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Effect of Treated Dairy Effluent Water on Yield, Nutrient Content and Uptake by Castor-Sorghum Sequence

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ABSTRACT

With increasing dairy industrial development, safe disposal of industrial effluent has become an ecological challenge. Finding suitable eco-friendly techniques for the potential utilization of these released effluents as a source of nutrients become essential. The present investigation was carried out to screen the effect of dairy effluent water in combination with FYM @ 5 t ha^{-1}, gypsum @1 t ha^{-1} and sewage-sludge @ 3 t ha^{-1} on the yield, nutrient content and uptake by castor-sorghum sequence as well as physico-chemical properties of soil. The findings revealed a remarkable effect on yield and nutrient uptake by crop with primary treated dairy effluent water when combined with FYM and gypsum. The application of FYM @ 5 t ha^{-1} or gypsum @ 1 t ha^{-1} in the soil, increased the yield, nutrient content and uptake by castor as well as succeeding fodder sorghum crop, when applied with tube well, as well as treated effluent water. Further work was carried out to study the effectiveness and suitability of dairy effluent on soil properties after harvest of the crop. Application of treated effluent water alone increased EC and reduced the availability of nutrients (N, P, K, S), while combination with FYM enhanced the soil fertility.

INTRODUCTION

Water quality plays an important role in the overall water balance of the environment. With rapid growing population, industrialization and improved living standards, the pressure on water resources is increasing (Kumar et al. 2005). Out of the total water consumed by human beings, more than 50% of it is consumed for industrial activity and only small proportion is used for drinking purpose. The water emerging out of industry is better termed as wastewater or industrial effluent (De 2002). Dairy industry is one of the major food industries in India, and India ranks first among the maximum major milk producing nation (Tripathi & Upadhyay 2003). Nowadays, dairy effluent water must be utilized as irrigation water to reduce the use of ground water. Zabek (1976), working on light soils observed that the irrigation with dairy effluents increased the NPK in soils and crops, green fodder and wheat grains. Ajmal et al. (1984) observed that the plant height was reduced by the use of 100% dairy processing effluent, but 25 to 75% effluent increased the plant height in kidney bean and pearl millet. Gautam & Bishnoi (1990) carried out experiments on germination of wheat seed with undiluted and diluted (1:1) dairy effluent and found more growth in diluted effluent. Pandit et al. (1996) found that the 25% diluted dairy effluent is beneficial for the cultivation of *Sorghum bicolor* L. Graeme and McKenzie (2004) studied the effect of dairy effluent on dry matter yield, nutritive characteristics and mineral content of perennial pasture. Bhatnagar & Gupta (2002) studied the effect of dairy effluent on soil properties and reported no change in soil physico-chemical properties.

India is the leader in the world castor seed and its oil production. It contributes about 55 per cent and 70 per cent of world area and production, respectively. Among the castor growing states, Gujarat holds first position with regards to area (52%), production (80%) and productivity (1833 kg/ha DOR, 2009-10) followed by Rajasthan & Andhra Pradesh. The productivity of Gujarat state compared to other states is the highest due to more than 90 per cent castor area covered by hybrids under irrigated conditions with special crop management practices.

Sorghum is an important forage crop grown in summer and *Kharif* seasons. It is becoming popular among the farmers of Gujarat State. Fodder and feeds are the major inputs in animal production, especially for milch animals. Gujarat is known for its dairy industry and multicut forage crops like sorghum and lucerne are extensively grown in milk shed areas of the State. Such intensive cropping of cereal forage crop naturally results in more nutrient mining from the soil.

MATERIALS AND METHODS

The research study was conducted in a farmer's field during 2013-14 and 2014-15 to investigate the effect of effluent water on yield, nutrient content and uptake by castor-sorghum sequence as well as physico-chemical properties of soil. The soil of the field was typic Ustipsemments, sandy loam in texture, well drain soil, slightly alkaline in reaction. From the fertility point of view, it has pH 7.92, EC 0.52 dSm^{-1}, organic carbon 0.45 %, available N 254 kg ha^{-1}, P_2O_5 24.29 kg ha^{-1}, K_2O 380 kg ha^{-1} and sulphur 5.73 kg ha^{-1}. The soil content micronutrients were DTPA-Fe, Mn, Zn and Cu about 7.22, 18.00, 1.61 and 1.60 mg kg^{-1} respectively.

An experiment comprised of ten treatments with three replications involving growing of GCH-7 variety of castor and GAFS-1 of sorghum as succeeding crop. For residual study, sorghum crop was grown after harvesting the castor crop. A statistical analysis was laid out under randomized complete block design. The treatments comprised were, T_1: Irrigation by tubewell water, T_2: Irrigation by treated effluent water, T_3: Alternate irrigation by tubewell and treated effluent water, T_4: Irrigation by 50% dilution of treated effluent water, T_5: Irrigation by tubewell water with soil application of gypsum @ 1 t ha^{-1}, T_6: Irrigation by tubewell water with soil application of FYM @ 5 t ha^{-1}, T_7: Irrigation by treated effluent water with soil application of gypsum @ 1 t ha^{-1}, T_8: Irrigation by treated effluent water with soil application of FYM @ 5 t ha^{-1}, T_9: Irrigation by tubewell water with soil application of sludge @ 3 t ha^{-1}, T_{10}: Irrigation by treated effluent water with soil application of sludge @ 3 t/ha.

Fertilizer recommended dose of castor (75:50:00-N: P: K kg ha^{-1}) was applied to all the treatments of experiment through urea and DAP fertilizers and FYM, sludge and gypsum were applied before sowing of crops. When the castor was at maturity stage and sorghum at flowering stage, the crop was harvested manually. Seed and straw samples were collected of castor and fresh weight of sorghum was recorded immediately after harvesting. Samples washed with distilled water, oven dried at 70°C till constant weight and dry straw weight was recorded. The dried plant samples were ground with stainless steel blade mixer and preserved in polythene bags for analysis. Initial and after harvest of the castor crop, plot wise soil samples were also collected and air dried in laboratory. The air dried soil samples were pounded with wooden mortar and pestle. After pounding, the soils were sieved through 2 mm sieve and preserved in polythene bags properly labelled and preserved for its chemical analysis. Soils were analysed by using standard procedures as described for pH (Jackson 1973), organic carbon (Walkely & Black 1934), available nitrogen (Subbiah & Asija 1956), available phosphorus (Olsen's et al. 1954), available potassium (Jackson 1973), available sulphur (Chesnin & Yien 1950) and micronutrients DTPA-Fe, Mn, Zn and Cu (Lindsay & Norvell 1978). The chemical analysis of the plant samples was carried out by digestion of 1 g of powdered plant samples with HNO_3: $HClO_4$ (4:1) di-acid mixture as per the procedure outlined by Jackson (1973) and acid extracts were prepared. This acid extract of plant samples were used to analyse for total content of P, K, S, Fe, Mn, Zn and Cu.

RESULTS AND DISCUSSION

Results of seed yield of castor, presented in Table 1, revealed that significantly higher value of seed yield (36.03 q ha^{-1}) was recorded under the treatment, irrigation by tubewell water with soil application of FYM @ 5 t ha^{-1} (T_6) than treatments T_1, T_2, T_3, T_4 and T_{10}. These results suggest that FYM amendments helped in increasing the yield of wheat, which may be attributed directly to nutritional effect as well as indirectly through improving soil properties. Similar finding were also reported by Mughra et al. (1996).

Green fodder yield of sorghum followed by castor revealed that significantly higher value of green fodder yield (33.62 t ha^{-1}) was recorded under treatment T_6 than treatments T_1, T_2, T_3, T_4 and T_{10}. However, it was at par with treatments, irrigation by tubewell water with soil application of gypsum @ 1 t/ha (T_5), irrigation by treated effluent water with soil application of gypsum @ 1 t/ha (T_7), irrigation by treated effluent water with soil application of FYM @ 5 t/ha (T_8), and irrigation by tubewell water with soil application of sludge @ 3 t/ha (T_9). Selvakumari et al. (2000) reported highest yield in rice when fly ash was applied in combination with FYM and fertilizer.

Effect of effluent water on macronutrient content and uptake by castor seed: The data revealed that N, P and S were significantly affected by the application of different treatments, whereas K content in castor seed did not found ny significant effect (Table 2). The highest N content (2.67 %) in seed was found due to application of T_5 (irrigation by

Table 1: Effect of treated effluent water on yield of castor and sorghum.

Treatments	Castor Seed yield (kg ha^{-1})	Sorghum Green fodder yield (t ha^{-1})
T_1	29.22	27.44
T_2	26.61	26.83
T_3	27.09	27.27
T_4	28.24	27.25
T_5	35.36	33.19
T_6	36.03	33.62
T_7	34.36	32.55
T_8	34.41	32.71
T_9	34.01	32.26
T_{10}	29.28	28.06
S.Em.±	1.89	1.67
C.D. at 5 %	5.62	4.96
C.V. %	10.41	9.59

Table 2: Effect of treated effluent water on macronutrients content and uptake by castor seed.

Treatments	Contents				Uptakes			
	N	P (%)	K	S	N	P (kg ha^{-1})	K	S
T_1	2.42	0.422	0.34	0.120	70.82	12.338	9.90	3.500
T_2	2.39	0.458	0.40	0.122	64.07	12.455	10.64	3.241
T_3	2.47	0.526	0.40	0.120	66.81	12.410	10.99	3.254
T_4	2.46	0.442	0.37	0.119	69.55	12.498	10.33	3.365
T_5	2.67	0.473	0.40	0.158	94.51	17.425	14.31	5.595
T_6	2.65	0.539	0.44	0.134	95.40	17.164	15.85	4.828
T_7	2.61	0.510	0.40	0.167	90.01	18.071	13.88	5.767
T_8	2.58	0.493	0.41	0.131	88.40	17.516	13.98	4.488
T_9	2.64	0.476	0.36	0.135	89.94	18.195	12.22	4.591
T_{10}	2.54	0.469	0.39	0.123	74.33	13.862	11.46	3.611
S.Em.±	0.06	0.005	0.02	0.005	5.74	0.865	1.11	0.340
C.D. at 5 %	0.18	0.014	NS	0.015	17.04	2.569	3.31	1.010
C.V. %	4.14	1.690	10.94	6.620	12.36	9.860	15.63	13.930

Table 3: Effect of treated effluent water on micronutrients content and uptake by castor seed.

Treatments	Contents				Uptakes			
	Fe	Mn (mg kg^{-1})	Zn	Cu	Fe	Mn (g ha^{-1})	Zn	Cu
T_1	94.00	15.67	33.000	6.00	275	45.73	96.52	17.63
T_2	94.33	12.67	33.667	5.00	250	33.54	89.54	13.16
T_3	89.00	15.00	33.333	7.00	244	41.21	90.46	18.70
T4	84.33	15.67	30.667	5.67	234	44.23	85.52	16.42
T5	90.67	12.00	28.667	6.67	321	42.33	101.70	23.61
T_6	100.67	17.33	35.333	7.33	363	62.45	127.31	26.47
T_7	85.33	13.00	33.667	6.67	296	44.56	116.23	22.82
T_8	95.00	15.33	34.667	7.00	325	51.68	119.52	23.95
T_9	89.67	15.00	33.667	6.33	306	51.01	114.73	21.61
T_{10}	92.33	14.33	32.667	6.00	269	41.70	95.09	17.32
S.Em.±	5.93	1.36	2.519	0.99	25	4.51	10.33	3.33
C.D. at 5 %	NS	NS	NS	NS	75	13.41	NS	NS
C.V. %	11.23	16.10	13.250	26.97	15	17.05	17.26	28.57

tube well water with soil application of gypsum @ 1 t ha^{-1}) treatment which was at par with T_6, T_9, T_7, T_8 and T_{10}. The highest P (0.539 %) and S (0.167 %) content in seed was found due to application of T_6 and T_7 treatment which was at par with the T_3 and T_5 treatment, respectively. In case of sulphur, it might be due to the fact that gypsum provides good amount of plant available SO_4^{2-} as stated by Singh (1985).

Whereas, application of tubewell water (T_1) noted significantly lowest P (12.34 kg ha^{-1}) and K (9.90 kg ha^{-1}) uptake by castor seed and application of treated effluent water alone (T_2) noted significantly lowest N (64.07 kg ha^{-1}) and S (3.24 kg ha^{-1}) uptake by castor seed. The results clearly indicated that the application of gypsum or FYM along with tubewell water or treated effluent or sludge increased the N, P, K, S uptake by castor seed. Plots having rate of gypsum or FYM applied had avoided the osmotic shock as well as specific-ion toxicities and supplied the crop with ample nutrition, thereby, increasing reproductive growth to a greater extent as compared to others. These outcomes corroborate the work of Minhas et al. (1991).

Effect of treated effluent water on micronutrients content and uptake by castor seed: The data on micronutrient (Fe, Mn, Zn and Cu) content in castor seed are presented in Table 3. The uptake of Fe and Mn content was significantly affected by various treatments while uptake of Zn and Cu was non-significant. The highest uptake of Fe (363 g ha^{-1}) and Mn (62.45 g ha^{-1}) was found due to application of T_6 treatment, which was at par with the T_8, T_5, T_9, T_7 in case of Fe uptake and T_8 and T_9 in case of Mn uptake by castor seed. FYM or gypsum in combination with effluent water was effective in improving Fe uptake by castor seed. Due to the

Table 4: Effect of treated effluent water on macronutrients and micronutrients content in castor straw.

Treatments	Contents				Uptakes			
	Fe	Mn (mg kg^{-1})	Zn	Cu	Fe	Mn (g ha^{-1})	Zn	Cu
T_1	1.20	0.20	1.17	0.117	170	66.67	20.33	6.00
T_2	1.26	0.22	1.39	0.118	171	65.00	20.67	5.67
T_3	1.32	0.22	1.41	0.117	184	65.33	19.67	6.67
T_4	1.29	0.22	1.29	0.117	166	55.33	17.67	6.00
T_5	1.43	0.24	1.42	0.130	185	74.67	19.00	7.00
T_6	1.41	0.23	1.59	0.128	245	90.33	21.67	7.67
T_7	1.36	0.25	1.41	0.132	221	63.67	18.33	6.67
T_8	1.39	0.24	1.46	0.122	236	76.33	21.00	7.00
T_9	1.33	0.25	1.29	0.129	191	64.33	20.67	5.33
T_{10}	1.33	0.22	1.36	0.119	190	72.67	20.33	6.00
S.Em.±	0.02	0.01	0.13	0.002	15	5.76	1.59	0.66
C.D. at 5 %	0.05	NS	NS	0.007	45	17.11	NS	NS
C.V. %	2.14	10.22	16.11	3.240	13	14.36	13.79	17.87

Table 5: Effect of treated effluent water on chemical properties of soil after harvest of castor crop.

Treatment	EC (d Sm^{-1})	pH (1:2)	Organic carbon (%)	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	S (kg ha^{-1})
T_1	0.63	7.79	0.479	213	17.77	377	4.76
T_2	0.86	7.93	0.385	210	21.78	397	5.22
T_3	0.73	7.88	0.429	220	21.44	406	5.10
T_4	0.72	7.88	0.414	235	19.53	419	4.95
T_5	0.71	7.81	0.462	266	27.09	421	6.13
T_6	0.66	7.76	0.490	271	30.71	440	5.82
T_7	0.78	7.85	0.444	244	26.21	429	6.04
T_8	0.84	7.84	0.485	264	29.44	435	5.70
T_9	0.75	7.91	0.453	250	22.65	419	5.58
T_{10}	0.85	7.92	0.379	234	23.38	405	5.29
S.Em.±	0.01	0.01	0.018	7	0.71	11	0.11
C.D. at 5 %	0.03	0.03	0.054	21	2.10	32	0.32
C.V. %	2.22	0.20	7.030	5	5.11	4	3.37

Table 6: Effect of treated effluent water on available micronutrients in soil after harvest of castor crop.

Treatments	Contents			
	Fe	Mn (mg kg^{-1})	Zn	Cu
T_1	7.67	17.33	1.46	1.58
T_2	6.93	17.74	1.44	1.61
T_3	7.37	17.42	1.61	1.60
T_4	6.47	16.28	1.22	1.23
T_5	6.32	14.48	1.63	1.30
T_6	7.73	17.93	1.74	1.63
T_7	7.02	17.50	1.63	1.56
T_8	7.06	18.47	1.63	1.62
T_9	6.90	17.32	1.57	1.41
T_{10}	6.45	17.94	1.56	1.57
S.Em.±	0.30	0.63	0.14	0.10
C.D. at 5 %	0.89	1.88	NS	NS
C.V. %	7.41	6.34	15.76	11.36

application of gypsum and FYM, the worse effect of irrigation water regarding EC was reduced, which favoured the uptake of Fe and Mn as reported by Padole et al. (1995).

Effect of effluent water on macronutrient content by castor straw: The data revealed that the N and K content in straw of castor was influenced significantly by various treatments, while P and K content in castor straw did not find any significant effect (Table 4). The significantly highest N and S content in straw (1.43 and 0.132 %) was noted due to the application of T_5 (irrigation with tubewell water with soil application of gypsum @ 1 t ha^{-1}) treatment and T_7 (irrigation with treated effluent water with soil application of gypsum @ 1 t ha^{-1}), respectively, which could be due to gypsum supplied such amount of sulphur to the plant.

Effect of effluent water on micronutrient content by castor straw: The application of different treatments signifi-

Table 7: Residual effect of treated effluent water on macronutrients content and uptake by of fodder sorghum after castor.

Treatments	Contents				Uptakes			
	N	P	K (%)	S	N	P (kg ha^{-1})	K	S
T_1	0.867	0.142	0.587	0.094	237	39.14	163	25.58
T_2	0.863	0.149	0.640	0.095	232	39.89	172	25.56
T_3	0.880	0.142	0.667	0.098	241	38.77	182	26.69
T_4	0.923	0.159	0.683	0.102	253	43.44	187	27.90
T_5	0.967	0.140	0.662	0.105	321	46.66	220	34.96
T_6	0.943	0.149	0.713	0.102	317	49.98	240	34.42
T_7	0.890	0.143	0.590	0.107	291	46.56	193	34.87
T_8	0.987	0.159	0.720	0.100	323	51.95	234	32.64
T_9	0.970	0.148	0.747	0.102	313	47.87	241	32.91
T_{10}	0.963	0.155	0.847	0.088	271	43.29	238	24.58
S.Em.±	0.042	0.007	0.055	0.003	23	3.12	22	1.76
C.D. at 5 %	NS	NS	NS	0.010	69	NS	NS	5.24
C.V. %	7.900	7.980	13.880	5.870	14	12.09	18	10.17

Table 8: Residual effect of treated effluent water on micronutrients content and uptake by of fodder sorghum after castor.

Treatments	Contents				Uptakes			
	Fe	Mn (mg kg^{-1})	Zn	Cu	Fe (g ha^{-1})	Mn	Zn	Cu
T_1	277	40.99	29.17	23.50	2641	389	280	220
T_2	262	39.95	27.35	27.25	2470	376	256	254
T_3	273	38.66	26.59	25.09	2602	368	253	240
T_4	278	39.43	29.11	23.21	2648	377	279	220
T_5	278	41.62	26.27	23.50	3234	483	306	273
T_6	263	40.16	27.07	23.54	3092	473	319	277
T_7	259	45.68	27.89	22.21	2960	522	318	253
T_8	265	41.61	27.51	27.34	3021	471	313	309
T_9	267	40.35	27.83	23.29	3017	455	315	263
T_{10}	265	45.13	25.41	23.64	2584	447	249	233
S.Em.±	11	2.67	1.76	2.52	180	39	26	28
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	7	11.18	11.11	18.02	11	16	16	19

cantly affected Fe and Mn content in castor straw, while Zn and Cu content in straw were non-significantly affected (Table 4). The highest Fe (245 mg kg^{-1}) and Mn (90.33 mg kg^{-1}) content in castor straw were found due to application of T_6 (irrigation by tubewell water with soil application of FYM @ 5 t ha^{-1}) treatment, which was at par with the T_6, T_8 and T_7 treatments in case of Fe content and T_8 and T_5 in case of Mn content in castor straw. The chelation and solubilization effects of the FYM on the bioavailability of micronutrients provided by the wastewater application to the soil could be responsible for the enhancement of Fe and Mn uptake by the plants as reported by Schalscha et al. (1990).

Effect of effluent water on soil properties after harvest of castor crop: The data on the pH, electrical conductivity and organic carbon were significantly affected due to various treatments (Table 5). The highest EC (0.86 dS m^{-1}) was found due to application of T_2 (irrigation by treated effluent water) treatment, which was at par with T_{10} and T_8 treatments. The lowest EC value (0.63 dS m^{-1}) was noted with the application of T_1 treatment, which was at par with T_6 treatment. Liu & Haynes (2014) noticed increase in EC value due to application of effluent water. The lowest pH (7.76) value was noted with the application of T_6 (irrigation by tubewell water with soil application of FYM @ 5 t ha^{-1}) treatment, which was at par with T_1 treatment. The significantly highest organic carbon (0.490 %) was found due to application of T_6 which was at par with the T_8, T_5, T_9 and T_7 treatments.

The lowest N (210 kg ha^{-1}) content in soil was found due to application of tubewell water alone, while lowest P_2O_5 (17.77 kg ha^{-1}) and K_2O (377 kg ha^{-1}) and S (4.76 kg ha^{-1}) were found due to application of effluent water alone. These

Table 9: Residual effect of treated effluent water on chemical properties of soil after castor sorghum cropping sequence.

Treatment	EC (d Sm^{-1})	pH (1:2)	Organic carbon (%)	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	S (kg ha^{-1})
T_1	0.63	7.79	0.383	210	16.75	356	3.53
T_2	0.69	7.80	0.367	205	21.74	371	3.77
T_3	0.69	7.82	0.370	216	21.65	378	4.42
T_4	0.65	7.79	0.353	228	18.88	395	4.48
T_5	0.67	7.80	0.420	255	21.54	394	5.36
T_6	0.67	7.75	0.430	258	28.18	427	4.43
T_7	0.65	7.82	0.397	240	24.68	410	5.12
T_8	0.72	7.70	0.410	247	25.98	408	4.81
T_9	0.70	7.76	0.433	240	18.10	386	3.90
T_{10}	0.73	7.69	0.360	231	20.54	380	3.49
S.Em.±	0.03	0.02	0.017	6	1.24	11	0.19
C.D. at 5 %	NS	0.04	0.052	18	3.70	34	0.56
C.V. %	6.54	0.34	7.700	4	9.89	5	7.56

Table 10: Residual effect of treated effluent water on available micronutrients in soil after castor-sorghum cropping sequence.

Treatments	Fe	Mn	Zn	Cu
	(mg kg^{-1})			
T_1	6.85	16.46	1.30	1.43
T_2	6.73	16.87	1.31	1.50
T_3	7.08	17.51	1.57	1.48
T_4	6.42	15.98	1.17	1.18
T_5	6.24	14.44	1.49	1.28
T_6	7.48	17.15	1.59	1.56
T_7	6.81	16.40	1.68	1.43
T_8	6.96	17.06	1.44	1.29
T_9	6.60	16.13	1.36	1.23
T_{10}	5.90	16.73	1.36	1.46
S.Em.±	0.30	0.62	0.13	0.09
C.D. at 5 %	NS	NS	NS	NS
C.V. %	7.79	6.54	15.73	11.28

results also corroborate with the finding of Hubbard et al. (1987).

The results on the DTPA-micronutrient content (Fe, Mn, Zn and Cu) in soil after harvest of castor are presented in Table 6. The data revealed that DTPA-micronutrients were not affected significantly due to application of different treatments, except Fe and Mn content in soil. The highest DTPA-Fe (7.73 mg kg^{-1}) and Mn (18.47 mg kg^{-1}) were found due to application of T_6 (irrigation by tubewell water with soil application of FYM @ 5 t ha^{-1}) and T_8 (irrigation by treated effluent water with soil application of FYM @ 5 t ha^{-1}) treatment, respectively. While it was at par with all treatments except T_4, T_{10} and T_5 treatments in case of DTPA-Fe and T_4 and T_5 in case of DTPA-Mn content in soil after the harvest of the crop.

Residual effect of effluent water on macronutrients content and uptake by fodder sorghum: The application of different treatments did not significantly affected the N, P and K content in fodder sorghum except S (Table 7). The S content in fodder sorghum was found due to the application of T_7 (irrigation by treated effluent water with soil application of gypsum @ 1 t ha^{-1}) treatment, which was at par with the T_5, T_9, T_6, T_4 and T_3 treatments.

Among the macronutrient uptake by fodder sorghum, the N and S uptake was influenced significantly by various treatments, while P and K uptake did not find any significant effect. The significantly highest N and S uptake by fodder sorghum (323 kg ha^{-1} and 34.96 kg ha^{-1}) was noted due to application of T_8 (irrigation by treated effluent water with soil application of FYM @ 5 t ha^{-1}) and T_5 (irrigation by tubewell water with soil application of gypsum @ 1 t ha^{-1}), respectively. The lowest N (232 kg ha^{-1}) and S (24.58 kg ha^{-1}) uptake by fodder sorghum was noted due to application of T_2 (irrigation by treated effluent water) and T_{10} (irrigation by treated effluent water with soil application of sludge @ 2 t ha^{-1}) treatments, respectively. The results clearly showed that application of effluent water alone, did not found any beneficiary residual influences on fodder sorghum. These results corroborate with the finding of Hati et al. (2006) in soybean-wheat cropping system.

Residual effect of effluent water on micronutrients content and uptake by fodder sorghum: The data on micronutrient (Fe, Mn, Zn and Cu) content and uptake by fodder sorghum are presented in Table 8 which were not affected significantly by different treatments.

Residual effect of effluent water on soil properties after harvest of fodder sorghum: The data showed that the pH and organic carbon were significantly affected due to various treatments, whereas, electrical conductivity was non-significant (Table 9). The application of alternate irrigation by tubewell and treated effluent water treatment significantly increased pH (7.82) and decreased the organic carbon (0.353

%) content in the soil after harvest of the crop.

The highest available N (258 kg ha^{-1}), P_2O_5 (28.18 kg ha^{-1}) and K_20 (427 kg ha^{-1}) was recorded with the application of T_6 (irrigation by tubewell water with soil application of FYM @ 5 t ha^{-1}) treatment. It is reported that the increase in available P and K status of the soil with the addition of FYM may be due to greater mobilization of native soil P and K, whereas T_5 treatment gave significantly increased S (33.29 kg ha^{-1}) in soil might be due to gypsum application.

The results on the DTPA-micronutrient content (Fe, Mn, Zn and Cu) in soil after harvest of castor-sorghum sequence are presented in Table 10. The data revealed that DTPA - micronutrients were not affected significantly due to the application of different treatments.

CONCLUSION

On the basis of the experimental data, it can be concluded that the result soil application of FYM @ 5t ha^{-1} or gypsum @ 1t ha^{-1} was, increased yield, nutrient content and uptake by castor as well as succeeding fodder sorghum crop when applied with tubewell as well as treated effluent water. An application of sludge @ 3t ha^{-1} can be beneficiary only when crops are irrigated through tubewell water. It is clearly indicated that the application of treated effluent water alone and sludge increased the electrical conductivity, and decreased the fertility of soil. However, the detrimental effect of treated effluent water can be minimized by the application of 5 t FYM ha^{-1} or 1 t gypsum ha^{-1} along with treated effluent water as well as maintain the soil fertility. It is also noted that the application of treated effluent water has no detrimental effect on residual sorghum crop.

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