IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 8, Issue 11 Ver. II (Nov. 2015), PP 89-96
www.iosrjournals.org

Effect of saline water irrigation and different management practices on soil available nutrient status, physical and biological properties

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Abstract: *A field experiment was conducted during rabi, 2012-2013 at the Water Technology Centre, College Farm, College of Agriculture, Rajendranagar, Hyderabad to evaluate nutrient status, physical and biological properties. The soil nutrients in post harvest soil were highest in C_4-green manure, C_4-FYM, C_4-green manure and C_2-FYM respectively. Assay of soil enzyme activity at 60 DAS indicated higher activities of urease, dehydrogenase and alkaline phosphatase in plots irrigated with C_2 water followed by C_3 water and alternate irrigation with C_3/C_4 water. Among management practices significantly highest activity was noticed in FYM followed by green manuring and magnetic treatment. However, the interaction effect was found to be non significant with regard to soil enzyme activities. The results of present study clearly indicated that good quality irrigation water (C_2) along with application of FYM @ 10 t ha^{-1} was the best among the all treatments tested. When use of C_4 class of irrigation water is the only available option, application of FYM @ 10 t ha^{-1} or green manuring is essential to mitigate the adverse effect of poor quality water so as for maintenance of soil health.*
Key words: *management practices, saline water, soil health, soil nutrient status*

I. Introduction

Efforts to increase crop production in arid and semiarid regions are often hindered by shortage of good quality water for irrigation. Therefore, it is necessary to use water of lower quality to meet the crop water requirements. Various irrigation management strategies have been proposed for using saline waters for irrigation. The safe and efficient use of saline water for irrigation is to undertake appropriate practices to prevent the development of excessive soil salination for crop production. Many factors should be considered in making management strategies, such as crops, crop cultivars, local climate, soil, type of salt, salinity levels, irrigation method and water management practices. The quality of ground water and its impact on soil properties in Bikaner district in Rajasthan. The ground water parameters like Na, Mg, Ca, etc. were dominated followed by carbonates and bicarbonates. The EC of soil was significantly and positively correlated with EC of irrigation water. The soil sodium adsorption ratio increased and the effects were greater on the top soil as compared to the lower layer of soil. The increase in irrigation water salinity had no effect on the soil acidity, but it decreased the water holding capacity. The cyclic use of saline and good quality canal waters can maintain the soil salinity at relatively low levels depending upon the proportion of the two waters. Cyclic use should be preferred especially when canal waters are utilised for initial irrigations since it would have both operational and performance advantages over the blending of the water supplies. Attempts were made to improve the water quality by exposing it to magnetic field and use of irrigating the crops. The physical and structural changes in electron orientation of water molecules when exposed to magnetic field will result in increase in mobility of ions in water, which in turn increase the solubility and penetration capability of water. Application of organic manures like farm yard manure or green manuring is one of the easiest methods to mitigate the adverse effects of use of poor quality water especially for small farmers who do not have resources to implement more costly corrective measures.

II. Material and methods

The experiment was carried out at the Water Technology Centre, College Farm, College of Agriculture, Rajendranagar, Hyderabad (Latitude $17^0$19' 19.2" N, Longitude $78^0$24' 39.2" E during winter (rabi) season, 2012-2013. The experiment was laid out in strip plot design with four main treatments, four sub treatments and three replications. The main treatments comprised of M_1: irrigation with C_2 quality (good) water, M_2: irrigation with C_3 quality (marginal) water, M_3: irrigation with C_4 quality (poor) water and M_4: alternate irrigations with C_3 followed by C_4. The sub treatments comprised of – S_1: control (no organic manure and magnetic treatment), S_2: FYM @ 10 t ha^{-1}, S_3: green manuring (Sunnhemp) in situ and S_4: magnetic treatment to irrigation water. The source of C_3 water for irrigating the crop was from an open well No. 2 and C_4 water from an open well No. 5 of College Farm, Rajendranagar and C_2 water obtained from Hyderabad Metropolitan Water Supply and Sewerage

Board (HMWSSB), Budvel. The farym yard manure was applied fifteen before date of sowing of crop and green manure was grown upto flowering and incorporated twenty days before date of sowing of crop.Sorghum variety CSV-216 R was sown on 26th October adopting a spacing of 40 x 15 cm. An amount of 360.5 mm water given through irrigation and effective rainfall of 70.6 mm was received during crop growth period. Thus a total 431.5 mm of water was used by the crop.

Soil samples after harvest of the crops were collected from the root zone at four points from each net plot and composite samples were prepared for chemical analysis, water stable aggregate (Aggregates > 0.25 mm in diameter) and saturated hydraulic conductivity. Samples were air dried, powdered, sieved through 2 mm sieve and used for further analysis. Soil samples were collected from the root zone at four points from each plot at 60 DAS and composite samples were prepared for microbiological activity analysis.

III. Results and discussion

3.1 Soil nutrient status

3.1.1 Available nitrogen (kg ha^{-1})

The data regarding to available nitrogen was presented in Table 3.1. Compared to initial status of soil available nitrogen (249.3 kg N ha^{-1}), a buildup in the available nitrogen status at crop harvest was noticed in different treatments. Among water quality levels, significantly the highest available nitrogen was recorded by the treatment C_4 quality (328.42 kg N ha^{-1}) which was followed by irrigation with C_3/C_4 quality water (325.09 kg N ha^{-1}). The lowest available nitrogen was observed in irrigation with C_2 quality (317.09 kg N ha^{-1}). When compared to initial available N, a buildup of 27 to 31 % was noticed. The highest buildup was noticed in C_4 quality (31 %) followed by C_3/C_4 (30 %), C_3 (29 %), C_2 (27 %).Among management practices, the highest was recorded by GM (377.73 kg N ha^{-1}) which was significantly higher over FYM @ 10 t ha^{-1}, MT and control. When compared to initial available N status, a buildup of 52 to 19 % was noticed. The highest buildup was noticed in GM (52 %), followed by control (24 %), FYM (23 %) and MT (19 %). Among the interactions, significantly the highest available nitrogen was recorded by C_4-GM (383.49 kg N ha^{-1}) which was followed by C_3/C_4 -GM (379.75 kg N ha^{-1}). The lowest available nitrogen recorded by C_2- MT (288.75 kg N ha^{-1}). When compared to initial status, the green manure treatment in combination with different quality of irrigation water recorded buildup in available N status. The higher buildup of N was possible that, application of organic manures like green manures or FYM and thus improved the soil microbial activities of the soil and thus resulted in higher available nitrogen content in the soils. In addition these manures have contributed considerable amount of N to the soil.

3.1.2 Available phosphorus (kg ha^{-1})

The data regarding to available phosphorus was presented in Table 3.1. Compared to initial status of the soil available phosphorus (42.18 kg P_2O_5 ha^{-1}), a buildup in the available phosphorus status at crop harvest was noticed in different treatments. Among water quality levels, significantly the highest available phosphorus was recorded by the treatment C_4 quality (57.13 kg P_2O_5 ha^{-1}) which was followed by irrigation with C_3/C_4 quality water (56.46 kg P_2O_5 ha^{-1}). The lowest available phosphorus was observed in irrigation with C_2 quality (54.63 kg ha^{-1}). When compared to initial available P, a buildup of 30 to 35 % was noticed. The highest buildup was noticed in C_4 quality (35 %) followed by C_3/C_4 (34 %), C_3 (32 %), C_2 (30 %). Among management practices, highest available phosphorus was recorded by FYM @ 10 t ha^{-1} (58.92 kg P_2O_5 ha^{-1}) which was significantly higher over GM, MT and control. When compared to initial available P status, a buildup of 21 to 40 % was noticed. The highest buildup was noticed in FYM (40 %) followed by control (32 %), MT (31 %) and GM (21 %). The interaction effect was found to be non significant. It ranges from 49.81 to 60.08 kg P_2O_5 ha^{-1}. When compared to initial status, the FYM treatment in combination with different quality of irrigation water recorded buildup in available P status. When the organic manures were added to the soil, during their decomposition, appreciable amounts of carbon di-oxide gets released, which forms the carbonic acid leading to increased solubility of P resulting in higher availability. In addition, some amounts of P got added to soil as a constituent of green manure/FYM.

3.1.3 Available potassium (kg ha^{-1})

The data regarding to available potassium was presented in Table 3.1. In general a depletion of available K was noticed in all the treatments, except in green manure management plots when compared to initial status (388.3 kg K_2O ha^{-1}).Among water quality levels, significantly the highest available potassium was recorded by the treatment C_4 quality (378.63 kg K_2O ha^{-1}) which was followed by irrigation with C_3/C_4 quality water (376.13 kg K_2O ha^{-1}). The lowest available potassium was observed in irrigation with C_2 quality (371.10 kg K_2O ha^{-1}). A depletion of 2 to 4.4 % was noticed. The highest depletion was noticed in C_2 quality (4.4 %) followed by C_3 (3.8 %), C_3/C_4 (3.1 %), C_4 (2 %). Among management practices, highest available potassium was recorded by GM (425.75 kg K_2O ha^{-1}) which was significantly higher over FYM @ 10 t ha^{-1}, MT and control. In green manure applied plots, 10 % buildup in available K was noticed. Where as a depletion of 10 % was noticed in MT, 8 % in control and 6 % in FYM applied plots. Among the interactions, significantly the highest available potassium was recorded by C_4-GM (429.70 kg K_2O ha^{-1}) which was followed by C_3/C_4 -GM (426.80 kg K_2O ha^{-1}). The lowest available potassium recorded by C_2- MT (343.90 kg K_2O ha^{-1}). When compared to initial status, the GM treatment in combination with different quality of irrigation water recorded buildup in available K status. The other management practices recorded depletion in available K status. The higher available K status in green manure applied plots could be due to the release of organic acids during decomposition process, which might have mobilized the non exchangeable forms of K and hence, increase in readily available form of K in soil solution. In addition green manures have contributed considerable quantity of potassium to soil.

3.1.4 Available sulphur (mg kg^{-1})

The data regarding to available sulphur was presented in Table 3.1. In general a buildup of available S was noticed in all the treatments, except in control plots when compared to initial status (4.8 mg S kg^{-1}). Among water quality levels, significantly the highest available sulphur was recorded by the treatment C_2 quality (4.91 mg S kg^{-1}) which was followed by irrigation with C_3/C_4 quality water (4.88 mg S kg^{-1}). The lowest available sulphur was observed in irrigation with C_4 quality (4.83 mg S kg^{-1}). When compared to initial available S, a buildup of 1 to 2 % was noticed. The highest buildup was noticed in C_2 quality (2 %) followed by C_3/C_4 (1.5 %), C_3 (1.5 %), C_4 (1 %). Among management practices, highest available sulphur was recorded by FYM @ 10 t ha^{-1} (5.20 mg S kg^{-1}) which was significantly higher over GM, MT and control. In control plots, 13 % depletion in available S was noticed. Where as a buildup of 8 % was noticed in FYM, 6 % in GM and 5 % in MT plots. Among the interactions, significantly the highest available sulphur was recorded by C_2-FYM (5.28 mg S kg^{-1}) which was on par with C_3-FYM (5.23 mg S kg^{-1}). The lowest available sulphur recorded by C_4- control and C_3/C_4-control (4.14 mg S kg^{-1}). When compared to initial status, the control treatment in combination with different quality of irrigation water recorded depletion in available S status. The other management practices recorded buildup in available S status. The buildup in available S might be due to application of organic manures like green manures or FYM and thus improved the soil microbial activities of the soil and thus resulted in higher available sulphur content in the soils. In addition these manures might have contributed considerable amount of S to the soil.

3.1.5 Sodium Adsorption Ratio (SAR)

The data regarding to SAR was presented in Table 3.2. In general a buildup of SAR was noticed in all the treatments, except in FYM management plots when compared to initial status (0.82). Though there was no significant difference in SAR either due to water quality or management practices or their interacrions. It ranged from 0.79 to 0.89 in different treatments. Maximum reduction in SAR was recorded when farmyard manure was applied. This was followed by the application of green manure. The results showed that the significance of farmyard manure and green manure improving the exchange of cations on soil complex and effectively overcome the adverse effects of saline water irrigation (Kahlown and Azam, 2003).

3.2 Soil physical properties

3.2.1 Saturated hydraulic conductivity (cm h^{-1})

The data regarding to saturated hydraulic conductivity was presented in Table 3.2. Compared to initial status (1.05 cm h^{-1}) of the soil, not much variability in conductivity was noticed at the time of harvest. Among water quality levels, the highest saturated hydraulic conductivity was recorded by the treatment C_2 quality (1.15 cm h^{-1}) which was on par with irrigation with C_3 quality water (1.14 cm h^{-1}). The lowest saturated hydraulic conductivity was observed in irrigation with C_4 quality (1.11 cm h^{-1}).When compared to initial status, a buildup of 6 to 10 % was noticed. Improvement in hydraulic conductivity was 10 % with C_2 quality followed by C_3 (9 %), C_3/C_4 (7 %) and C_4 (6 %). Among management practices, highest saturated hydraulic conductivity was recorded by FYM @ 10 t ha^{-1} (1.21 cm h^{-1}) which was significantly higher over GM (1.14 cm h^{-1}), MT (1.10 cm h^{-1}) and control (1.06 cm h^{-1}). 1 to 15 % improvement in hydraulic conductivity was noticed when compared to initial with highest improvement in FYM (15 %) followed by GM (9 %), MT (5 %) and control (1 %). The interaction effect between water quality and management practices were found to be non significant. Amer (2010) observed gradual decrease in saturated hydraulic conductivity in clay loam soil with the increase in amount of salinity of the irrigation water in corn.

3.2.2 Per cent of aggregates > 0.25 mm in diameter

The data regarding to per cent of aggregates > 0.25 mm in diameter was presented in Table 3.2. Among water quality levels, significantly the highest per cent of aggregates > 0.25 mm in diameter was recorded by the treatment C_2 quality (51.68) which was on par with C_3 quality water (51.40). The lowest per cent of aggregates

> 0.25 mm in diameter was recorded by irrigation with C_4 quality (49.93). When compared to C_4 quality, an improvement of 1 to 4 % was noticed. More per cent of > 0.25 mm in diameter aggregates was noticed in C_2 (4 %) followed by C_3 (3 %) and C_3/C_4 (1 %). Among management practices, the highest per cent of aggregates > 0.25 mm in diameter was found in FYM @ 10 t ha^{-1} (54.15) which were significantly higher over GM, MT and control. When compared to control, 7 to 16 % more aggregates were noticed under various treatments. The highest improvement was noticed in FYM (16 %) followed by GM (12 %) and MT (7 %). However, the interaction between water quality and management practices was not significantly influenced. When compared to C_4-control, the FYM treatment in combination with different quality of irrigation water recorded highest per cent of aggregates > 0.25 mm in diameter. The lowest per cent of aggregates > 0.25 mm in diameter was recorded by irrigation with C_4 quality might be due to the dispersion of soil causes clay particles to plug the soil pores, decrease the mean weight diameter under increased saline water irrigation. It is possible that due to the cementing action of intermediate microbial synthesis and decay such as microbial produced gums and polysaccharides intermixed with clay might have resulted in higher per cent of aggregates > 0.25 mm in diameter in farm yard manure applied treatments. In treatments where poor quality water used the microbial activity might be less and lower per cent of aggregates > 0.25 mm in diameter was noticed (Brady, 1990).

3.3 Biological activity of soil at 60 DAS

The data regarding to biological activity was presented in Table 3.3. Compared to the initial status of the soil, increased enzymatic activity was found at 60 DAS. The effect of main and sub treatments were found to be significant and their interactions were found to be non significant.

3.3.1 Urease activity (µg of NH_4^+ g^{-1} soil h^{-1})

Among water quality levels, significantly the highest urease activity was recorded by the treatment C_2 (3.14 µg of NH_4^+ g^{-1} soil h^{-1}) which was followed by C_3 (3.05 µg of NH_4^+ g^{-1} soil h^{-1}). The lowest urease activity was recorded by irrigation with C_4 quality (2.91 µg of NH_4^+ g^{-1} soil h^{-1}. Urease activity increased by 2.4 to 2.6 % when compared to initial status. The highest increase was noticed in C_2 quality (2.6 %) followed by C_3 and C_3/C_4 (2.5 %), C_4 (2.4 %). Among management practices, the highest urease activity was found in FYM @ 10 t ha^{-1} (3.49 µg of NH_4^+ g^{-1} soil h^{-1}) which was significantly higher over GM, MT and control. When compared to initial activity 2.1 to 2.9 % increase was noticed. The highest activity was noticed in FYM (2.9 %) followed by GM (2.7 %), MT (2.4 %) and control (2.1 %). Among interactions, the highest urease activity was recorded by C_2-FYM (3.54 µg of NH_4^+ g^{-1} soil h^{-1}) which was followed by C_3-FYM (3.52 µg of NH_4^+ g^{-1} soil h^{-1}). The lowest urease activity was recorded in C_4-control (2.38 µg of NH_4^+ g^{-1} soil h^{-1}). When compared to initial, the FYM treatment in combination with different quality of irrigation water recorded higher urease activity. The increased enzyme activity with different organic manures like FYM and GM can be attributed to the increased population of micro organisms like bacteria and fungi, due to increased availability of substrate, which helps in releasing the enzymes of extracellular origin (Singaram and Kamala Kumari, 2000; Uma Reddy, 1997).

3.3.2 Dehydrogenase activity (µg of TPFg^{-1} soil d^{-1})

Among water quality levels, significantly the highest dehydrogenase activity was recorded by the treatment C_2 quality (4.84 µg of TPFg^{-1} soil d^{-1}) which was on par with C_3 quality water (4.80 µg of TPFg^{-1} soil d^{-1}). The lowest dehydrogenase activity was recorded by irrigation with C_4 quality (4.69 µg of TPFg^{-1} soil d^{-1}). When compared to initial status, DHA increased by 45 to 49 % with highest in C_2 quality (49 %) followed by C_3 (48 %), C_3/C_4 (46 %) and C_4 (45 %). Among management practices, the highest dehydrogenase activity was observed in FYM @ 10 t ha^{-1} (5.20 µg of TPFg^{-1} soil d^{-1}) which was significantly higher over GM, MT and control. When compared to initial 34 to 60 % more DHA was observed with highest in FYM (60 %) followed by GM (51 %), MT (42 %) and control (34 %). Among interactions, the highest dehydrogenase activity was recorded by C_2-FYM (5.26 µg of TPFg^{-1} soil d^{-1}) which was followed by C_3-FYM (5.24 µg of TPFg^{-1} soil d^{-1}). The lowest dehydrogenase activity was found in C_4-control (4.28 µg of TPFg^{-1} soil d^{-1}). When compared to initial, the FYM treatment in combination with different quality of irrigation water recorded higher dehydrogenase activity.

3.3.3 Alkaline phosphatase activity (µg of p-nitrophenol g^{-1} soil h^{-1})

Among water quality levels significantly the highest alkaline phosphatase activity was recorded by the treatment C_2 quality (36.36 µg of p-nitrophenol g^{-1} soil h^{-1}) which was on par with C_3 quality water (35.68 µg of p-nitrophenol g^{-1} soil h^{-1}). The lowest alkaline phosphatase activity was recorded by irrigation with C_4 quality (34.13 µg of p-nitrophenol g^{-1} soil h^{-1}). When compared to initial 2.5 to 2.7 % higher activity was noticed. The highest activity was noticed in C_2 quality (2.7 %) followed by C_3 and C_3/C_4 (2.6 %) and C_4 (2.5 %). Among management practices, highest alkaline phosphatase activity was found in FYM @ 10 t ha^{-1} (39.20 µg of p-nitrophenol g^{-1} soil h^{-1}) which was significantly higher over GM, MT and control. When compared to initial, 2.3

to 2.9 % increase was noticed with highest in FYM (2.9 %) followed by GM (2.7 %), MT (2.5 %) and control (2.3 %). Among interactions, the highest alkaline phosphatase activity was recorded by C_2-FYM (40.61 μg of p-nitrophenol g^{-1} soil h^{-1}) which was followed by C_3-FYM (39.61 μg of p-nitrophenol g^{-1} soil h^{-1}). The lowest alkaline phosphatase activity was found in C_4-control (30.41 μg of 4-nitrophenol g^{-1} soil h^{-1}). When compared to initial, FYM treatment in combination with different quality of irrigation water recorded highest alkaline phosphatase activity. The higher alkaline phosphatase activity in C_2-FYM might be due to production of organic acids during decomposition of farm yard manure in good quality water irrigation. The lower alkaline phosphatase activity in C_4-control might be due to adverse effect of salinity of water on the alkaline phosphatase enzyme activity. High salt concentration in irrigation water reduces the solubility and denatures the enzyme proteins through the disruption of tertiary protein structure which is essential for enzyme activity (Rietz and Haynes, 2003). The results of present study clearly indicated that good quality irrigation water (C_2) along with application of FYM @ 10 t ha^{-1} was the best among the all treatments tested. Sorghum crop was found to tolerate the marginal quality (C_3) water. In situations where C_3 water is available for irrigation, application of FYM @ 10 t ha^{-1} may be recommended to get higher yields and improvement of soil health. In situations where both C_3 and C_4 water is available, alternate irrigation with C_3 water and C_4 water along with application of FYM @ 10 t ha^{-1} can be recommended. When use of C_4 class of irrigation water is the only available option, application of FYM @ 10 t ha^{-1} or green manuring is essential to mitigate the adverse effect of poor quality water so as to obtain fairly good yields and for maintenance of soil health.

IV. Conclusion

The results of present study clearly indicated that good quality irrigation water (C_2) along with application of FYM @ 10 t ha^{-1} was the best among the all treatments tested. Sorghum crop was found to tolerate the marginal quality (C_3) water. In situations where C_3 water is available for irrigation, application of FYM @ 10 t ha^{-1} may be recommended to get higher yields and improvement of soil health. In situations where both C_3 and C_4 water is available, alternate irrigation with C_3 water and C_4 water along with application of FYM @ 10 t ha^{-1} can be recommended. When use of C_4 class of irrigation water is the only available option, application of FYM @ 10 t ha^{-1} or green manuring is essential to mitigate the adverse effect of poor quality water so as to obtain fairly good yields and for maintenance of soil health.

Acknowledgements

With respectful regards and indebtedness I proffer my deep sense of gratitude and heartfelt thanks to my parents, friends and faculty of college of agriculture for their brilliant counsel, constructive suggestions, indefatigable guidance, evincive criticism and inspiring encouragement to embellish the present study.

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Table 3.1 Effect of saline water irrigation and management practices on available nitrogen, phosphorus, potassium content (kg ha^{-1}) and sulphur (mg kg^{-1}) of post harvest soil of rabi Sorghum

	Available Nitrogen (kg N ha-1)					Available Phosphorus (kg P2O5 ha-1)				
Treatments	Control	FYM	GM	MT	Mean	Control	FYM	GM	MT	Mean
C2	306.53 (23)*	301.01 (21)	372.08 (49)	288.75 (16)	317.09 [27]	57.65 (37)*	57.48 (36)	49.81 (18)	53.59 (27)	54.63 [30]
C3	308.59 (24)	306.26 (23)	375.60 (51)	293.97 (22)	321.11 [29]	58.17 (38)	58.65 (39)	50.62 (20)	54.50 (29)	55.49 [32]
C4	313.02	313.48	383.49	303.69 (22)	328.42	59.41 (41)	60.08	52.48	56.53	57.13

	(23)	(26)	(54)		[31]		(42)	(24)	(34)	[35]
C3/C4	311.07 (25)	309.75 (24)	379.75 (52)	299.77 (20)	325.09 [30]	58.97 (40)	59.46 (41)	51.60 (22)	55.80 (32)	56.46 [34]
Mean	309.80 (24)	307.63 (23)	377.73 (52)	296.55 (19)		58.55 (32)	58.92 (40)	51.13 (21)	55.11 (31)	
	Initial 249.3					Initial 42.18				
	S.Em (±)		C.D (P=0.05)			S.Em (±)		C.D (P=0.05)		
W	0.56		1.94			0.17		0.60		
M	0.35		1.22			0.16		0.55		
W at same M	0.84		2.49			0.18		NS		
M at same W	0.92		2.89			0.23		NS		
Available Potassium (kg K2O ha-1)						Available Sulphur (mg S kg-1)				
C2	355.90 (-8)*	362.30 (-7)	422.30 (9)	343.90 (-11)	371.10 [-4.4]	4.20 (-12)*	5.28 (10)	5.10 (6)	5.05 (5)	4.91 [2]
C3	357.60 (-8)	366.10 (-6)	424.20 (9)	345.50 (-11)	373.35 [-3.8]	4.16 (-13)	5.23 (9)	5.06 (5)	5.04 (5)	4.87 [1.5]
C4	361.50 (-7)	369.60 (-6)	429.70 (11)	353.70 (-9)	378.63 [-2]	4.14 (-14)	5.06 (5)	5.20 (8)	4.94 (3)	4.83 [1]
C3/C4	359.50 (-7)	367.60 (-5)	426.80 (10)	350.60 (-10)	376.13 [-3.1]	4.14 (-14)	5.21 (8)	5.09 (6)	5.08 (6)	4.88 [1.5]
Mean	358.63 (-8)	366.40 (-6)	425.75 (10)	348.43 (-10)		4.16 (-13)	5.20 (8)	5.11 (6)	5.03 (5)	
	Initial 388.3					Initial 4.8				
	S.Em (±)		C.D (P=0.05)			S.Em (±)		C.D (P=0.05)		
W	0.53		1.83			0.01		0.02		
M	0.34		1.18			0.02		0.07		
W at same M	0.36		1.07			0.02		0.06		
M at same W	0.61		2.04			0.02		0.05		

* **Figures in parentheses indicate the percentage of build up / depletion over initial content**

W: Water quality (Main Treatments)

C_2: Irrigation with C_2 quality (good) water
C_3: Irrigation with C_3 quality (marginal) water
C_4: Irrigation with C_4 quality (poor) water
C_3/ C_4: Alternate irrigations with C_3 followed by C_4

M: Management practices (Sub Treatments):

M_1: Control (No organic manure and magnetic treatment)
M_2: FYM @ 10 t ha^{-1}
M_3: GM: Green manuring in situ (Sunnhemp)
M_4: MT: Magnetic treatment to irrigation water

Table 3.2 Effect of saline water irrigation and management practices on sodium absorption ratio (SAR), hydraulic conductivity (cm h^{-1}) and per cent of aggregates > 0.25 mm diameter of post harvest soil of rabi Sorghum

	SAR					**Hydraulic conductivity**					**Per cent of aggregates > 0.25 mm diameter**				
	Control	FYM	GM	MT	**Mean**	Control	FYM	GM	MT	**Mean**	Control	FYM	GM	MT	**Mean**
C2	0.86 (4)*	0.79 (-3)	0.81 (-1)	0.84 (2)	**0.82 [0]**	1.09 (4)	1.23 (17)	1.16 (10)	1.12 (7)	**1.15 [10]**	47.43	55.21 (16)**	52.98 (11)	51.10 (7)	**51.68 [4]*** **
C3	0.87 (6)	0.79 (-3)	0.81 (-1)	0.83 (1)	**0.83 [1]**	1.05 (0)	1.22 (16)	1.13 (8)	1.14 (9)	**1.14 [9]**	47.07	54.64 (16)	52.92 (12)	50.97 (8)	**51.40 [3]**
C4	0.89 (8)	0.81 (-1)	0.83 (1)	0.84 (2)	**0.84 [2]**	1.05 (0)	1.19 (13)	1.12 (7)	1.07 (2)	**1.11 [6]**	45.62	53.44 (17)	51.67 (13)	49.00 (7)	**49.93**
C3/C4	0.88 (7)	0.80 (-2)	0.82 (0)	0.86 (4)	**0.84 [2]**	1.06 (1)	1.20 (14)	1.15 (10)	1.08 (3)	**1.12 [7]**	46.74	53.32 (14)	51.92 (11)	49.54 (5)	**50.38 [1]**
Mean	**0.88 (6)**	**0.80 (-2)**	**0.82 (0)**	**0.84 (2)**		**1.06 (1)**	**1.21 (15)**	**1.14 (9)**	**1.10 (5)**		**46.72**	**54.15 (16)**	**52.37 (12)**	**50.15 (7)**	
	Initial 0.82					**Initial 1.05**									
	S.Em (±)		C.D (P=0.05)			S.Em (±)		C.D (P=0.05)			S.Em (±)		C.D (P=0.05)		
W	0.004		NS			0.001		0.01			0.17		0.58		
M	0.004		NS			0.003		0.01			0.16		0.55		
W at same M	0.007		NS			0.004		NS			0.28		NS		
M at same W	0.008		NS			0.004		NS			0.30		NS		

* **Figures in parentheses indicate the percentage of build up / depletion over initial content in case of SAR and hydraulic conductivity**

** **Figures in parentheses ( ) indicate the percentage of increase over control**

*** **Figures in parentheses [ ] indicate the percentage of increase over C_4 quality**

W: Water quality (Main Treatments) :

C_2: Irrigation with C_2 quality (good) water

C_3: Irrigation with C_3 quality (marginal) water

C_4: Irrigation with C_4 quality (poor) water

C_3/ C_4: Alternate irrigations with C_3 followed by C_4

M: Management practices (Sub Treatments):

M_1: Control (No organic manure and magnetic treatment)

M_2: FYM @ 10 t ha^{-1}

M_3: GM: Green manuring in situ (Sunnhemp)

M_4: MT: Magnetic treatment to irrigation water

Table 3.3 Effect of saline water irrigation and management practices on urease (µg of NH_4^+ g^{-1} soil h^{-1}), dehydrogenase (µg of TPFg^{-1} soil d^{-1}) and alkaline phosphatase (µg of p-nitrophenol g^{-1} soil h^{-1}) activity in soil at 60 DAS of rabi Sorghum

	Urease (µg of NH_4^+ g^{-1} soil h^{-1})					**Dehydrogenase (µg of TPFg^{-1} soil d^{-1})**					**Alkaline phosphatase (µg of p-nitrophenol g^{-1} soil h^{-1})**				
Treatments	Control	FYM	GM	MT	**Mean**	Control	FYM	GM	MT	**Mean**	Control	FYM	GM	MT	**Mean**
C_2	2.64 (119)*	3.54 (195)	3.33 (177)	3.05 (154)	**3.14 [161]**	4.40 (36)*	5.26 (62)	5.07 (56)	4.64 (43)	**4.84 [49]**	32.18 (138)*	40.61 (200)	37.70 (179)	34.95 (158)	**36.36 [169]**
C_3	2.54 (111)	3.52 (193)	3.25 (170)	2.91 (142)	**3.05 [154]**	4.37 (35)	5.24 (62)	4.92 (52)	4.68 (44)	**4.80 [48]**	31.99 (136)	39.61 (193)	36.95 (173)	34.15 (152)	**35.68 [164]**
C_4	2.38 (98)	3.41 (184)	3.13 (160)	2.72 (126)	**2.91 [142]**	4.28 (32)	5.12 (58)	4.80 (48)	4.53 (40)	**4.69 [45]**	30.41 (125)	38.31 (183)	35.48 (162)	32.31 (139)	**34.13 [152]**
C_3/C_4	2.44 (103)	3.49 (191)	3.19 (166)	2.79 (132)	**2.98 [148]**	4.33 (34)	5.18 (60)	4.75 (48)	4.53 (38)	**4.70 [46]**	31.50 (133)	38.26 (183)	36.25 (168)	33.01 (144)	**34.76 [157]**
Mean	**2.50 (108)**	**3.49 (191)**	**3.23 (168)**	**2.87 (138)**		**4.35 (34)**	**5.20 (60)**	**4.89 (51)**	**4.59 (42)**		**31.52 (133)**	**39.20 (190)**	**36.60 (171)**	**33.61 (148)**	
	Initial 1.20					**Initial 3.24**					**Initial 13.5**				
	S.Em (±)		C.D (P=0.05)			S.Em (±)		C.D (P=0.05)			S.Em (±)		C.D (P=0.05)		
W	0.02		0.06			0.03		0.10			0.23		0.78		
M	0.01		0.04			0.02		0.07			0.11		0.37		
W at same M	0.03		NS			0.03		NS			0.29		NS		
M at same W	0.03		NS			0.04		NS			0.34		NS		

* **Figures in parentheses indicate the percentage of build up / depletion over initial content**

W: Water quality (Main Treatments) :

C_2: Irrigation with C_2 quality (good) water

C_3: Irrigation with C_3 quality (marginal) water

C_4: Irrigation with C_4 quality (poor) water

C_3/C_4: Alternate irrigations with C_3 followed by C_4

M: Management practices (Sub Treatments):

M_1: Control (No organic manure and magnetic treatment)

M_2: FYM @ 10 t ha^{-1}

M_3: GM: Green manuring in situ (Sunnhemp)

M_4: MT: Magnetic treatment to irrigation water