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Nutrient dynamics as influenced by different levels of drip and surface irrigation methods in the rhizosphere of beetroot crop under saline vertisols

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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 nitrogen 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

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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.

Water logging 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). 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 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 was 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.

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 approach and 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.

Fertilizer application for surface irrigation :

For the experimental plot, recommended dose of inorganic fertilizers 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 fertilizers are given below :

Table A : Split application of fertilizers

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

Nutrient dynamics :

To determine the nitrogen dynamics, 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.

RESULTS AND DISCUSSION

The maximum available nitrogen (N) of 188 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 N of 128 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 15 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 N of 195 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper point and lowest N of 134 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point during 2008-'09. In the salinity level-II, the maximum available N of 191 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 N of 132 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point during 2007-'08. During 2008-'09 the highest available N of 195 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 N of 136 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point. Similarly, the maximum available N of 192 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 N of 136 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 15 cm from dripper point during 2007-'08 under the salinity level-III. During 2008-'09, the highest N of 205 kg ha^{-1} at a horizontal distance of 15 cm in the soil profile of 0-15 cm depth and lowest available N of 139 kg ha^{-1} in the soil profile of 45-60 cm bellow dripper were recorded.

In case of irrigation level of 0.8 ET (Fig. 2) under the salinity level-I, the maximum available N of 181 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 N of 130 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 15 cm away from dripper point during 2007-'08 . Similarly, the highest available N of 186 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper point and lowest N of 133 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point during 2008-'09. In the salinity level-II, the maximum available N of 184 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper point and minimum available N of 131 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 N, of 195 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontally away from the dripper point and lowest N of 132 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 N of 185 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 N of 135 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 60 cm from dripper point during 2007-'08 under the salinity level-III. During 2008-'09, the highest N of 196 kg ha^{-1} at a horizontal distance of 30 cm in the soil profile of 0-15 cm depth and lowest available N of 136 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point were recorded.

Under the irrigation level of 1.0 ET (Fig. 3) in the salinity level-I, the maximum available N of 173 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 N of 125

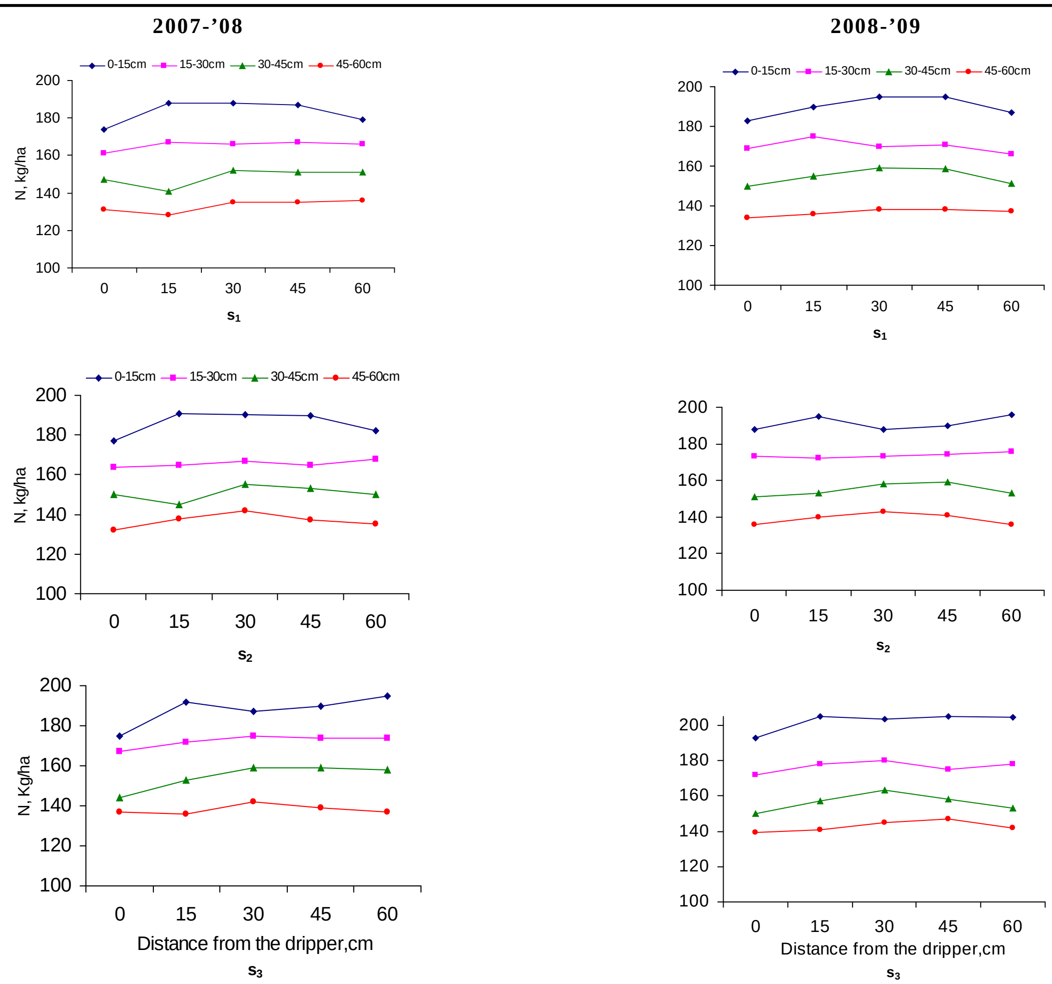

Fig. 1 : Nitrogen (N, kg ha^{-1}) dynamics as influenced by drip irrigation at 0.6 ET with different salinity levels

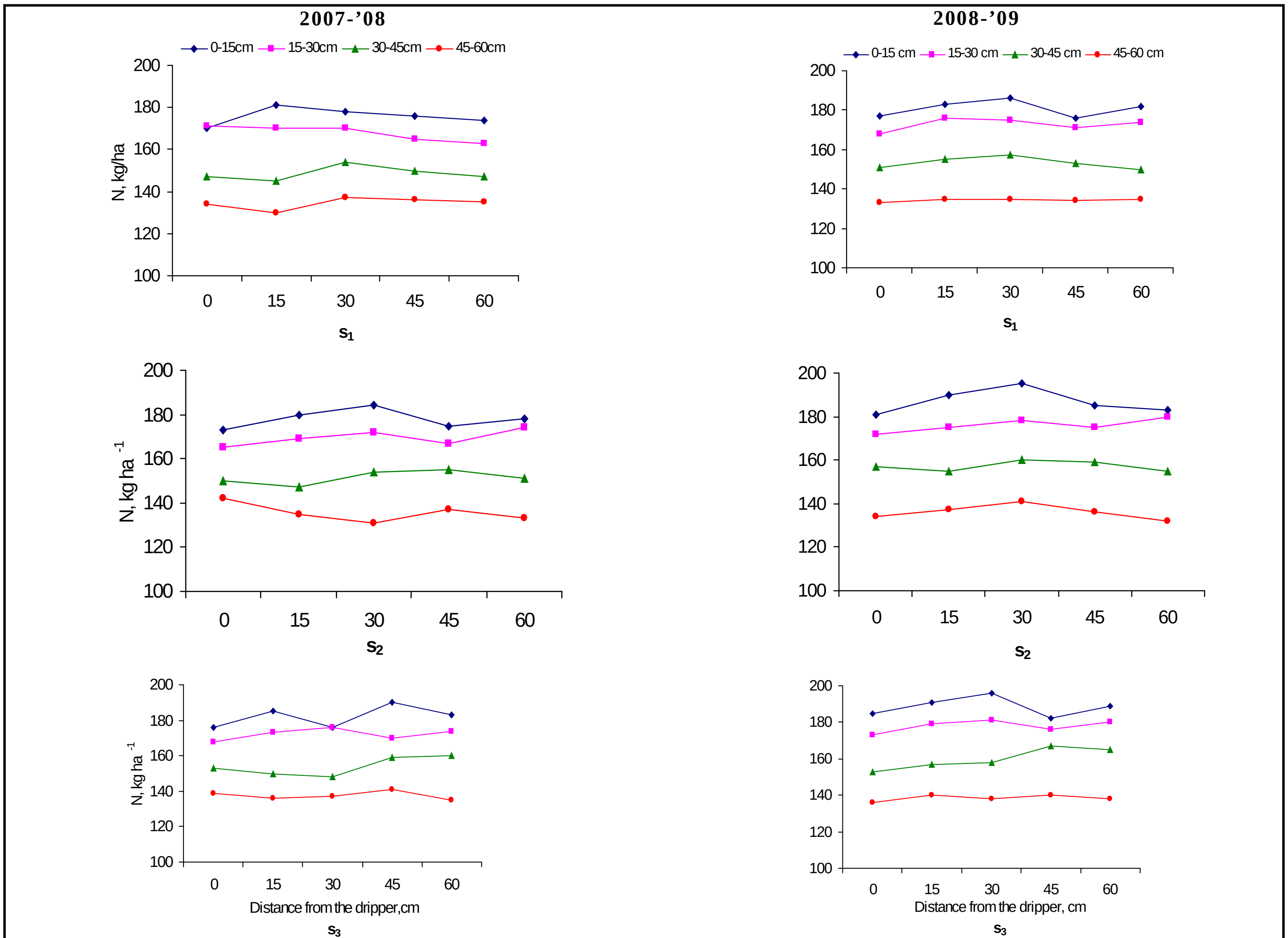

Fig. 2 : Nitrogen (N, kg ha^{-1}) dynamics as influenced by drip irrigation at 0.8 ET with different salinity levels

kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 60 cm away from dripper point during 2007-08. Similarly, the highest available N, of 179 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper point and lowest N of 128 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 N of 178 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper point and minimum available N of 129 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 N, of 185 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontally away from the dripper point and lowest N of 133 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 N of 181 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper and minimum available N of 131 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 N of 188 kg ha^{-1} at a horizontal distance of 30 cm in the soil profile of 0-15 cm depth and lowest available N of 135 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 N of 164 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 60 cm horizontal distance away from the dripper point and minimum available N of 127 kg ha^{-1} in the soil profile of 45-60 cm depth at 60 cm horizontal distance away from the dripper point during 2007-08. Similarly, the highest available N of 172 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper point and lowest N of 132 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm away from dripper point during 2008-09. In the salinity level-II, the maximum available N of 170 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper point and minimum available N of 129 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point during 2007-'08. During 2008-'09 the highest available N, of 177 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontally away from the dripper point and lowest N of 136 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point. Similarly, the maximum available N of 173 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper and minimum available N of 131 kg ha^{-1} in the soil profile of 45-60 cm depth at 15 cm horizontal distance away from the dripper point during 2007-'08 under the salinity level-III. During 2008-'09, the highest N of 181 kg ha^{-1} at a horizontal distance of 30 cm in the soil profile of 0-15 cm depth and lowest available N of 135 kg ha^{-1} in the soil profile of 45-60 cm depth bellow dripper point were recorded.

Similarly in drip irrigation at 1.4 ET (Fig. 5) in the salinity level-I, maximum available N of 172 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 N of 132 kg ha^{-1} in the soil profile of 45-60 cm depth at 60 cm horizontal distance away from the dripper point during 2007-'08 . Similarly, the highest available N, of 176 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 N of 134 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 N of 178 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 N of 134 kg ha^{-1} in the soil profile of 45-60 cm bellow dripper point during 2007-'08. During 2008-'09 the highest available N, of 182 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 45 cm horizontally away from the dripper point and lowest N of 136 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm from dripper point. Similarly, the maximum available N of 178 kg ha^{-1} was observed in the soil profile of 0-15 cm depth at 30 cm horizontal distance away from the dripper and minimum available N of 132 kg ha^{-1} in the soil profile of 45-60 cm depth at 30 cm horizontal distance away from the dripper point during 2007-'08 under the salinity level-III. During 2008-

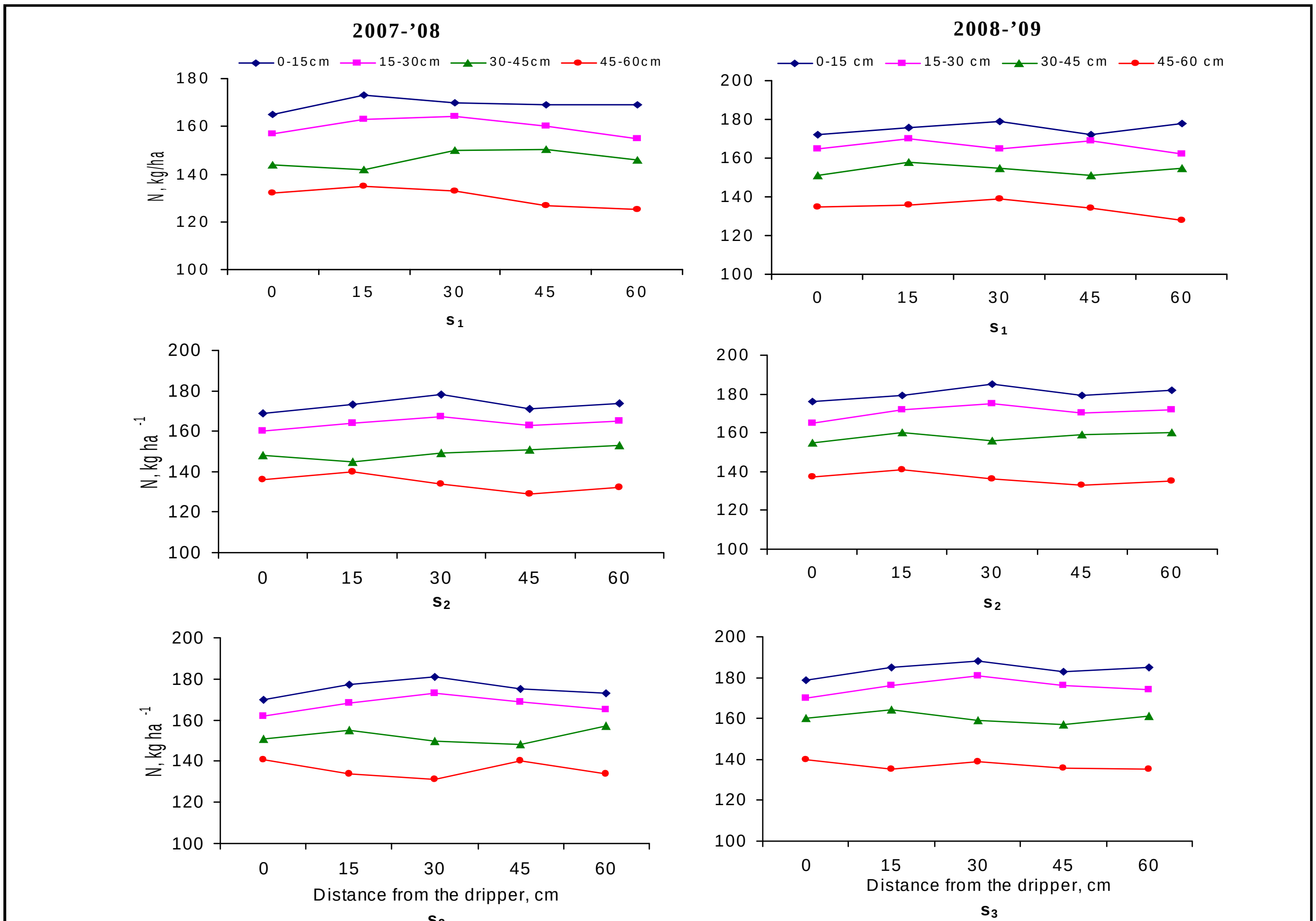

Fig. 3 : Nitrogen (N, kg ha^{-1}) dynamics as influenced by drip irrigation at 1.0 ET with different salinity levels

'09, the highest N of 185 kg ha^{-1} at a horizontal distance of 30 cm in the soil profile of 0-15 cm depth and lowest available N of 136 kg ha^{-1} in the soil profile of 45-60 cm depth at a horizontal distance of 30 cm from dripper point were recorded. Similar work on the related paper were also done by Ahlwalia *et al*., 1993 on tomato and cauliflower, Antony and Singandhupe, 2004 on capsicum, Tognetti *et al.*, 2003 and Cassel *et al*., 2001 on sugerbeets, Hartz *et al.*, 2005 on tomato, Ravi *et al*., 2007

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

Irrigation levels	2007-'08 Salinity levels			Mean	2008-'09 Salinity levels			Mean
	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

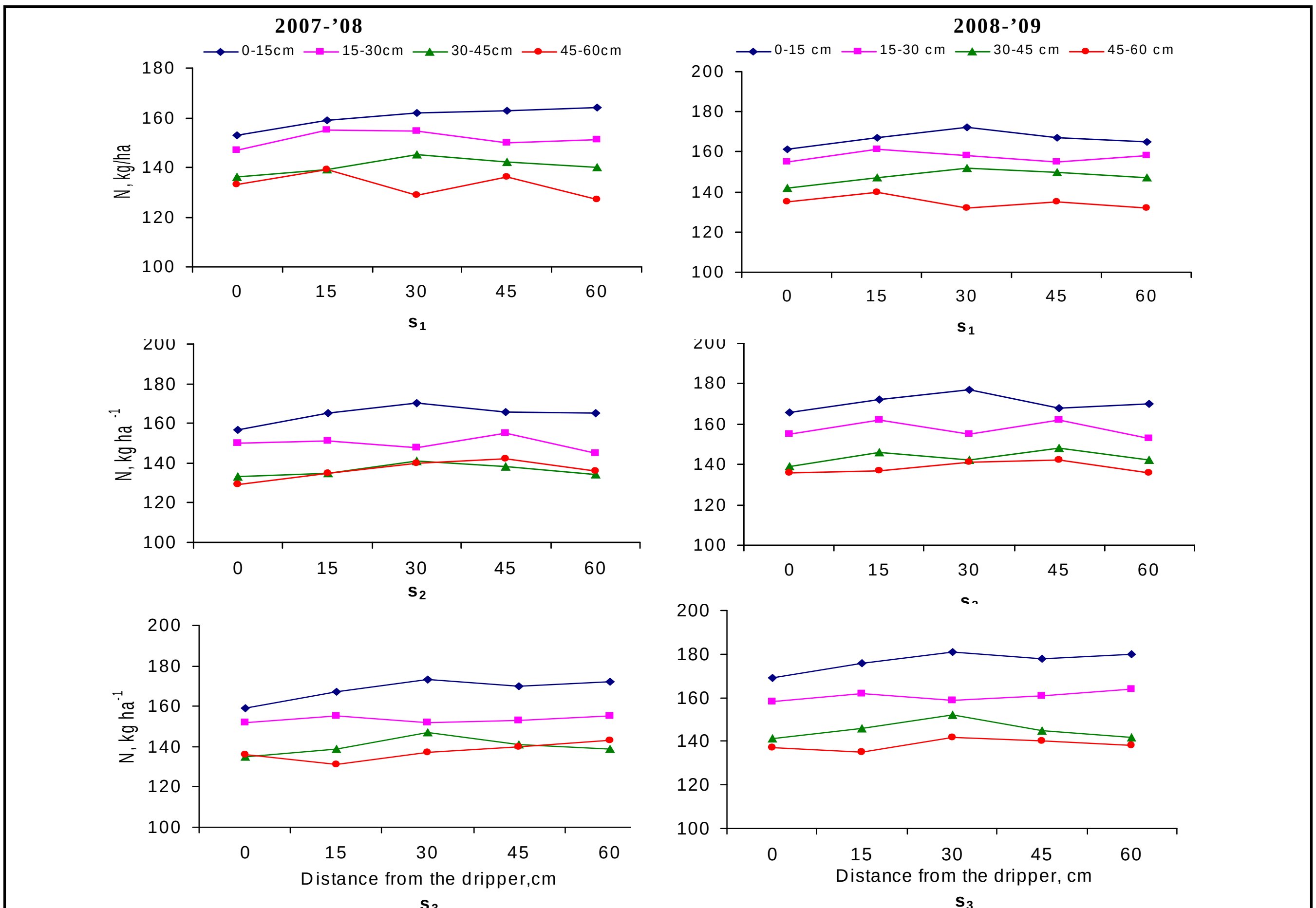

Fig. 4 : Nitrogen (N, kg ha^{-1}) dynamics as influenced by drip irrigation at 1.2 ET with different salinity levels

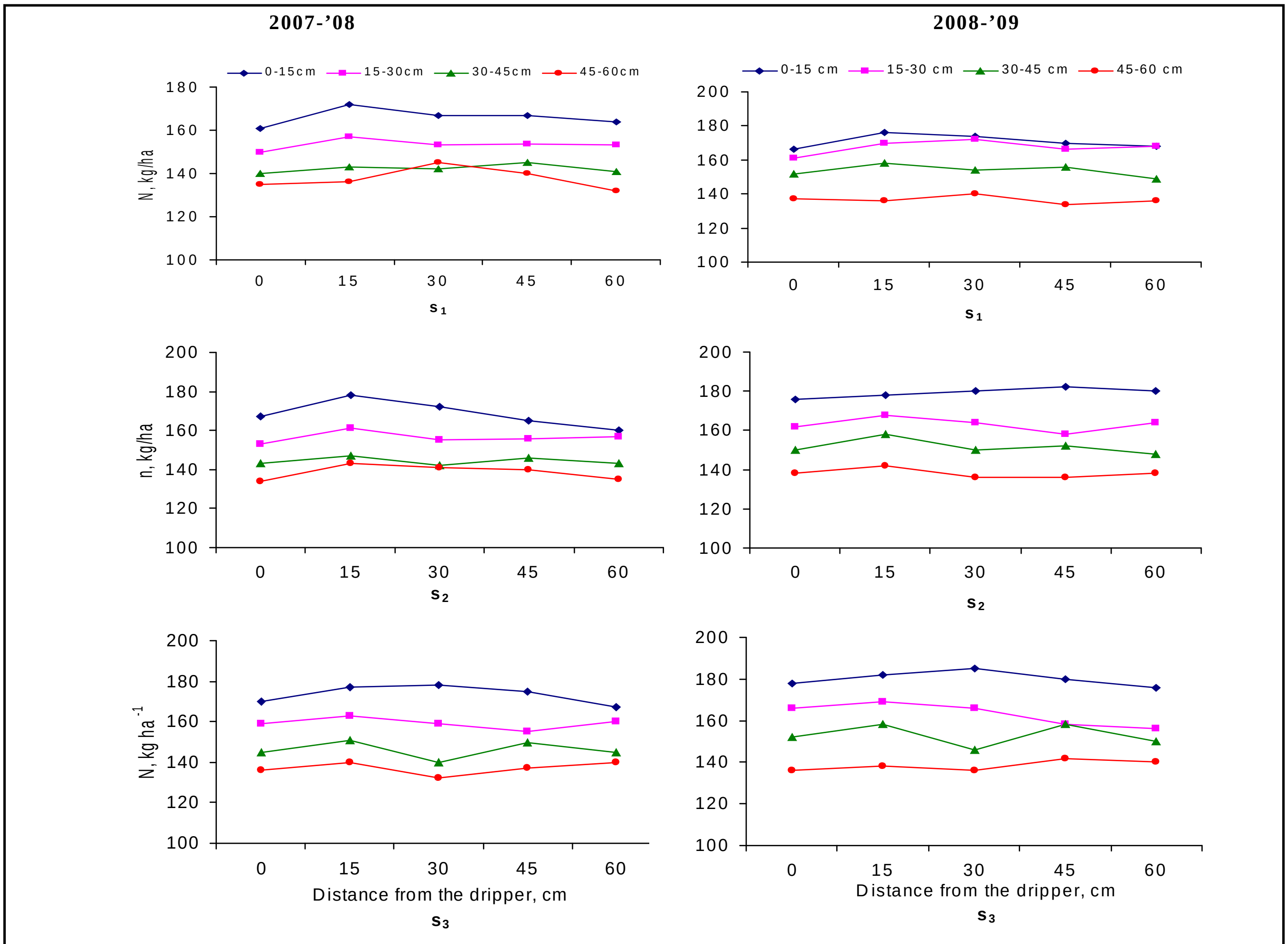

Fig. 5 : Nitrogen (N, kg ha^{-1}) dynamics as influenced by drip irrigation at 1.4 ET with different salinity levels

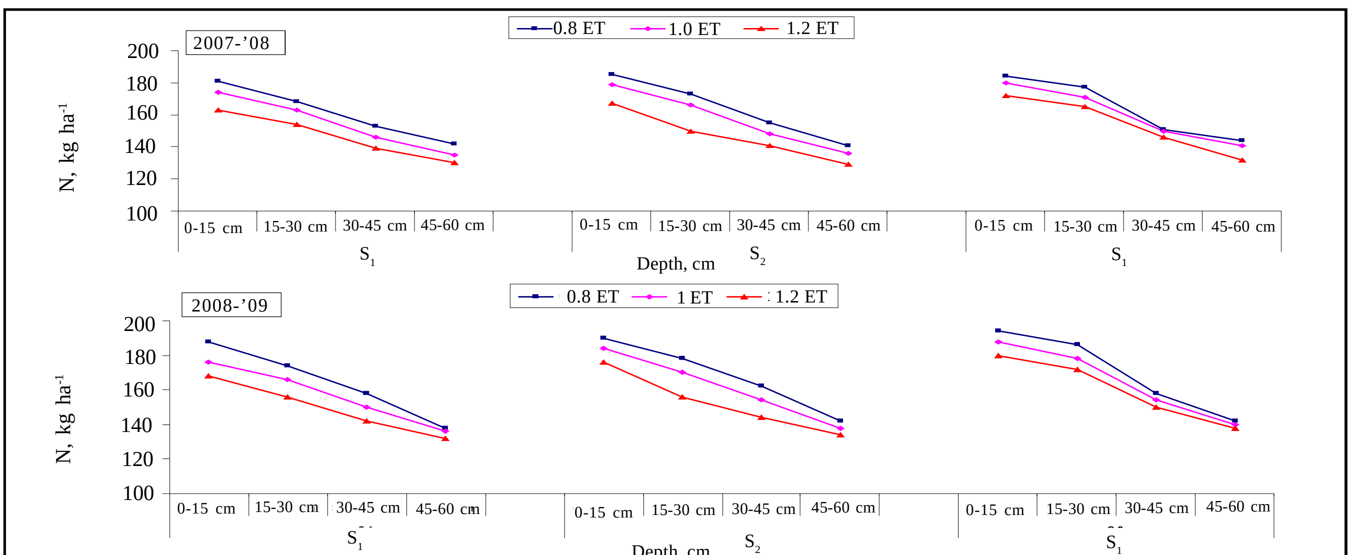

Fig. 6 : Nitrogen (N, kg ha^{-1}) dynamics as influenced by surface irrigation with different salinity levels

on arecanut.

Under surface irrigation irrespective al salinity levels, highest N was observed in the soil profile of 0-15 cm depth which, decreased at the lower depths and lowest N 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 nitrogen 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); Aujla *et al.*, 2005 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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