Soil pH

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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 salt 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 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. Irrigation was scheduled based on climatological approachand the daily evapotranspiration (ET) rate of beetroot was estimated using the following equation :

$$ET = Ep \times Kp \times Kc$$

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

$$Q = ET \times A \times B$$

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.

Salt movement :

To determine the salt 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. Electrical conductivity of soil was analysed using conductivity bridge in 1:2.5 soil water suspension.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Drip irrigation:

The minimum soil pH of 8.11 was observed at the dripper point, which increased to 8.29 at 60 cm radial distance and 8.25 at 60 cm vertical depth during 2007-08 in drip irrigation with the irrigation level of 0.6 ET (Fig. 1) under the salinity level-I. Similarly, the lowest soil pH of 8.14 observed at the dripper point, gradually increased to 8.32 radially and 8.23 vertically downwards at a distance 60 cm away from the dripper point during 2008-09. In the salinity level-II, the lowest pH of 8.15 was observed at the dripper point, which gradually rose to 8.33 at 60 cm radial distance and 8.25 at 60 cm vertical depth during 2007-08. During 2008-09 the initial soil pH of 8.168.16 observed at dripper, gradually increased to 8.34 and 8.28 at 60 cm away from the dripper horizontally and vertically, respectively. Similarly, the minimum pH of 8.22 was observed near the dripper point, which gradually increased to 8.35 at 60 cm radial distance and 8.30 at 60 cm vertical depth during 2007-08 in the salinity level-III. The soil pH of 8.23 at the dripper point, increased to 8.39 and 8.32 at 60 cm horizontally and vertically down ward from the dripper during 2008-09.

Under the irrigation level of 0.8 ET (Fig. 2) in the salinity level-I, the minimum soil pH of 8.09 was observed at dripper point, which increased to 8.22 at 60 cm radial distance and 8.20 at 60 cm vertical depth during 2007-08. Similarly, the lowest pH of 8.12 was observed at the dripper point, which gradually increased to 8.28 at 60 cm radial distance and 8.24 at 60 cm vertical depth during 2008-09. In the salinity level-II, the lowest pH of 8.12 at the dripper point, gradually increased

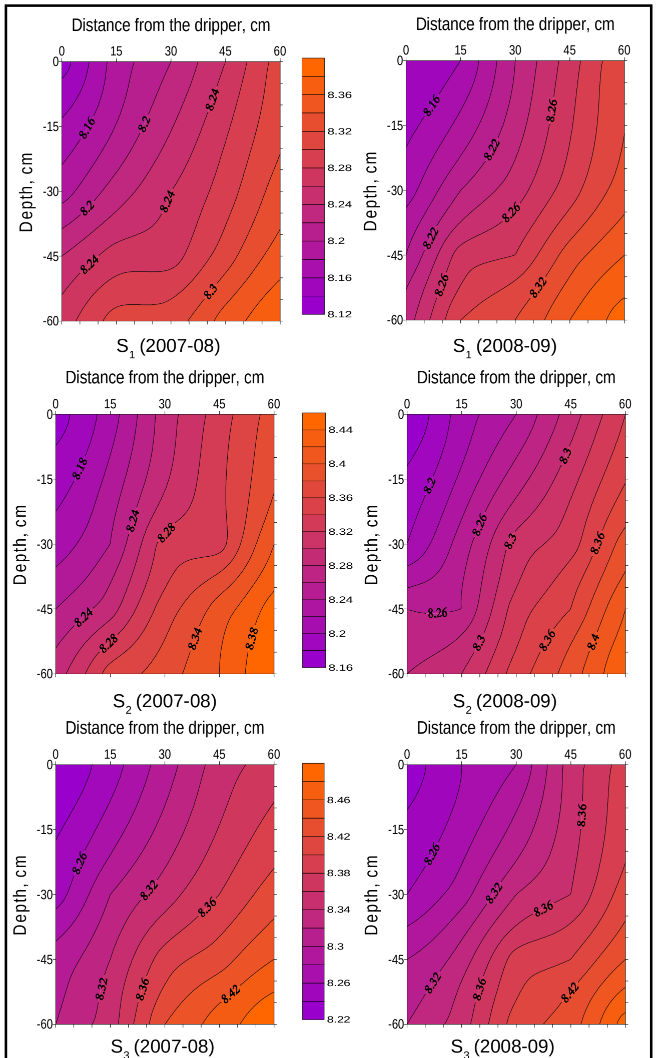

Fig. 1 : Salt concentration (Soil pH) as influenced by drip irrigation at 0.6ET

to 8.26 at 60 cm radial distance and 8.20 at 60 cm vertical depth during 2007-08. During 2008-09, the pH below the dripper was 8.15 which increased to 8.27 at 60 cm radial distance and 8.23 at 60 cm vertical depth. Similarly, the minimum pH of 8.19 was observed near the dripper point, which gradually increased to 8.30 at 60 cm radial distance and 8.27 at 60 cm vertical depth during 2007-08, respectively in the salinity level-III. The soil pH of 8.21 was observed below the dripper, gradually rose to 8.33 at a distance of 60 cm both horizontally and vertically downwards away from the dripper during 2008-09.

In case of irrigation level of 1.0 ET (Fig. 3) under the salinity level-I, the minimum soil pH of 8.07 was observed at the dripper, which increased to 8.15 at 60 cm radial distance and 8.14 at 60 cm depth during 2007-08. Similarly during 2008-09 the soil pH 8.11 at dripper gradually increased to 8.19 at a distance 60 cm away both horizontally and vertically

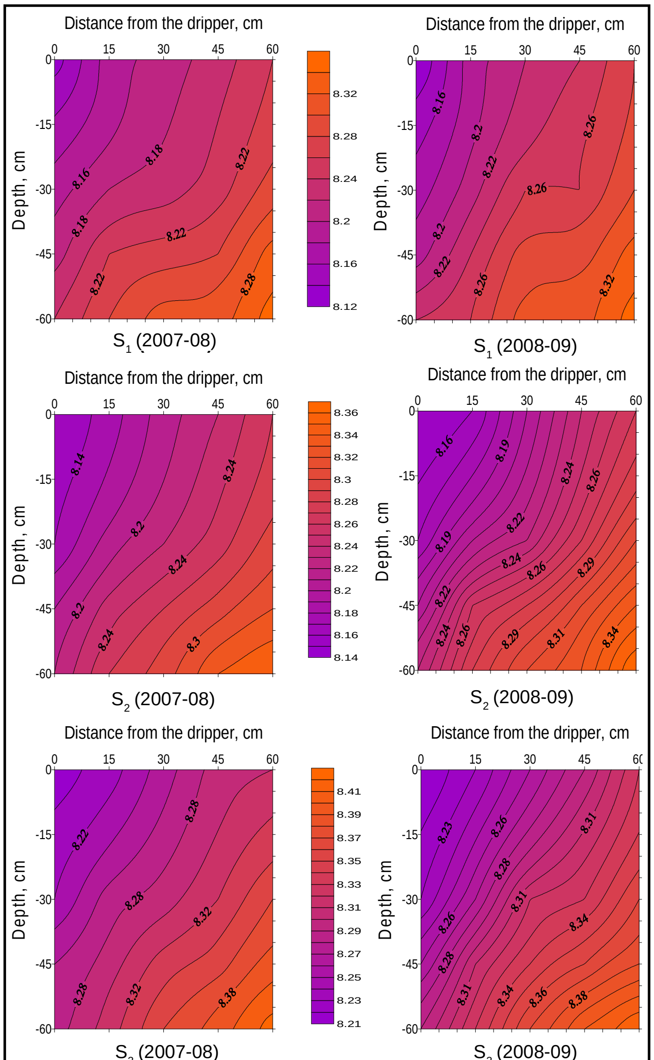

Fig. 2 : Salt concentration (Soil pH) as influenced by drip irrigation at 0.8 ET

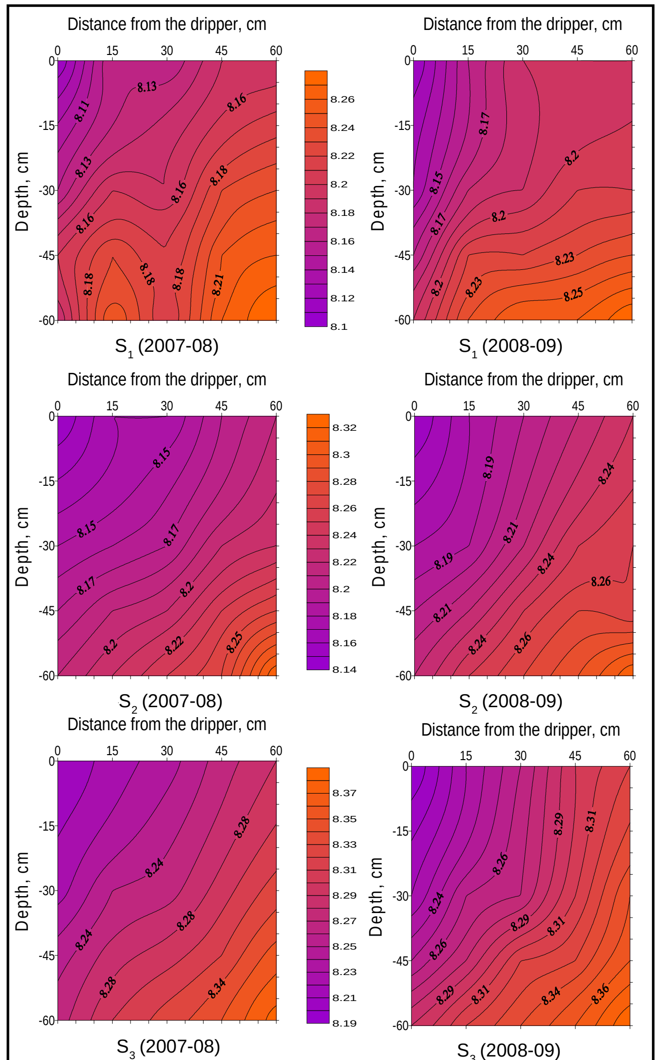

Fig. 3 : Salt concentration (Soil pH) as influenced by drip irrigation at 1.0 ET

downward from the dripper point during 2008-09. In the salinity level-II, the soil pH of 8.11 at the dripper point, gradually increased to 8.19 at 60 cm radial distance as well as at 60 cm vertical depth during 2007-08. During 2008-09, the pH of 8.15 at dripper gradually increased to 8.24 and 8.22 at 60 cm horizontally and vertically downwards away from the dripper, respectively. Similarly, the minimum pH of 8.16 was observed near the dripper point, which gradually increased to 8.28 at 60 cm radial distance and 8.25 at 60 cm vertical depth during 2007-08. During 2008-09, the lowest pH of 8.19 was observed at the dripper point that gradually increased to 8.32 at 60 cm horizontally away and vertically downwards from the dripper, respectively in the salinity level-III.

Under the irrigation level of 1.2 ET (Fig. 4)in the salinity level-I, the minimum soil pH of 8.05 was observed at dripper point, which increased to 8.15 at 60 cm radial distance and 8.12 at 60 cm vertical depth during 2007-08. Similarly, the lowest pH of 8.09 observed at dripper point, gradually increased to 8.17 radially as well as vertically downwards at a distance of 60 cm away from the dripper point during 2008-09. In the salinity level-II, the minimum pH of 8.07 was observed at the dripper point, which gradually increased to 8.17 at 60 cm radial distance and 8.15 at 60 cm vertical depth during 2007-08. During 2008-09, the lowest salinity of 8.13 was observed below dripper gradually increased to 8.22 and 8.20 at a distance of 60 cm horizontally and vertically downwards away from the dripper, respectively. Similarly, the minimum pH of 8.11 was observed near the dripper point, which gradually increased to 8.23 at 60 cm radial distance and 8.20 at 60 cm vertical depth during 2007-08 in the salinity level-III. During 2008-09, the lowest pH of 8.16 was observed at dripper, increased to 8.30 and 8.26 at a distance 60 cm horizontally and vertically downwards away

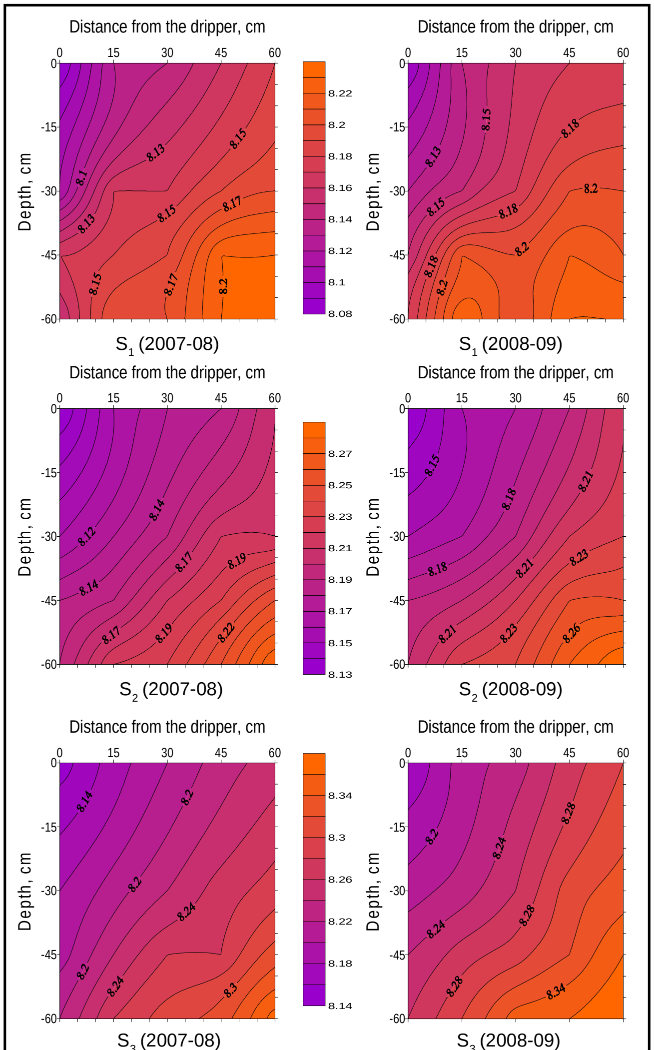

Fig. 4 : Salt concentration (Soil pH) as influenced by drip irrigation at 1.2 ET

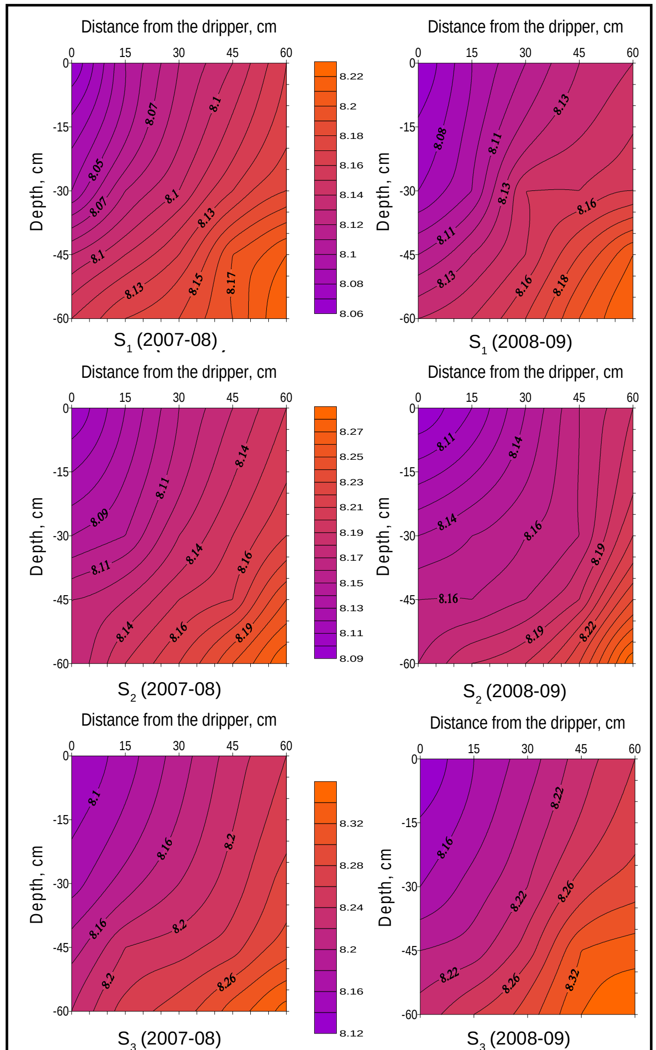

Fig. 5 : Salt concentration (Soil pH) as influenced by drip irrigation at 1.4 ET

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 from the dripper, respectively.

Similarly in drip irrigation at 1.4 ET (Fig. 5)in the salinity level-I, the minimum soil pH of 8.0 was observed at dripper point, which increased to 8.13 at 60 cm radial distance and 8.12 at 60 cm vertical depth during 2007-08. Similarly the least soil pH of 8.09 observed at dripper point, increased to 8.14 at 60 cm both radial distance and vertical depth during 2008-09. In the salinity level-II, the lowest pH of 8.05 was observed at dripper point, which gradually increased to 8.15 at 60 cm radial distance and 8.12 at 60 cm vertical depth during 2007-08. During 2008-09 the lowest soil pH of 8.09 was observed below dripper gradually increased to 8.19 and 8.17 at a distance of 60 cm horizontally and vertically downwards away from the dripper, respectively. Similarly, the minimum pH of 8.08 was observed near dripper point, which increased to 8.22 at 60 cm radial distance and 38.18 at 60 cm vertical depth during 2007-'08 in the salinity level-III. The least soil pH of 8.12 observed at dripper point, increased to 8.26 at 60 cm radial distance and 8.23 at 60 cm vertical depth during 2008-09.

Surface irrigation:

In salinity level-I, the maximum soil pH of 8.19 at 60 cm depth and minimum salinity of 8.12 at 15 cm depth were observed at irrigation level of 0.8 ET during 2007-08. Similarly, during 2008-09 the highest soil pH of 8.17 at 60 cm depth and at least pH of 8.15 at 15 cm depth were noticed. Under the salinity level-II, the lowest pH of 8.16 was observed at 15 cm depth which gradually increased to 8.23 at 60 vertical distance during 2007-08. During 2008-09, the minimum pH of 8.17 at 15 cm depth and the maximum of 8.24 at 60 cm depth were noticed. Similarly, the minimum pH of 8.19 and 8.20 at 15 cm, and the maximum of 8.29 and 8.31 at 60 cm vertical depth during2007-'08 and 2008-09, respectively in the salinity level-III. The salt accumulation was observed more in 0.80 ET than 1.0 and 1.2 ET. This was due to less volume of water applied at 0.8 ET compared to 1.0 and 1.2 ET, which was just sufficient for crop evapotranspiration and inadequate for removable of salts. Therefore, accumulation of salts was noticed. Among the salinity levels, salt concentration was more in salinity level-III than the other salinity levels especially at 0.8 ET level of irrigation.

The above discussion reveals that in drip irrigation, irrespective of the levels of irrigation, the soil salinity around the dripper was minimum as compared to the distance far away from the dripper and below it. The salts were pushed beyond the root zone as the volume of applied water increased.

The salinity increased to a maximum value close to the wetting front. Similar findings were reported by Moolman (1988) and Abu-Awwad and Hill (1991). The salt content was low near the dripper and increased towards the periphery from the emitter in all the drip irrigated treatments. These results are in line with the results obtained by Fulzele (1994), Bharambe *et al.* (2001) and Kamel Nagaz *et al.* (2007). The salt concentration occurred more in the profile irrigated with 0.6 ET and 0.8 ET and less salt concentration was observed with 1.2 and 1.4 ET. In surface irrigation salt accumulation was more in 0.8 ET than 1.0 and 1.2 ET. These results corroborate the results obtained by Manjunath *et al.* (2004). Among the salinity levels, salt concentration was more in salinity level-III than the other salinity levels especially at 0.8 ET level of irrigation.

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 beetroot is a viable proposition for cultivation in salt-affected soils for greater yield with less amount of water.

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