Indian Journal of Agricultural Sciences **83** (10): 1031–7, October 2013/Article

Effect of manure and chemical amelioration on crop yields and soil biological activities in saline soils of semiarid Indo-Gangetic alluvium (*Typic ustrochrepts)* type in India

R S SISODIA[1], MUNNA LAL[2], D ASHOK VARDHAN[3], R B SINGH[4], ASIT MANDAL[5], M C MANNA[6], V K SINGH[7] and BRAJENDRA[8]

Raja Balwant Singh College, Bichpuri, Agra, Uttar Pradesh 283 105

Received : 8 February 2013; Revised accepted: 26 April 2013

ABSTRACT

Reclamation of saline-alkali soils will require both leaching to remove soluble salts and application of amendments to lower ESP. The effects of these amelioration techniques on soil salinity were examined in terms of the yield performance of wheat (*Triticum aestivum* L.) and pearl millet (*Pennisetum glaucum* L.R Br.) and the soil biochemical properties. Grain yield reduction was significantly higher for bajra and wheat at 40 sodium adsorption ratio (SAR) than at 30 SAR. In the 0-15 cm soil layer, dehydrogenase activity (DHA) increased by 31.6 % at an electrical conductivity (ECe) of 691 µs/m than at an EC of 2241 µs/m. A decrease in microbial biomass carbon (MBC) was evident at EC of 2241 µs/m and 2181 µs/m in the 0-15 cm and 15-30 cm soil layers, respectively. The average pH (1:2) of the saline soil dropped from 8.9 to 8.0 and the average ESP was reduced from 28.5 to 16.1. Higher concentrations of C pools (soil MBC (SMBC), water-soluble C (WSC) and acid-hydrolyzable carbohydrates (AHC)) were observed in the surface layers (0-15 cm) than in the deeper layer (15-30 cm). MBC was 23 % greater after the gypsum treatments (250 mg/kg soil) than after FYM treatments (203 mg/kg soil). This suggests that gypsum application, followed by organic amendments, is a better option in salt-affected soil in terms of crop productivity as well as soil biological activities.

Key words : C pools, Grain yield, Gypsum, Manures, Saline soil, Soil biological activities

Approximately 952 million hectares of land worldwide are affected by salinity and alkalinity, of which 7.1 million hectares of land are in India. Saline and alkaline soil occurs extensively in the arid and semiarid regions of India (Abrol *et al*. 1988). Plant growth is inhibited under such conditions due to unfavorable pH, excessive salt, imbalance of nutrients and poor soil structure. Irrigation-induced soil sodicity creates problems for cultivation and also in growth performance. Salt toxicity is one of the major edaphic factors limiting the salinized and/or sodic soils throughout the world. Apart from natural salinization, human-induced secondary salinization occurs frequently as a consequence of overproduction and irrigation caused by improper management of irrigation facilities, poor soil internal drainage conditions and unsuitable quality of irrigation water (Liang *et al.* 2005). In general, there are two major approaches to reclaiming salinized soils, one to accelerate the soil desalinization process by leaching salts down the profiles, and the other to enhance the tolerance of the existing crop cultivars to salt stress coupled with new salt-tolerant crop species. These measures are especially crucial for sustainable agriculture in developing countries such as India where soil resources per capita are limited.

Although information are available on physico-chemical properties of crop residue and organic manure and their effects on plant growth, but few attempts have been made to study microbiological activity in the semiarid Indo-Gangetic region of India (Rao and Pathak 1996). Dehydrogenase (DHA) activity is widely used as a generalized comparative index of soil microbial activity (Skujin 1973) as it indicates catabolic activity of microorganisms under anaerobic conditions. Microbial biomass represents an important reservoir of nutrients in the soil and is of crucial importance for long-term fertility of soils. Microbial biomass C (MBC) and DHA activity were responsive to soil pH and could be increased by

[1] Resarch Associate (e mail: sisodia_rs2@rediffmail.com), IISS, Bhopal, [2] Research Associate (e mail: munnalalsingh10@gmail.com), CRIDA, Hyderabad,. [3] Research Associate (e mail: ashokvardhand@gmail.com), CRIDA, Hyderabad; [4] Soil Physicist (e mail: aicrpsalinity@gmail.com); [5] Scientist (e mail: asit.iari@gmail.com), IISS, Bhopal; [6] Principal Scientist (e mail: madhabcm, @yahoo.com), IISS, Bhopal; [7] Associate Professor (e mail: vksingh_singh@rediffmail.com), JNKVV, College Agriculture, Tikamgarh (Madhya Pradesh). [8] Senior Scientist (e mail: birju1973@gmail.com), DRR Rajendranagar, Hyderabad, Andhra Pradesh.

the addition of gypsum to saline soils (Rao and Ghai 1985, Raubuch and Beese 1993). There is a need to examine the effects of organic manure incorporated into the rhizosphere or of bulk soil on the activity of some key enzymes related to soil nutrient cycling under a pearl millet *(Pennisetum glaucum* L. R Br)– wheat (*Triticum aestivum* L.) cropping system.

Soil organic matter is an essential component playing a key multifunctional role in the quality and physical and biological properties of soil (Smith *et al.* 1999). Physicochemical and biological problems arising from a lack of organic matter are usually evident in salinized and/or sodic soils, e g reduced water- and nutrient-holding capacity, poor soil aggregation, low cation exchangeable capacity and reduced microbial activity.

MATERIALS AND METHODS

The sodic soil at this site is representative of such soils of the Indo-Gangetic 1 alluvial plains of northern India. In general, these soils are formed under the influence of sodium carbonate and bicarbonate and are highly sodic throughout the profile. This experimental site was located between 27º2´N latitude and 77 º9´E longitudes characterized as a semiarid agroclimatic eco-region. The climate of the area is of a subtropical, monsoonal type and is characterized by dry summer, hot rainy season, warm autumn and cool winter. The maximum temperature rises up to 45°C in summer and the minimum reaches 2°C in winter. The average annual rainfall of a saline site representative of semiarid zones ranges between 500 and 675 mm, whereas that of the saline site representing arid zones is 250-350 mm. The soil of the experimental site was sandy loam (*Typic Ustrochrepts*) and its physiochemical properties are given in Table 1. Natural vegetation such as seasonal weeds continued to grow until the present study began in 2005. For the establishment of treatment, the experimental field was planted in rainy season with pearl millet (July-October 2005), followed by winter wheat (November 2005 to April 2006) and the same crop rotation was continued until 2008.

The treatments selected for this study consisted of: T1: nonsaline irrigated water + recommended doses of NPK for pearl millet followed by recommended doses of NPK for wheat (Control), T2: 30 milliequivalent sodium adsorption ratio (SAR) + NPK; T3: 40 SAR+ NPK; T4: 30 SAR + FYM @ 2.5 tonnes/ha + NPK; T5: 40 SAR+ FYM @ 2.5 tonnes/ha 19 + NPK; T6: 30SAR + gypsum @ 2.5 tonnes/ha + NPK; T7:40 SAR + gypsum @ 2.5 tonnes/ha 20 + NPK; T8:30SAR + green manure (GM) @ 8.4 tonnes/ha+ NPK, T9:40 SAR+ GM @ 8.4 tonnes/ha 21 + NPK. The land at the experimental site was very well drained and the water table always remained below 4 m during the study period. The field plots (2.5 m × 2.5 m size) were lined with polyethylene sheet down to a depth of 0.9 m to avoid lateral fluxes of salts and water. Pearl millet var. BJ 104/BK-560 and wheat WL 711 were grown in rotation on fixed plots and irrigated with different water quality treatments with 0, 30 and 40 SAR. This water was synthesized by dissolving stated amounts of NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$ in canal water. Half of the recommended N dose was given along with full P and K doses as basal doses, and the remaining half N dose was given after 21 days after sowing, through urea, superphosphate and KCl to both pearl millet and wheat.

Table 1 Physicochemical characteristics of the experimental soil

Soil characteristics	Value
Mechanical analysis	
Sand (%)	68.95
Silt (%)	16.01
Clay (%)	15.6
Textural class	Sandy loam
EC (ms/m at 25 oC)	665
pH (1:2.5 soil: water suspension)	8.2
Organic carbon (%)	0.28
Water soluble cat ions (me/l)	
Ca^{++}	6.1
Mg^{++}	7.9
Na^{++}	16.0
K^{+}	0.2
Water soluble anions (me/l)	
$CO^{3—}$	Nil
HCO^{3-}	8.4
Cl^{-}	11.3
SO_4	11.3
Exchangeable sodium percentage	28.5
Available nitrogen (kg/ha)	190
Available phosphorus (kg/ha)	16.4
Available potash (kg/ha)	216
Available zinc (kg/ha)	3.0

The FYM (205, 6.5, 2.5 and 4.5g/kg as total organic carbon, N, P and K) was applied each year before sowing the pearl millet. Recommended doses of 120:60:60 N: P: K for pearl millet and wheat were followed for all treatments during the experimental period. Gypsum (2.5 tonnes/ha) was applied once a year by broadcasting followed by incorporation with a rotavator to a depth of 10 cm. After 90 days after sowing dhaincha was used as green manure, and only leaf fall was incorporated manually before sowing of the next crop for the respective plots every year. The pearl millet crop was grown every year under rainfed conditions, whereas wheat was irrigated five times from wells at different stages that were critical for water stress, such as crown root initiation (21 days after sowing, DAS), maximum tillering (55 DAS), late joining (75 DAS), flowering (100 DAS) and the milking grain stage (135 DAS). At maturity, the crops were harvested manually at ground level with sickles and the harvested above-ground biomass was removed from the plots. The grains were separated from straw using a plot thresher, airdried and the grain yield recorded.

The physical and chemical parameters of the soils were determined by following the procedures described by Richards (1954) and Piper (1996). Dehydrogenase activity (DHA) in these soils was assayed by the method of Casida *et al.* (1964) by using 2, 3, 5- triphenyl tetrazolium chloride (TTC) as the electron acceptor and expressing the result in micrograms of triphenylformazan (TPF) per gram soil. MBC was determined in moist soil samples after a 3-day pre-incubation period at 25^o C to achieve basal respiration conditions (Srivastava and Singh 1989). MBC in sub-samples of the pre-incubated soils (12-g dry weight equivalent) was determined by the ethanol-free chloroform-fumigation extraction method (Vance *et al.* 1987) using a kc =0.45 conversion factor (Jenkinson and Ladd 1981).

The acid-hydrolysable carbohydrate-C value was obtained after the hydrolysis of a 5g (oven-dried at 65^{o}C) soil sample with 50 mL of 3 N H_2SO_4 for 24 hr at about 85^o C. Aliquots of the extracts were treated with 0.2 % anthrone reagent and measured colorimetrically at 625 nm. In addition, hot water-soluble C was determined in whole soil sub-samples (10 g) by shaking with 100 mL deionized water for 1 hr, followed by centrifugation at 10 000 rpm for min, and the supernatant was filtered through a 0.45-µm membrane (Campbell *et al.* 1999); values were expressed on dry weight basis.

The experiment was laid out in a randomized complete block design with three field replications for each treatment. The data were subjected to analysis of variance (ANOVA) as described by Gomez and Gomez (1984). When significant interactions between treatments and soil depths were detected, one-way repeated measures ANOVA was done separately for each soil depth. Separation of means was compared by Tukey's pairwise test. Two-way repeated measures ANOVA test was used to assess differences between treatments and aggregate size distribution; significant interaction was detected between treatments and aggregate size. None of the data violated assumptions for parametric statistical tests (ANOVA, linear regression). SPSS 11.5 package was used for all the statistical tests ($P < 0.05$).

RESULTS AND DISCUSSION

Yield and uptake of nutrients

In general, the plots receiving chemical fertilizer (T1) without salinized irrigation water recorded higher grain yields compared to salinized irrigation (Table 2). The average grain reduction for all the three years was significantly higher in the 30 SAR- and 40 SAR irrigated plots, and the yield reduction varied from 30 to 54.8% for pearl millet and 6.6 to 31.5% for wheat crop over control T1 treatment. Differences in grain yield due to amelioration treatments (FYM, gypsum and green manure) were at par (T4-T9). Furthermore, application of gypsum at 2.5 tonnes/ha 22 with 30 SAR

Table 2 Effects of different levels of saline irrigated water with gypsum, manures and fertilizers on grain yields of pearl millet and wheat

Treatment	Pearl millet (tonnes/ha)			Mean	Wheat (tonnes/ha)			Mean
	2005-06	2006-07	2007-08	2005-08	2005-06	2006-07	2007-08	2005-08
T1	2.80	3.19	3.04	2.97	4.25	4.13	3.90	4.09
T2	1.45	1.65	1.66	1.52	3.13	2.89	3.05	3.02
T3	1.18	1.46	1.38	1.34	2.89	2.74	2.76	2.80
T4	1.76	2.16	1.89	1.90	3.78	3.09	3.20	3.36
T5	1.53	2.03	1.78	1.82	3.76	3.08	3.16	3.33
T6	1.99	2.26	2.66	2.08	4.02	3.57	3.87	3.82
T7	1.86	2.18	2.07	1.98	3.94	3.26	3.62	3.61
T8	1.49	1.84	1.77	1.68	3.64	3.01	3.08	3.24
T9	1.47	1.67	1.74	1.60	3.21	2.99	3.06	3.09
SEM	0.002	0.005	0.003		0.018	0.008	0.005	
LSD	0.024	0.037	0.032		0.073	0.049	0.039	

salinized irrigation (T6) consistently gave higher crop yield over other ameliorative treatments in all the three years for both bajra and wheat. It appears that the application of gypsum could maintain higher growth and development of both crops. The present results were consistent with the findings of Prakash *et al.* (1994). The significant increase observed in plant nutrient status was due to the application of gypsum that might have improved the physicochemical properties of soil (Table 3).

N and P uptake were also higher in the plots receiving chemical fertilizers and non salinized irrigated water (Table 3). Application of gypsum made soil conditions favorable for both the crops with respect to chemical properties of the soil, which could have led to increased nutrient uptake and resulted in yields equivalent to those observed with chemical fertilizer and non-salinized irrigated water. This was in accordance with the findings of Linga *et al.* 2006. Data pooled from the differences in grain yields of pearl millet and wheat over three years were due to FYM, green manure and gypsum application (Table 3). Thus, it may be inferred that the best ameliorative effect was due to the fertilizer in combination with gypsum at the rate of 2.5 tonnes/ha (T6). Furthermore, it may be concluded that application of FYM (T4, T5) or green manure (T8, T9) was the next best ameliorative option due to better improvement of physicochemical and biological properties of the soil.

Soil organic carbon, water-soluble carbon, acid-hydrolyzable carbohydrates and DHA

Significant improvement was observed in soil total organic carbon (TOC) concentrations in bulk soil samples of the non-salinized irrigated soil (T1) from the topsoil (0-15 cm, approximately 57.1 %) and from a depth of 15-30 cm (25 %, Table 5). The magnitude of the increase in total SOC

Table 3 Effects of different levels of saline irrigated water with gypsum, manures and fertilizers on uptake (kg/ha) of N and P by pearl millet and wheat

Treatment	N uptake (Pearl millet)				P uptake (Pearl millet)				N uptake (Wheat)				P uptake (Wheat)			
	2005-06	2006-07	2007-08	Mean	2005-06	2006-07	2007-08	Mean	2005-06	2006-07	2007-08	Mean	2005-06	2006-07	2007-08	Mean
T1	37.80	41.20	39.90	39.63	5.60	6.40	5.80	5.93	71.40	70.40	64.80	68.87	10.20	10.20	10.00	10.13
T2	15.80	17.70	17.70	17.07	1.30	1.60	1.20	1.37	38.70	35.60	37.30	37.20	3.80	3.80	3.50	3.7
T3	12.10	14.90	14.40	13.80	0.90	1.10	0.90	0.97	30.70	29.10	28.80	29.53	2.90	3.30	2.60	2.933
T4	23.30	28.30	24.00	25.20	2.80	4.00	3.10	3.30	54.30	46.10	47.10	49.17	6.50	5.90	5.50	5.967
T5	18.60	24.30	12.20	18.37	2.20	3.00	2.40	2.53	48.10	42.10	42.70	44.30	5.30	4.90	4.50	4.9
T6	27.50	31.10	36.20	31.60	3.60	4.70	5.20	4.50	61.20	57.40	61.30	59.97	8.40	8.20	8.30	8.3
T7	22.90	26.50	25.00	24.80	3.00	3.60	3.20	3.27	50.50	45.60	49.50	48.53	6.30	6.10	6.40	6.267
T8	20.00	24.80	23.40	22.73	2.50	3.50	3.20	3.07	62.50	44.00	45.40	50.63	6.70	6.50	6.10	6.433
T9	18.00	20.20	20.90	19.70	2.20	2.70	2.30	2.40	43.90	41.50	42.40	42.60	4.50	4.70	4.50	4.567
SEM:	0.007	0.007	0.009		0.002	0.003	0.003		0.159	0.066	0.064		0.010	0.006	0.006	
LSD	0.145	0.144	0.161		0.079	0.099	0.09		0.690	0.445	0.436		0.173	0.137	0.133	

Table 4 Effects of different levels of saline irrigated water with gypsum, manures and fertilizers on SOC at 0-15 and 15-30 cm soil depths after 3 years of continuous cropping

Treatment	SOC(g/kg) after Ist crop		SOC(g/kg) after IInd crop	
	0-15cm	15-30 cm	0-15cm	15-30 cm
T1	4.4	3.5	4.0	3.2
T2	3.0	2.0	2.9	2.3
T3	2.7	1.8	2.7	2.1
T4	3.4	2.8	3.6	2.8
T5	3.2	2.5	3.8	2.7
T6	3.0	2.2	3.5	2.3
T7	3.0	2.2	3.2	2.3
T8	3.1	2.4	3.5	2.6
T9	3.2	2.3	3.4	2.5
SEM	0.080	0.010	0.010	0.010
LSD	0.480	0.130	0.200	0.150

was greater in the ameliorative treatment receiving FYM @ 5.0 tonnes/ha with 30 SAR and recommended chemical fertilizer (T4) than with other ameliorations. It was also found that the SOC content was relatively higher after the second crop than after the first crop.

There were higher concentrations of C pools (SMBC, WSC and AHC) and higher DHA activity in the surface layer (0-15 cm) than in the deeper layers (15-30 cm) (Tables 5 and 6). DHA activity was lower where reclamation was initiated with pearl millet as the first crop than with wheat crop as the first crop. However, the trend seen for MBC was different from that for DHA activity. MBC was significantly greater in treatments where reclamation was init iated with

Table 5 Effects of different levels of saline irrigated water with gypsum, manures and fertilizers on SMBC and DHA at 0-15 cm depth after 3 years of continuous cropping

Treatment	SMBC(g/kg)			DHA(g/kg)		
	Ist crop 0-15cm	IInd crop 0-15cm	Mean	Ist crop 0-15cm	IInd crop 0-15cm	Mean
T1	261	263	262	62.4	58.6	60.5
T2	170	175.0	173	41.4	41.6	41.5
T3	163	167.0	165	38.9	40.3	39.6
T4	248	252.0	250	59.2	57.6	58.4
T5	233	237.0	235	56.7	57.1	56.9
T6	202	203.0	203	42.5	44.5	43.5
T7	189	186.0	188	42.1	42.5	42.3
T8	209	232.0	221	50.6	50.7	50.7
T9	234	212.0	223	46.6	48.0	47.3
SEM:	10.70	9.8		0.7	0.23	
LSD	38.10	31.8		1.47	0.83	

Table 6 Effects of different levels of saline irrigated water with gypsum, manures and fertilizers on WSC and AHC at 0-15 cm soil depth after 3 years of continuous cropping

Treatment	WSC(ppm)			AHC(g/kg)		
	Ist crop	IInd crop	Mean	Ist crop	IInd crop	Mean
T1	106	120	113	320.0	370.0	345.0
T2	79	91.0	85	203.0	280.0	242.0
T3	73	89.0	81	252.0	284.0	268.0
T4	104	110.0	107	319.0	340.0	330.0
T5	98	107.0	103	310.0	322.0	316.0
T6	89	96.0	93	274.0	292.0	283.0
T7	80	95.0	88	264.0	290.0	277.0
T8	91	101.0	96	306.0	317.0	311.0
T9	90	98.0	94	300.0	314.0	307.0
SEM	1.94	1.87		10.2	5.1	
LSD	2.41	2.37		34.6	8.72	

gypsum. After three years of reclamation, MBC varied from 188 to 203 mg/kg soil in treatments with gypsum when compared with its variation from 235 to 250 mg/kg soil in treatments with FYM (Table 5). Microbial biomass is an essential component of labile C. It is sometimes used as a surrogate for labile C pools because it can readily be determined through physical and biochemical methods. Our results showed that MBC varied from 5.8 to 7.2 % of total organic carbon. The WSC content varied from 18.2 to 83.1 mg C/kg that accounted for 2.5 to 3.3 % of TOC, whereas acid hydrolyzable carbohydrates accounted for 6.9 to 10.5 % TOC in the top (0-15 cm) surface layer (Table 6). Although the active pool is a small fraction of SOM, its concentration is buffered by replenishment mechanisms such as desorption from soil colloids, dissolution from litter and exudation from plant roots.

Higher microbial biomass in gypsum treatments corresponded with lower exchangeable sodium percentage and high Ca^{2+} and Mg^{2+} 7 resulted in higher yield of bajra8wheat. The ratio of DHA activity to MBC was greater in FYM treatments than in gypsum treatments, whereas microbial biomass, when expressed as a percentage (%) of total organic carbon, was greater in gypsum treatments than in manure treatments (Table 5). On an average, a slightly greater reduction in the pH and exchangeable sodium percentage was observed in the 0-15-cm soil layer of plots treated with gypsum when compared with those amended with FYM. The treatments with FYM was continued for three years and thereby enhanced the *in situ* decomposition of organic matter along with gypsum application showed approximately lower pH and less exchangeable sodium than with other treatments. This confirmed that FYM had an additional effect over gypsum application alone in the reclamation of saline soil. Soil management practices and types of cultivation have a greater influence on soil microorganisms than do different soil types. Similarly, the yield of pearl millet, when used as a test crop after three years of reclamation, was significantly greater in treatments wherein soil was reclaimed with FYM for two years without a gypsum amendment and when the harvested grass was allowed to decompose *in situ.* Changes in microbiological properties with time during the reclamation process were comparatively greater than changes in the chemical properties of saline soils. Similarly, others have reported that changes in total N and organic carbon over time are smaller than changes in MBC and N.

Excessive amounts of salts present in the soil have an adverse impact on soil microbial biomass, soil respiration and DHA activity. The decrease in MBC was evident at ECe > 32 and 19 dS/m in the 0-15 cm and 0-30 cm soil layers. DHA activity was declined by 71 to 87 % at ECe of 28 and 40.8 dS/m (Batra and Manna 1997). Soil microbial activities in alkaline soil have been shown to suffer due to carbon stress, and low biological activity observed in highly saline soils is predominantly due to ex-osmosis from microbial cells (Batra and Manna 1997, Batra *et al.* 1997).

Interrelationships

This experiment results showed that the interrelationships among various C fractions and active fractions of carbon were the most sensitive indicators of soil quality parameters (Table 7, Fig 1). There was a significantly negative correlation ($r = 0.62$, $P < 0.01$) between SOC and EC. Positive correlation was observed between SOC and WSC ($r = 0.47$, $P < 0.05$) and AHC ($r = 0.77$, $P < 0.01$). Similarly, a significant correlation was observed between SMBC and DHA ($r = 0.71$, $P < 0.01$). Water-soluble fractions are considered to be

Table 7 Correlation matrix between soil chemical properties and biological activities (R2Value)

	pH	ECe	ESP (%)	Ca^{2+}	Mg^{2+}	Na^{+}
			0-15 cm depth			
DHA	0.286	0.324	0.505	0.137	0.290	0.336
WSC	0.253	0.318	0.552	0.389	0.214	0.357
WSCa	0.295	0.270	0.483	0.285	0.288	0.401
SMBC	0.468	0.557	0.752	0.393	0.274	0.518
OC	0.449	0.618	0.748	0.465	0.374	0.552
			15-30 cm depth			
DHA	0.309	0.332	0.516	0.334	0.405	0.277
WSC	0.345	0.332	0.599	0.409	0.323	0.238
WSCa	0.358	0.306	0.535	0.399	0.532	0.376
SMBC	0.483	0.391	0.399	0.589	0.615	0.466
OC	0.506	0.556	0.764	0.605	0.364	0.371

DHA, Dehydrogenase activity, WSC, water soluble carbon; WSCa, water soluble carbhohydrate,SMBC, soil microbial biomass carbon, OC, organic carbon

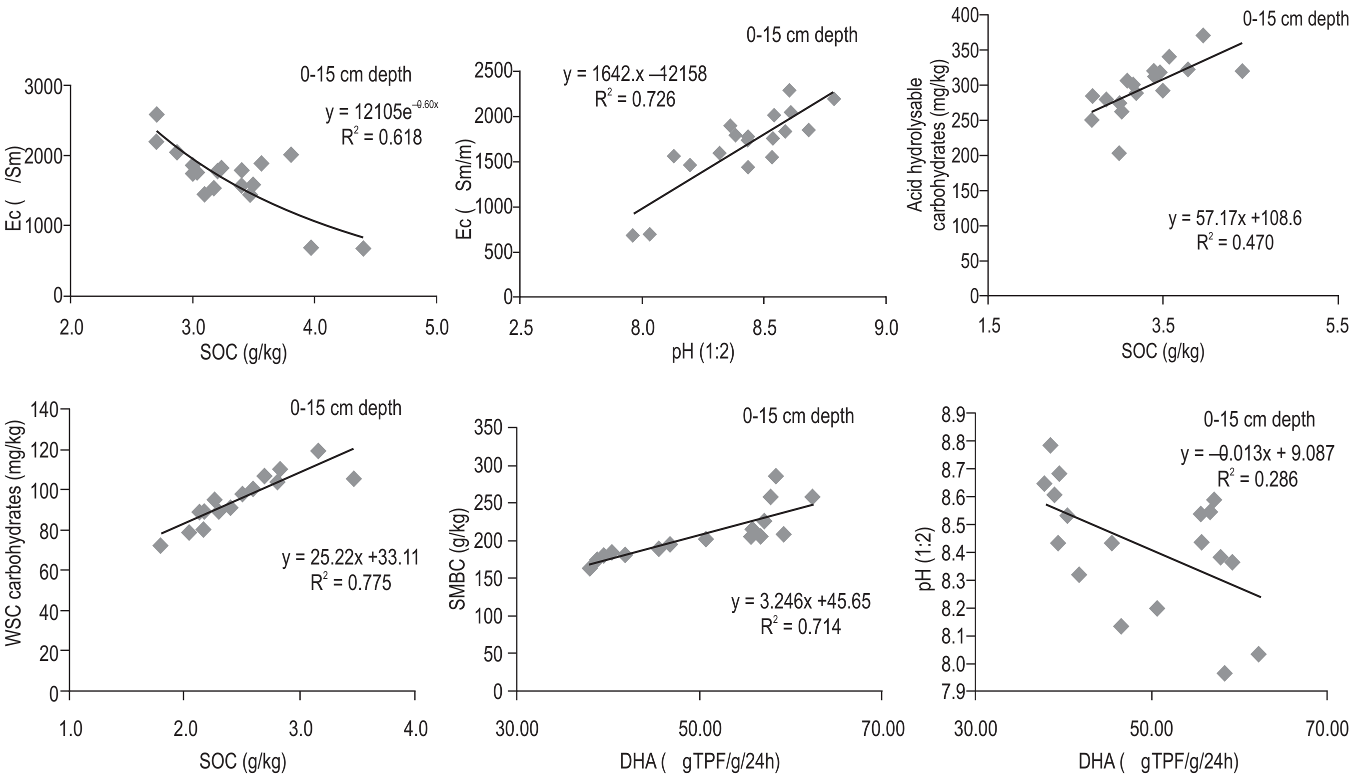

Fig 1 Interrelationships between SOC (Soil organic carbon) and EC, pH, AHC (Acid hydrolyzable carbohydrates), WSCa (Water-soluble carbohydrates), DHA (Dehydrogenase activity) and SMBC (Soil microbial biomass carbon)

the most active and highly labile components of total SOC that catalyze nutrient supply (N, P, S and other nutrients) in response to management practices. In particular, hot water-soluble carbon is considered to be the most active part of SOC (Six *et al*. 2000). Therefore, the application of fertilizer in combination with manure or chemical amendments every year may contribute more labile C that acts as a source of energy and improves nutrient supply and crop yield.

In this study, average values of soil biological activities were relatively higher under chemical and manure application than under irrigation with salinized water alone. Chemicals and manures provide chemical energy and C source for microorganisms, respectively. This is one of the reasons why SOC storage was not higher in these treatments than in the ameliorative treatments.

Soil organisms contribute to the maintenance of soil quality because they control the decomposition of plant and animal materials, biogeochemical cycling including nitrogen fixation, the formation of soil structure and the fate of organics applied to soils. A large, diverse, and active population of soil organisms may be the most important indicator of a healthy, high-quality soil. Yet, soil biological activity may be the most difficult indicator to satisfactorily measure and interpret. This situation is unlikely to change in the near future. So, for a working definition of soil biological quality and ease of analysis, measurement of the biochemical attributes of soil is the only option at present. SOM influences many soil properties including biological activity, all of which are related to a number of key soil functions.

DHA activity has been widely used as a generalized comparative index of microbial activity but it has not always been consistently correlated with microbial activity. There have been numerous attempts to correlate soil biological fertility with the activities of extracellular soil enzymes, but strong correlations can be expected only in unmanaged ecosystems or low input agricultural systems. Increased activities of several enzymes have been shown with the addition of organic amendments and green manure / crop residues. Soil microbial community and their activity influence the distribution and decomposition of organic residues in soil, these mechanisms increase the substrate surface and increase the turnover rate of microbial biomass.

CONCLUSION

From this study, we can conclude that the yield of crops and soil biological activities, such as DHA and MBC, were considerably reduced with increasing soil salinity, whereas these parameters increased with organic carbon content in these soils. However, microbial activity was affected by osmotic stress in conditions of excess salinity. The saline soil from an arid region dominated by neutral salts has higher DHA and MBC values. Our results suggest that chemical amelioration with gypsum and FYM / green manure can be utilized for soil when pearl millet and wheat are to be grown in semiarid soils.

REFERENCES

Abrol I P, Yadav J S P and Massoud F I. 1988. Salt-affected soils and their management. FAO Soils Bulletin in 39, FAO, Rome.

Batra L, Kumar A, Manna M C and Chhabra R. 1997. Microbiological and chemical amelioration of alkaline soil by growing Karnal grass and gypsum application. *Experimental Agriculture* **33:** 389–97.

Batra L and Manna M C. 1997. Dehydrogenase activity and microbial 1 biomass carbon in salt affected soil of semi arid and arid regions. *Arid Soil Research and Rehabilitation* **11:** 295–303.

Liang YC, Jin S, Microslav N, Yu P, Chen W and Jiang Y. 2005. Organic manure stimulate biological activity and barley growth in soil subject to secondary salinization. *Soil Biology & Biochemistry* **37:** 1 185–95.

Prakash V, Sharma N L and Singh R. 1994. Effect of soil amendments on soil properties and yield of rice and barley in a salt affected soil. *Current Agriculture* **18**: 35-40.

Rao. D L N and Pathak H. 1996. Ameliorative influenced of organic matter on the biological activity of salt affected soils. *Arid Soil Research and Rehabilitation* **10:** 311–9.

Rao D L N and Ghai S K 1985. Urease and dehydrogenase activity of alkali and reclaimed soils. *Australian Journal of Soil Research* **23:** 661–5.

Raubuch M and Beese F. 1993. Distribution of microbial biomass and 1 activity in forest soils along an European spruce and pine location. *Mitteilungen der Deutschen Bodenkudlichen Gesellschaft* **71:** 373–6.

Six J, Paustian K, Elliott ET and Combrink C. 2000. Soil structure and organic matter. I. Distribution of aggregate-size classes and aggregates-associated carbon. *Soil Science Society of America Journal* **64:** 681–9.

Skujin S J. 1973. Dehydrogenase: An indicator of biological activities in arid soils. *Bulletins from the Ecological Research Committee (Stockholm)* **17**: 235–41.