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Characterization of Soils in Different Categories Depending On Effect of Different Quality Water in Kalyayat Block of Kaithal District

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ABSTRACT

The EC_e in most of the soil profiles decreased down the profile, i.e., highest being in surface layer (0-15 cm depth) and lowest at 45-60 cm soil depth. The pH of all soil profiles decreased with depth, the highest was found in surface layer (0-15 cm) and lowest at the depth of 45-60 cm. There was a decreasing trend in CEC with increase in depth reason can be ascribed to increase in sodium ion, high clay content and organic matter at upper layer of soil profile and decreasing downwards. The distribution and concentration of major cations like Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} and major anions like CO_3^{2-}, HCO_3^{-}, Cl^{-}, and SO_4^{2-} showed a decreasing trend with depth in all profiles.

Key words: *Saline, Alkali, EC_e, CEC, ESP*

INTRODUCTION

Soils are considered as the integral part of the landscape and their characteristics are largely governed by the landforms on which they have developed[14, 15]. Salt affected soils and poor-quality ground waters are primary constraints for sustainable agriculture in arid and semi-arid climatic zones of central Haryana[20]. High evaporation during the dry season and lack of good quality water for irrigation caused salt accumulation in soil profiles. The use of poor quality ground water for irrigation has increased salt build-up in soil profiles and caused reduced productivity. Naturally, salts are drained from the Himalayas and Siwalik through rivers/streams and are accumulated at the alluvial plains[16]. The lack of adequate internal drainage in lower topographic regions prompted soil salinization[3]. Canal irrigation in undrained areas has caused waterlogging, formation of high water table and secondary salinization in soils. Due to dynamic nature, these soils showed variable extent during dry and wet seasons. The reported extents of salt affected soils in Haryana varied from 4.54 to 2.32 lakh ha[1] and needs verification using modern tools and field studies. Due to complex nature, salt affected soils vary widely in salt composition, physical properties, internal drainage and pedogenic processes.

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The irrigation with poor quality (sodic with RSC) ground water has favoured salt enrichment leading to poor soil health[7]. The introduction of canal irrigation from Western Yamuna Canal (WYC) in Haryana during the 1950s accentuated upward movement of salt by rising water table [17]. Due to the over use of irrigation water in poorly drained areas, waterlogging and secondary salinization appeared and caused losses in productivity for rice (42%), wheat (38%) and sugarcane (61%) crops[13]. Soil physicochemical characteristics and water quality appraisal for irrigation are valuable inputs for precise assessment of reclamation and management. In the present study, an attempt was made to analyse physico-chemical characteristics of some soils profiles and appraise quality of ground water samples collected from benchmark locations in Kalayat block of Kaithal district of Haryana for reclamation and management.

MATERIAL AND METHODS

With the aim of analysing the effects of ground water quality on the chemical properties of the soil, the soil samples were collected from fields at various profile depths of 0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm with the help of auger, irrigated with all identified categories of groundwater. Sampling process was started in the month of June before the showers of monsoon. Locations of different sampling sites were recorded by using GPS.

Water-soluble and Exchangeable Sodium

With the help of flame photometer Water-soluble sodium was determined. By soaking soil sample in neutral ammonium acetate solution for several hours exchangeable sodium was extracted. This effectively displaced Na^+ ions from the exchangeable complex. With the help of flame photometer, the Na^+ ions released from the exchanged sites in ammonium acetate extract was measured.

Cation Exchange Capacity (CEC)

Cation exchange capacity of soil samples was determined by treating the soil with sodium acetate (CH_3COONa) solution (pH 8.2) for replacement of exchangeable cations by Na^+ ions. The excess of salt was washed down by alcohol and adsorbed Na^+ ions were replaced by $NH^{4+,}$ using neutral normal ammonium acetate (CH_3COONH_4) solution. The Na^+ ions released from the exchanged sites were measured in ammonium acetate extract with the help of flame photometer.

Exchangeable Sodium Percentage (ESP)

The percentage of cation exchange capacity of soil occupied by sodium is known as exchangeable sodium percentage. Ratio of exchangeable sodium to that of cation exchange capacity multiplied by 100 gives the value of Exchangeable sodium percentage.

RESULTS AND DISCUSSION

Effect of different quality waters on chemical properties of soil in Kalayat block

To study the effect of irrigation water on soil properties, 5 representative soil sites (based on different categories of irrigation water) were selected, sampled and analysed for their chemical properties.

Good quality water

Dubal

Location of water and soil sampling site of village Dubal in Kalayat block lies between 29^0 44’ 850” N and 76^0 13’ 275” E. The chemical constituents of tube-well water are presented in the Table 1, having EC (1.9 dSm^{-1}), pH (7.53), RSC (0.00 me l^{-1}) and SAR 8.34 $(mmol\ l^{-1})^{1/2}$. After analysing the different parameters of irrigation water, this was categorized as good water (A) as per AICRP classification.

The depth-wise physico-chemical properties of soil profile where good quality of water (A) has been used presented in the Table 2. The cation exchange capacity (CEC), exchangeable sodium percentage (ESP) and saturation percentage of soil profile varied from 13.37-14.29 cmol (+) kg^{-1}, 5.69-6.45 and 42.95-45.10%, respectively. These soil properties showed a decreasing trend with the depth of soil profile.

The chemical composition of saturation extract of soil profile is presented in the Table 3.

Surface layer (0-15cm) of soil profile was found with maximum salt concentration having highest ECe 2.66 dSm^{-1} value and it showed a decreasing trend with increase in depth of the soil profile. Similar trend was noticed in SARe having maximum value 5.93 $(mmol\ l^{-1})^{1/2}$ in the surface layer and it varied in between 4.37-5.93 $(mmol\ l^{-1})^{1/2}$. Cations and anions showed the decreasing trend along with the depth of the soil profile.

Soil profile shows mean cationic composition in the order of $Na^{+}>Mg^{2+}>Ca^{2+}>K^{+}$ similarly the anionic composition of saturation extract was in the order of $Cl^{-}> SO_4^{2-}> HCO_3^{-}>CO_3^{2-}$. The pH of saturation extract was varied in between 7.24-7.60 and it showed decreasing trend down the soil profile. After analysing all parameters and according to U.S Salinity laboratory the soil of this profile classified as normal.

Marginally Saline water

Dumra

Location of water and soil sampling site of village Dumra in Kalayat block lies between 29^0 43' 530" N and 76^0 20' 380" E. The chemical constituents of tube-well water are presented in the Table 1, having EC (3.77 dSm^{-1}), pH (7.79), RSC (0.00 me l^{-1}) and SAR 8.91 $(mmol\ l^{-1})^{1/2}$. After analysing the different parameters of water, this was categorized as marginally saline (B1) as per AICRP (1989) classification.

The depth-wise physico-chemical properties of soil profile where marginally saline water (B1) was used by farmer presented in the Table 2. The cation exchange capacity (CEC), exchangeable sodium percentage (ESP) and saturation percentage of soil profile varied from 11.38-13.04 cmol (+) kg^{-1}, 7.55-9.55 and 38.60-42.20 % respectively. Soil properties showed a decreasing trend with the depth of soil profile. Chemical composition of saturation extract of soil profile is presented in the Table 3. Surface layer (0-15cm) of soil profile was found having maximum salt concentration having highest ECe 4.12 (dSm^{-1}) value and it showed a decreasing trend with increase in depth. Similar trend was noticed in SARe having maximum value 8.81 $(mmol\ l^{-1})^{1/2}$ in the surface layer and it varied in between 8.19-8.81 $(mmol\ l^{-1})^{1/2}$. Cationic and anionic composition showed the decreasing trend along with increase in depth of the soil profile.

Soil profile showed mean cationic composition in the order of $Na^{+}>Mg^{2+}>Ca^{2+}>K^{+}$ similarly the anionic composition of saturation extract was in the order of $Cl^{-}> HCO_3^{-}> SO_4^{2-}> CO_3^{2-}$. The pH of saturation extract was varied in between (7.80-8.35) and it showed decreasing trend down the soil profile. After analysing all parameters and according to U.S Salinity laboratory the soil of this profile classified as Saline.

High SAR saline

Kalayat

Location of water and soil sampling site of Kalayat lies between 29^0 40' 626" N and 76^0 13' 577" E. The chemical constituents of tube-well water are presented in the Table 1 having EC (4.56 dSm^{-1}), pH (8.92), RSC (0.00 me l^{-1}) and SAR 13.27 $(mmol\ l^{-1})^{1/2}$. After analyzing the different parameters of water, this was categorized as high SAR saline (B3) as per AICRP (1989) classification.

The depth-wise physico-chemical properties of soil profile where high SAR saline water (B3) was used by farmer presented in the Table 2. The cation exchange capacity (CEC), exchangeable sodium percentage (ESP) and saturation percentage of soil profile varied from 12.82-13.91 cmol (+) kg^{-1}, 14.84-15.63 and 41.70- 44.20 % respectively. Soil properties showed a decreasing trend with the depth of soil profile. Chemical composition of saturation extract of soil profile is presented in the Table 3. Surface layer (0-15cm) of soil profile was found having maximum salt concentration having highest ECe 4.58 (dSm^{-1}) value and it showed a decreasing trend with increase in depth of the soil profile. Similar trend was noticed in SARe having maximum value 12.27 $(mmol\ l^{-1})^{1/2}$ in the surface layer and it varied in between

11.92-12.27 (mmol $l^{-1})^{1/2}$. Cations and anions showed the decreasing trend along with increase in depth of the soil profile.

Soil profile shows mean cationic composition in the order of Na^+> Mg^{2+}> Ca^{2+}>K^+ similarly the anionic composition of saturation extract was in the order of Cl^{--} >SO_4^{2-}> HCO_3^- >CO_3^{2-}. The pH of saturation extract was varied in between (7.64-8.38) and it showed decreasing trend down the soil profile. After analysing all parameters and according to U.S Salinity laboratory the soil of this profile.

Marginally alkali water

Dundwa

Location of water and soil sampling site of village Dundwa in Kalayat block lies between 29^0 42' 549" N and 76^0 11' 621" E. The chemical constituents of tube-well water are presented in the Table 1 having EC (1.8 dSm^{-1}), pH (8.53), RSC (2.80 me l^{-1}) and SAR 9.67 (mmol $l^{-1})^{1/2}$. After analysing the different parameters of water, this was categorized as marginally alkali (C1) as per AICRP classification.

The depth-wise physico-chemical properties of soil profile where marginally alkali water (C1) has been used by farmer presented in the Table 2. The cation exchange capacity (CEC), exchangeable sodium percentage (ESP) and saturation percentage of soil profile varied from 12.18-13.48 (cmol (+) kg^{-1}), 15.97-16.45 and 40.30-43.20 %, respectively. Soil properties showed a decreasing trend with increasing depth of soil profile. Chemical composition of saturation extract of soil profile is presented in the Table 3. Surface layer (0-15cm) of soil profile was found having maximum salt concentration having highest ECe 3.52 (dSm^{-1}) value and it showed a decreasing trend with increase in the depth of the soil profile.

Similar trend was noticed in SAR_e having maximum value 13.39 (mmol $l^{-1})^{1/2}$ in the surface layer and it varied in between 12.88-13.39 (mmol $l^{-1})^{1/2}$. Cations and anions showed the decreasing trend along with increase in depth of the soil profile.

Soil profile showed mean cationic composition in the order of Na^+> Mg^{2+}> Ca^{2+}>K^+ similarly the anionic composition of saturation extract was in the order of HCO_3^{--}>Cl^{--} >CO_3^{2-}> SO_4^{2-}. The pH of saturation extract was varied in between (8.41-8.82) and it showed decreasing trend down the soil profile. After analysing all parameters and according to U.S Salinity laboratory the soil of this profile classified as sodic.

Highly Alkali water

Saind

Location of water and soil sampling site of village Saind in Kalayat block lies between 29^0 46' 551" N and 76^0 13' 107" E. The chemical constituents of tube-well water are presented in the Table 1, having EC (3.9 dSm^{-1}), pH (9.53), RSC (5.26 me l^{-1}) and SAR 12.87 (mmol $l^{-1})^{1/2}$. After analyzing the different parameters of water, water of village Saind was categorized as highly alkali (C3) as per AICRP classification.

The depth-wise physico-chemical properties of soil profile where highly alkali (C3) water was used by farmer presented in the Table 2. The cation exchange capacity (CEC), exchangeable sodium percentage (ESP) and saturation percentage of soil profile varied from 12.59-13.89 (cmol (+) kg^{-1}), 18.47-19.25 and 41.20-44.15 % respectively. Soil properties showed a decreasing trend with increasing depth of soil profile. Chemical composition of saturation extract of soil profile is presented in the Table 3. Surface layer (0-15cm) of soil profile was found having maximum salt concentration having highest ECe 3.81 (dSm^{-1}) value and it showed a decreasing trend with increase in depth of the soil profile with minimum value of 3.12 (dSm^{-1}) in 45-60 cm depth. Similar trend was noticed in SAR_e having maximum value 17.46 (mmol $l^{-1})^{1/2}$ in the surface layer and it varied in between 16.18-17.46 (mmol $l^{-1})^{1/2}$. Cations and anions showed the decreasing trend along With increase in depth of the soil profile.

Soil profile showed mean cationic composition in the order of Na^{+}> Mg^{2+}> Ca^{2+}>K^{+} similarly the anionic composition of saturation extract was in the order of HCO_3^{-} >Cl^{-} >CO_3^{2-}>SO_4^{2-}. The pH of saturation extract was varied in between (8.85-9.67) and it showed decreasing trend down the soil profile. After analysing all parameters and according to U.S Salinity laboratory the soil of this profile classified as sodic.

Table 1: Chemical composition of tube well water used for irrigation in different locations

Location	EC	pH	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	RSC	SAR	CLASS
Dubal	1.90	7.53	1.30	2.30	10.10	4.90	0.40	1.30	3.64	13.10	0.20	0.00	8.34	A
Dumra	3.77	7.79	0.00	1.30	26.80	8.88	0.00	3.60	10.08	23.30	0.16	0.00	8.91	B1(Marginally saline)
Kalayat	4.56	8.92	0.00	1.20	31.20	12.00	0.30	3.10	8.68	32.20	0.10	0.00	13.27	B3(High SAR saline)
Dudwa	1.80	8.53	1.50	5.20	10.00	0.40	0.15	1.00	2.90	13.50	0.12	2.80	9.67	C1(Marginally akali)
Saind	3.90	9.53	4.00	10.00	24.30	0.20	0.09	2.30	6.44	26.90	2.20	5.26	12.87	C3(Highly alkali)

Table 2: Physico-chemical properties of soil profile of different locations

Location	Soil depth (cm)	CEC cmol (+) kg^{-1}	ESP %	Saturation %
Dubal	0-15	14.29	6.45	45.10
	15-30	13.89	6.18	44.15
	30-45	13.42	6.00	43.05
	45-60	13.37	5.69	42.95
Dumra	0-15	13.04	9.55	42.20
	15-30	12.78	8.73	41.60
	30-45	11.95	8.79	39.80
	45-60	11.38	7.55	38.60
Kalayat	0-15	13.91	15.63	44.20
	15-30	13.46	15.38	43.15
	30-45	13.22	15.05	42.60
	45-60	12.82	14.84	41.70
Dudwa	0-15	13.48	16.45	43.20
	15-30	13.02	16.19	42.15
	30-45	12.59	16.05	41.20
	45-60	12.18	15.97	40.30
Saind	0-15	13.89	19.25	44.15
	15-30	13.42	18.96	43.05
	30-45	13.00	18.56	42.10
	45-60	12.59	18.47	41.20

Table 3: Chemical composition of saturation extract of soil profile of different locations

Location	Soil depth (cm)	EC_e (dSm^{-1})	pH (1:2)	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	SARe (m mol l^{-1})$^{1/2}$
				(me l^{-1})								
Dubal	0-15	2.66	7.60	0.65	3.76	16.00	8.56	5.20	9.25	13.25	1.35	5.93
	15-30	2.40	7.45	0.60	3.42	15.20	7.15	4.75	8.98	11.80	1.30	5.20
	30-45	2.23	7.32	0.42	3.24	14.82	6.70	4.30	8.25	11.23	1.20	4.86
	45-60	2.00	7.24	0.42	2.96	13.80	5.25	3.25	7.84	10.15	1.15	4.37
Dumra	0-15	4.12	8.35	3.20	12.85	16.80	8.00	3.85	11.25	24.20	1.55	8.81
	15-30	4.09	8.21	2.95	12.05	16.60	7.85	3.70	11.10	23.10	1.40	8.49
	30-45	3.92	7.96	2.75	11.86	15.96	7.50	3.60	10.85	22.30	1.35	8.30
	45-60	3.83	7.80	2.62	11.48	15.32	7.35	3.35	10.70	21.70	1.25	8.19
Kalayat	0-15	4.58	8.38	3.25	7.60	22.50	11.50	4.10	8.25	30.50	1.50	12.27
	15-30	4.42	8.34	3.11	7.25	21.74	11.06	3.94	8.10	29.86	1.35	12.17
	30-45	4.28	7.79	2.98	7.10	20.96	10.16	3.62	7.86	28.80	1.25	12.02
	45-60	4.05	7.64	2.80	6.96	20.11	9.86	3.25	7.76	27.96	1.10	11.92
Dudwa	0-15	3.52	8.82	5.75	15.65	8.60	4.25	2.10	5.10	25.40	1.65	13.39
	15-30	3.42	8.76	5.43	15.42	8.25	4.10	1.97	4.94	24.60	1.50	13.23
	30-45	3.35	8.63	5.20	14.96	8.00	3.95	1.80	4.80	23.86	1.45	13.13
	45-60	3.23	8.41	4.95	14.65	7.65	3.45	1.70	4.62	22.90	1.35	12.88
Saind	0-15	3.81	9.67	5.85	16.74	10.42	4.15	1.96	3.75	29.50	1.85	17.46
	15-30	3.60	9.45	5.64	15.88	9.80	3.95	1.80	3.60	28.54	1.65	17.37
	30-45	3.41	9.12	5.33	15.24	8.81	3.74	1.74	3.45	26.85	1.25	16.67
	45-60	3.12	8.85	4.96	14.23	8.16	3.30	1.60	3.10	24.80	1.15	16.18

Table 4: Correlation matrix between chemical parameters of water and saturation extract of soil of Kalayat block

Water / Soil	EC	pH	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	SAR
ECe	0.768*	0.333	-0.291	-0.130	0.823**	0.557	0.802**	0.804**	0.741*	-0.029	0.556
pH	0.336	0.759*	0.695*	0.801**	0.275	-0.317	0.164	0.162	0.354	0.664	0.545
CO_3^{2-}	0.26	0.689*	0.637	0.740*	0.194	-0.315	0.116	0.105	0.28	0.458	0.492
HCO_3^-	0.123	0.550	0.595	0.729*	0.085	-0.435	0.096	0.069	0.102	0.428	0.232
Cl^-	0.568	-0.199	-0.762*	-0.711*	0.656	0.843**	0.656	0.674*	0.545	-0.352	0.236
SO_4^{2-}	0.567	-0.207	-0.777*	-0.732*	0.654	0.855**	0.651	0.671*	0.549	-0.407	0.250
Ca^{2+}	0.052	-0.542	-0.762*	-0.748*	0.158	0.494	0.263	0.261	-0.003	-0.492	-0.332
Mg^{2+}	0.200	-0.463	-0.783*	-0.667*	0.324	0.517	0.489	0.478	0.11	-0.454	-0.293
N^{a+}	0.763*	0.622	0.123	0.242	0.753*	0.343	0.648	0.653	.776*	0.241	0.784*
K^+	0.268	0.15	-0.122	0.056	0.34	0.07	0.35	0.352	0.226	0.034	0.084
SARe	0.461	0.791*	0.654	0.701*	0.378	-0.131	0.221	0.224	0.508	0.568	0.743*

** Correlation is significant at the 0.01 level of significance; * Correlation is significant at the 0.05 level;
NS shows nonlinear correlation between variables

EC_e in most of the soil profiles decreased down the profile, i.e., highest being in surface layer (0-15 cm depth) and lowest at 45-60 cm soil depth. The reason might be ascribed to the high concentration of soluble salts in the surface layer due to high evapotranspiration as a result of which the soluble salts come to the surface layer by capillary action and also leaching of salts had not taken place from top to lower layers as sampling was done prior to monsoon. The decrease in EC_e was also due to reduced concentration of calcium and magnesium in the soil solution. The results are in agreement with Mediratta, Singh[18], Qadir *et al.*[11] and Raghubanshi and Singh[12], Vijaykant[19].

The pH of all soil profiles decreased with depth, the highest was found in surface layer (0-15 cm) and lowest at the depth of 45-60 cm. The high values are possibly due to presence of soluble and exchangeable sodium along with HCO_3^- ions, which precipitate as calcium and magnesium carbonates during evaporation. Therefore, high pH values indicate development of salinity and sodicity in the area. The results are in confirmation with those of Deshmukh[5] and Vijaykant[19]. The pH of all soil profiles decreased with depth, the highest was found in surface layer (0-15 cm) and lowest at the depth of 45-60 cm. The high values are possibly due to presence of soluble and exchangeable sodium along with HCO_3^- ions, which precipitate as calcium and magnesium carbonates during evaporation. Therefore, high pH values indicate development of salinity and sodicity in the area. The results are in confirmation with those of Deshmukh[5] and Vijaykant[19].

Cation-exchange capacity (CEC) is a measurement of the soil's ability to hold positively charged ions and nutrients. There was a decreasing trend in CEC with increase in depth reason can be ascribed to increase in sodium ion, high clay content and organic matter at upper layer of soil the soil profile and decreasing downwards reported by More *et al.*[9], Christensen, Jayaprakash *et al*[8]. Simillar results were found by Vijayakant[19] in Kaithal block and Gulha block of Kaithal district. Similar trend was followed in case of saturation percentage; it also decreases with increase with depth reason may be ascribed to increase in compaction which led to decrease in pore size[10].

Exchangeable Sodium percentage determines the percentage of exchangeable sodium adsorbed on soil exchange complex. Decreasing trend was found to follow at all sights with increase in depth of soil profile reason may be ascribed to presence of higher exchangeable sodium at the surface layer as the prevailing conditions facilitate it. The decreasing ESP with increasing depth also indicates that process of alkalization had started at the surface and proceeded in downward direction. The results are in confirmation with those of More *et al.* [9] and Amin[2].

The distribution and concentration of major cations like Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} and major anions like CO_3^{2-}, HCO_3^{-}, Cl^{-}, and SO_4^{2-} showed a decreasing trend with depth in all profiles. The more pronounced concentration of cations and anions at upper surfaces and their decrease with depth was may be due to the upward movement of the ions with the capillary water during the summer months as the rise in temperature leads to high evapotranspiration thereby increasing the concentration of these ions in surface layers. Moreover, the sampling was done before showers of rainfall. The carbonate ions are almost lesser in amount in majority of soil samples. This is due to precipitation of calcium and magnesium as carbonates. The results are in agreement with More *et al.*[9] Gandhi *et al.*[6] and Deshmukh[5].

Based on the data of present investigation, correlation coefficient between water and soil parameters is given in Table 4. It showed that correlation coefficient between electrical conductivity of irrigation water (ECiw) and electrical conductivity of saturation extract of soil (ECe) highly positively and significantly correlated (0.768**). In case of sodium adsorption ratio of irrigation water (SARiw) and sodium adsorption ratio of saturation extract of soil (SARe) showed positive and significant correlation (0.743*).

CONCLUSION

It has been concluded from present investigation that continuous use of low quality water resulted in salt accumulation throughout the soil profiles. Due to high salt concentration in top layer highest electrical conductivity and sodium adsorption ratio of saturation extract was observed in upper layers of the soil which goes on decreasing with depth of soil profile. With increase in salinity of irrigation water salinity of soil also increases with the extent of time, and the value of leaching requirement (LR) goes on increasing. To prevent soil hazard and to minimize crop damage conjunctive use of water for irrigation should be done. To minimize the irrigating the crops. Alternative irrigation with good quality and poor-quality water use in addition with good soil water management strategies will help in maintaining adequate salt-water balance for good crop growth.

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