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Effect of Depth and Frequency of Saline Well Water Irrigation and FYM on Yield of Wheat-Maize-Groundnut/Paddy Cropping Sequence on Two Calcareous Sodic Soils of Coastal Belt

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ABSTRACT

A field experiment was conducted on fixed plots on shallow red soil of the Shil farm and medium black soil of the Metra farm, located on the coastal belt of Junagadh district in Gujarat to study the effect of frequency (D_1-12 days and D_2-8 days) and Depth L_0-4 cm and L_1-6 cm at Shil farm and 8 cm at Metra farm) of poor quality well waters (EC 4.4 to 5.9 dSm^{-1} at Shil farm and 4.9 to 6.4 dS m^{-1} at Metra farm) in conjunction with FYM(F_0-0 and F_1-25 Mg ha^{-1} FYM) on yields of wheat (Rabi), maize fodder (Summer) and groundnut at Shil/Paddy at Metra (kharif) grown in a sequence and on soil properties. The mean of the three years results showed that frequent irrigation (i.e. after 8 days) of larger depth (i.e. 6 cm) in the presence of FYM (25 Mg ha^{-1}) significantly increased grain and straw yield of wheat and fodder yield of maize over less frequent irrigation (i.e. after 12 days) of shallower depth (i.e. 4 cm) in the absence of FYM at the Shil farm. The D_2L_1 treatment not only produced maximum yield of these crops but also sustained the productivity of the succeeding kharif crops of groundnut at Shil and paddy at Metra farm.

The larger depth of irrigation significantly reduced the EC of the subsoil layers. FYM also produced same effect after monsoon at Metra farm. However, application of FYM significantly increased ESP of surface layer after monsoon at Shil farm.

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INTRODUCTION

Ingress of sea water in the ground water along the coastal belt of Saurashtra region of Gujarat State posed a serious problem of poor quality of well waters (Anon, 1986). The productivity of both the soils and crops of these areas has been declining with the continuous use of these poor quality well waters. The effectiveness of the ameleorative measures for use of such waters varies with quality of water, type of soil, crop, management practices and climatic conditions. Hence the suitability of particular water varies with location to location depending on the above factors. Therefore, it is essential to develop a location specific technology. The good management for the use of saline well waters in right quantity and frequency alongwith use of amendments help in sustaining the productivity of both the soil and crop (Manchanda *et al.*, 1985, Keshwa and Singh, 1988). Keeping this in view a field experiment was conducted during 1981 to 1983 at two locations of the coastal belt area of Saurashtra to study the effect of depth and frequency of irrigation with poor quality well

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waters and FYM on yield of different crops grown in rotation and soil properties.

MATERIALS AND METHODS

The soil of the Shil farm was shallow, stony, red and well drained (Entisol), while that of Metra farm was medium black (Inceptisol) calcareous fine alluvium moderately drained. The properties of the experimental soils and the periodic quality of well waters used are reported in tables 1 and 2, respectively. The eight treatment combinations consisted of three factors each of two levels, viz., frequency (D_1-12 and D_2-8 days for wheat and D_1-15 and D_2-10 days for maize fodder) in the main plots and depth (L_0-4 cm and L_1-6 cm at Shil and 8 cm at Metra) of irrigation waters in the sub plots and FYM (F_0-0 and F_1-25 Mg ha^{-1}) in the sub-sub plots were replicated 4 times in a split-split-plot design. Crop rotations wheat-maize-groundnut at Shil and wheat-maize- paddy at Metra were followed. Farmyard manure was applied every year to wheat (J 24) crop before sowing. The residual effect of FYM was studied with irrigation treatments on maize (Ganga Safed 2) in summer and that of all the treatments on groundnut (GAUG 10) and Paddy (IET 6278) in kharif.

The recommended agronomic practices (seed rate, spacing, fertiliser dose etc.) were followed for the respective crop. The irrigation schedule as per the treatments was followed for irrigating wheat and maize. Groundnut and paddy were rainfed. However, one or more protective irrigations were given to these

TABLE 1

Initial physico-chemical properties of the experimental soil.

Characteristic	*Depth of soil (cm)*				
	METRA FARM			*SHIL FARM*	
	0-15	*15-30*	*30-45*	*0-15*	*15-30*
Physical					
Stone (%)	10.3	6.8	13.5	16.1	62.1
Sand (%)	26.5	33.7	35.0	22.0	14.6
Silt (%)	18.5	14.2	2.4	19.6	19.7
Clay (%)	55.0	52.1	52.6	58.4	65.7
Textural class	Clay	Clay	Clay	Clay	Clay
Bulk density (g cm^{-3})	1.51	1.50	1.66	1.3	---
Chemical					
Lime (%)	48.3	58.3	67.5	8.8	15.5
Organic C. (%)	0.78	0.33	0.36	0.78	0.70
CEC (C mol (P^+) kg^{-1})	46.5	38.6	37.4	40.4	42.1
pHs	8.5	8.3	8.2	7.9	8.1
pH (1:2.5)	7.6	7.6	7.6	7.2	7.1
ECe (dS m^{-1})	1.9	1.8	1.9	3.1	2.4
EC (1:2.5) (dS m^{-1})	0.64	0.47	0.45	0.59	0.47
Exchangeable cation (C mol $(P)^+$ kg^{-1})					
Ca	18.20	13.74	13.22	22.25	22.43
Mg	8.23	6.93	5.85	7.19	9.02
Na	19.23	17.51	17.85	10.18	10.05
K	0.84	0.46	0.45	0.76	0.64
ESP	41.36	45.31	47.46	25.21	23.84

TABLE 2

Quality of saline well water used for irrigation during Nov. 1980 to May 1983

Characteristic	Metra farm	Shil farm
EC (1:2.5) (dS m^{-1})	4.9 - 6.4	4.4 - 5.9
pH (1:2.5)	7.1 - 8.7	7.2 - 8.3
SSP	64.2 - 80.0	34.3 - 48.0
SAR (C mol kg^{-1})	10.6 - 20.0	3.9 - 7.0

SSP - Soluble sodium percentage.

crops depending on rainfall conditions. In the first year, moog was taken in summer at both the places but due to its failure, it was substituted by maize in the subsequent two years. The yield of paddy crop for the third year was not included for statistical analysis as this crop was demaged by the cyclone. The annual rainfall was 1066, 617 and 1794 mm during the years 1981, 1982 and 1983, respectively.

The composite soil sample were collected before the start of the experiment as well as after harvest of each crop from different depths (0-15 and 15-30 cm at Shil and 0-15, 15-30 and 30-45 cm at Metra). The well water samples were collected periodically. The soil samples were analysed for their physico-chemical properties and water samples for EC, pH, anions and cations as per the methods discribed by Piper (1950) and Richards(1954).

RESULTS AND DISCUSSION

Effect on crop yield

Main effect : The data (Table 3) for individual years as well as pooled yield of all the crops of both the sites revealed that, in general, the average yields of both the irrigated crops grown on shallow red soils at Shil farm were significantly affected by all the main effects, except FYM. On the other hand in the medium black soil at Metra farm, irrigation frequency and FYM have significantly affected the mean straw yield of wheat and green fodder yield of maize. The pooled data revealed that the crops irrigated at shorter interval than longer interval, with greater depth than lower depth and with FYM (@ 25 Mg ha^{-1}) against no FYM produced significantly higher yields.

The frequency as well as depth of irrigation did not produce any adverse effect on the yield of paddy at the Metra farm and groundnut at Shil farm. Similarly, FYM also failed to produce any significant effect on these crops, except pod yield of groundnut at Shil farm where it was increased significantly with the FYM (Table 4).

The beneficial effect of more frequent and deeper depth of irrigation with saline waters in wheat is attributed to better moisture regime and low accumulation of salts in the root zone particularly in shallow red soils at the Shil farm. Though, frequent irrigation to maize did not increased mean green fodder yield significantly in individual years, but its average effect was found significant at both the sites. The favourable residual effect of FYM on groundnut yield is ascribed to better physical conditions of fruiting zone soil resulting in increased water holding capacity (Biswas *et al.*, 1969) which help in easy peg penetration and better pod development. Unlike other field crops, groundnut being geotropism, needs soft and moist soil conditions in the fruiting zone. The nonsignificant residual effect of irrigation treatment on kharif crops could be due to leaching of salts from the root zone leading to almost normal conditions as before the start of the experiment. This is also evident from Fig. 1.

TABLE 3

Effect of frequency and depth of irrigation water and FYM on the yearwise and pooled yields (Mg ha^{-1}) of wheat and maize.

Treatment	Wheat grain yield				Wheat straw yield				Maize green fodder yield		
	1980-1981	1981-1982	1982-1983	Mean	1980-1981	1981-1982	1982-1983	Mean	1982	1983	Mean
					METRA FARM						
D_1	2.63	3.73	3.36	3.24	3.13	4.42	4.35	3.96	13.9	9.5	11.7
D_2	3.16	3.80	3.56	3.51	3.84	4.71	4.96	4.50	17.1	14.4	15.8
C. D. (0.05)	0.20	NS	NS	NS	0.40	NS	NS	0.26	NS	NS	3.1
L_0	2.79	3.72	3.51	3.34	3.38	4.44	4.78	4.20	14.2	11.2	12.7
L_1	2.99	3.81	3.41	3.41	3.59	4.69	4.57	4.27	16.8	12.7	14.8
CD (0.05)	0.20	NS	NS	NS	0.22	NS	0.23	NS	NS	NS	NS
F_0	2.85	3.75	3.46	3.35	3.36	4.41	4.59	4.12	14.3	10.6	12.5
F_1	2.95	3.77	3.46	3.39	3.61	4.72	4.72	4.35	16.8	13.3	15.0
CD (0.05)	NS	NS	NS	NS	0.23	NS	NS	0.19	2.2	2.1	1.5
					SHIL FARM						
D_1	2.32	3.62	2.16	2.70	2.62	4.23	3.56	3.47	4.81	6.16	4.98
D_2	3.24	4.15	3.04	3.47	3.46	4.56	4.56	4.20	6.27	9.22	8.25
CD (0.05)	0.40	0.31	0.20	0.59	0.60	NS	0.58	0.23	NS	1.89	1.92
L_0	2.47	3.79	2.44	2.88	2.71	4.36	3.79	3.62	4.49	4.73	4.62
L_1	3.09	4.00	2.77	3.28	3.37	4.44	4.34	4.05	6.59	10.68	8.61
CD (0.05)	0.41	NS	0.15	0.15	0.50	NS	0.45	0.25	1.98	1.38	1.9
F_0	2.69	3.78	2.49	2.99	2.96	4.26	3.96	3.73	5.29	6.39	5.84
F_1	2.87	3.96	2.72	3.18	3.12	4.59	4.16	3.94	5.79	8.99	7.39
CD (0.05)	0.13	NS	NS	0.12	NS	0.22	NS	0.21	NS	1.52	NS

TABLE 4

Residual effect of frequency and depth of irrigation water and FYM on the yearwise and pooled yields (mg ha^{-1}) of paddy and groundnut.

Treatment	Paddy yield (Metra farm)						Groundnut yield (Shil farm)							
	Grain			Straw			Pod				Haulm			
	1981	1982	Mean	1981	1982	Mean	1981	1982	1983	Mean	1981	1982	1983	Mean
D_1	3.02	2.63	2.83	2.89	2.65	2.77	1.34	1.00	1.24	1.19	2.66	1.53	2.52	2.24
D_2	2.85	2.46	2.66	2.80	2.57	2.68	1.39	1.03	1.22	1.21	2.68	1.49	2.38	2.19
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
L_0	2.84	2.51	2.68	2.81	2.54	2.67	1.32	1.00	1.20	1.17	2.60	1.58	2.39	2.19
L_1	3.03	2.58	2.81	2.88	2.69	2.78	1.41	1.03	1.26	1.23	2.74	1.43	2.52	2.23
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F_0	2.77	2.44	2.61	2.60	2.65	2.63	1.32	0.92	1.15	1.12	2.26	1.52	2.27	2.15
F_1	3.10	2.66	2.88	3.09	2.57	2.83	1.41	1.12	1.32	1.18	2.68	1.50	2.64	2.28
CD (0.05)	NS	NS	NS	0.30	NS	NS	NS	0.18	0.16	0.08	NS	NS	0.18	NS

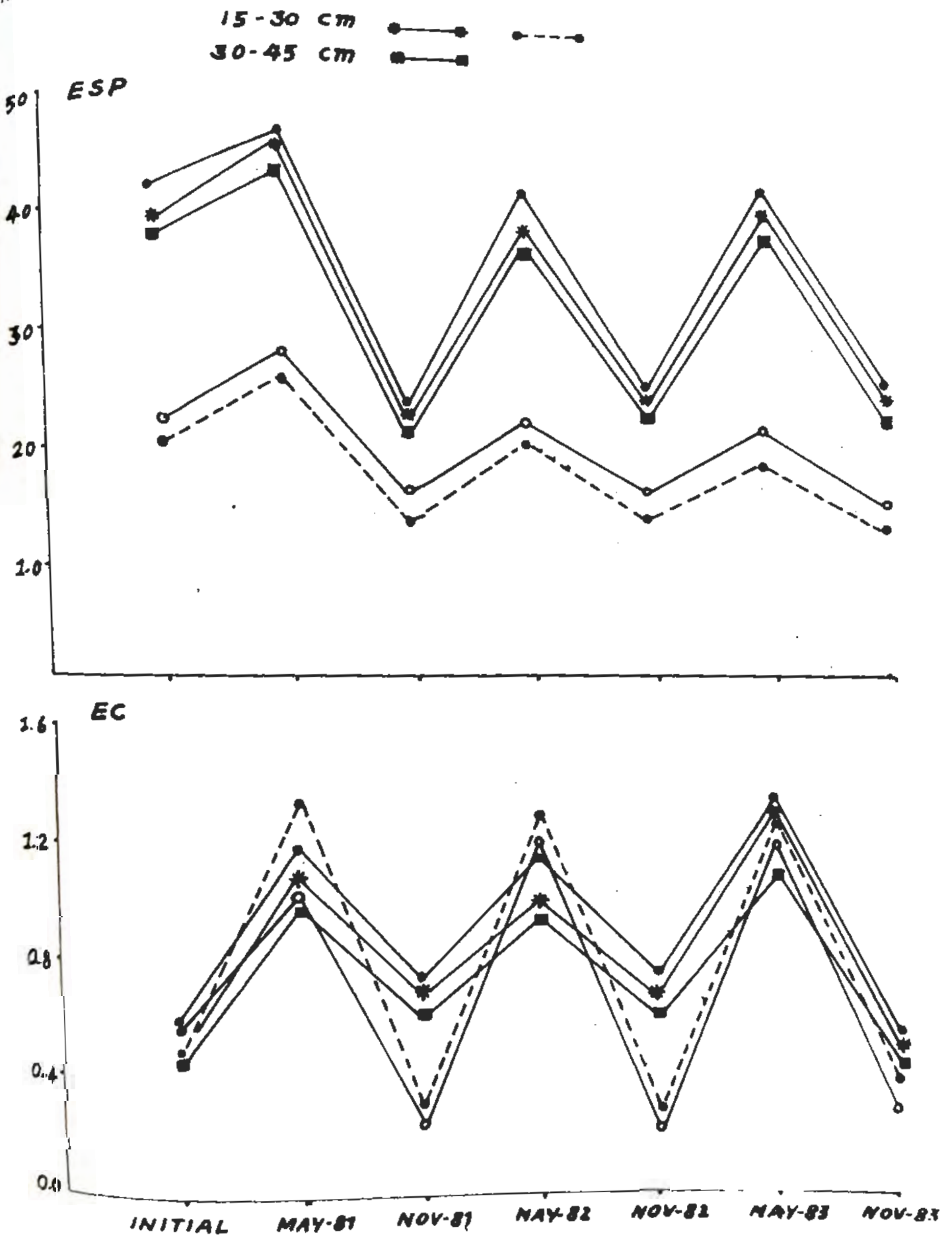

Fig. 1 : Periodic change in EC and ESP during 1981 8?

Interaction effect : The interacting effect of frequency and depth of irrigation water (D x L) was found significant on grain yield of wheat and of maize green fodder at Shil farm (Table 5). The highest grain yield of wheat (3.51 Mg ha^{-1}) and green fodder yield of maize (10.95 Mg ha^{-1}) were recorded in D_2L_1 treatment combination. This could be due to continuous moisture supply and removal of salts from the root zone in the shallow red well drained soil of Shil with this treatment combination (Table 7). On the other hand, in the medium black soil, at the Metra farm, this treatment combination failed to produce any significant impact directly on the irrigated crops. This may probably due to sufficient rootmass of these crops in this soil which can utilise the moisture for the crop growth even where the crop is less frequently (D_1) irrigated with lower depth of water (L_0). However, in this soil the residual effect of this interaction (D x L) significantly affected the kharif paddy crop. The treatment combination D_1L_1 recorded significantly higher grain yield of paddy (3.04 Mg ha^{-1}) than D_2L_1 (2.57 Mg ha^{-1}).

Effect on soil properties

Periodic effect : Irrespective of treatments, overall mean values of EC and ESP of the soil analysed periodically (Fig. 1) revealed that, in general, irrigation with saline waters tended to increase the values of both these soil parameters and reached to the higher peak at the end of the harvest of maize i.e. at the end of May but these values came down to the lowest peak even below the initial values after the harvest of monsoon crops i.e. at the end of October at both the locations. It is seen that whatever salts accumulated in the soils through saline irrigation waters were definitely leached out from the root zone of the soil during monsoon in each year.

Main effect : The treatmentwise soil analysis for EC and ESP in 1983 (Table 6) revealed that the main effects of irrigation and FYM treatments on the soil EC and ESP were negligible both before and after monsoon at both the locations. No beneficial effect of FYM on EC and ESP of soil may be ascribed to the initial highly saline-sodic conditions of the two soils.

Interaction effect : The EC and ESP values of surface and subsurface were significantly affected by D x L, D x F and L x F interactions (Table 7) only after monsoon but they were absent before monsoon i.e. in irrigated conditions. The highest values of EC (0.24 dS m^{-1}) and ESP (15.7) were recorded with D_2L_0 and D_2L_1 and the lowest values (i.e. 0.20 dS m^{-1} and 12.3) in D_2L_1 and D_1L_1 treatment combinations, respectively, in the shallow red soil at Shil farm.

TABLE 5

Interaction effect of frequency (D) and depth (L) of irrigation on yield (Mg ha^{-1}) of different crops.

Treatment combinations	*Metra farm*	*Shil farm*	
	Paddy grain	*Wheat grain*	*Maize green fodder*
D_1L_0	2.61	2.35	3.49
D_1L_1	3.04	3.06	6.27
D_2L_0	2.75	3.42	5.54
D_2L_1	2.57	3.51	10.95
CD (0.05)	0.36	0.21	1.52

TABLE 6

Main effect of different treatments on EC $_{1:2.5}$ (dS m^{-1}) and ESP of the soil before (B) and after (A) monsoon in 1983.

	Soil depth (cm)									
	Metra farm						*Shil farm*			
	0-15		*15-30*		*30-45*		*0-15*		*15-30*	
	B	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*
Electrical conductivity (EC)										
D_1	1.25	0.40	1.04	0.40	1.00	0.40	1.26	0.22	1.37	0.24
D_2	1.15	0.40	0.98	0.39	0.93	0.39	1.21	0.22	1.24	0.25
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
L_0	1.25	0.39	1.09	0.39	1.05	0.39	1.38	0.23	1.43	0.26
L_1	1.15	0.41	0.93	0.40	0.88	0.40	1.15	0.21	1.18	0.23
CD (0.05)	NS	NS	0.09	NS	0.16	NS	NS	NS	NS	NS
F_0	1.17	0.42	1.03	0.45	0.99	0.42	1.29	0.20	1.38	0.22
F_1	1.22	0.39	0.99	0.38	0.94	0.37	1.24	0.25	1.23	0.27
CD (0.05)	NS	NS	NS	0.04	NS	0.04	NS	NS	NS	NS
Exchangeable sodium percentage (ESP)										
D_1	46.8	23.7	46.7	25.8	52.1	24.7	23.9	13.9	24.7	13.2
D_2	45.8	24.1	45.9	26.3	51.7	25.5	24.2	14.9	23.4	13.3
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
L_0	46.6	24.2	46.5	26.7	52.6	24.8	24.3	15.3	23.1	13.8
L_1	46.6	23.7	46.0	25.4	51.2	25.3	23.7	13.6	24.4	12.8
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F_0	45.8	23.8	46.2	26.5	51.7	25.6	23.7	12.9	24.4	13.1
F_1	46.8	24.1	46.3	25.6	52.1	24.5	24.3	15.9	23.2	13.5
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	1.0	NS	NS
Initial value (B)										
EC	0.64		0.47		0.45		0.59		0.47	
ESP	41.4		45.3		47.5		25.2		23.8	

NS= Nonsignificant

TABLE 7

Interaction effect of frequency (D) x depth (L), frequency x FYM (F) and depth x FYM, on EC 1:2.5 (dSm^{-1}) and ESP of two soil types.

	Shallow red soil						*Medium black soil*	
	EC (dSm^{-1})		*ESP*		*ES (dSm^{-1})*	*ESP*		*ESP*
	(0-15)	*(15-30)*	*(0-15)*		*(0-15)*			*(0-15)*
	L x F				D x L			D x F
L_0F_0	0.20	0.21	13.2	D_1L_0	0.21	15.7	D_1F_0	22.7
L_0F_1	0.26	0.31	17.4	D_1L_1	0.23	12.3	D_1F_1	24.8
L_1F_0	0.20	0.24	12.8	D_2L_0	0.24	14.9	D_2F_0	24.7
L_1F_1	0.23	0.23	14.5	D_2L_1	0.20	15.7	D_2F_1	23.5
CD (0.05)	0.02	0.05	1.5	---	0.02	1.3	---	2.0

The D x F interaction had significantly influenced the ESP only in the surface layer of the medium black soil at Metra farm. The highest (24.8) and the lowest (22.7) values were recorded with D_1F_1 and D_1F_0 treatment combinations, respectively. The highest values of ESP (17.4) and EC in surface (0.26 dS m^{-1}) and the subsurface (0.31 dS m^{-1}) layers in shallow red soil were recorded with treatment combination L_0F_1, whereas the corresponding lowest values (12.8 and 0.20 dS m^{-1}) were noted with L_1F_0 (Tabel 7). The results indicated that extra water provided for leaching in the shallow red soil was effective in reducing salinity (EC) and sodicity (ESP) from rootzone only in the presence of organic matter.

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