Journal of Soil Salinity and Water Quality 12(1), 80-88, 2020

Effect of Poor-quality Water on Soil Enzyme Activities in Arid Soils of Punjab

BK Yadav

Punjab Agricultural University, Regional Research Station, Bathinda-151001, Punjab, India
E-mail: bkyadav74@pau.edu

Abstract

Soil salinization is one of the most serious land degradation problems in the world. Excessive amounts of salts present in the soil have an adverse impact on soil microbial population and their activities. The aim of this study was to analyze the impact of soil agriculture management such as continuous poor quality water irrigation in arid soils on soil chemical, soil dehydrogenase and enzymes activity. Soil pH increased with increase in soil depth, and slightly higher soil pH was recorded in tube well water irrigated soils as compare to canal water. The higher soil electrical conductivity (EC) was recorded in tube well water irrigated soils compared to canal water in surface soils, and decreased with soil depth. The water quality not affected the soil organic carbon. A higher dehydrogenase activity (7.0 % and 4.0%) was reported in surface soils (0-15 cm) as compared to subsurface soils (15-30 cm) with canal water and tube well water, respectively. The poor quality water slightly influences the DHA in upper soil layers and reduced the activity by 2.9% in surface soil. Similarly, acid and alkaline phosphatase activity was higher in surface soils as compared to sub surface soils, irrespective of water quality. The surface (0-15cm) soils showed 3.3% and 3.4% higher acid phosphatase compare to subsurface (15-30 cm) soils irrigated with canal and tube well water, respectively. Whereas, in surface soils (0-15 cm) 3.4% and 1.5% more alkaline phosphatase was reported as compared to subsurface soils (15-30 cm) irrigated with canal and tube well water, respectively.

Key words: Soil enzyme, Soil salinity, Soil dehydrogenase, Acid phosphatase, Alkaline phosphatase, Arid soil

Introduction

Soil enzyme activities are very sensitive to both natural and anthropogenic disturbances and show a quick response to the induced changes. Soil dehydrogenase activity (DHA) has been recognized as an important indicator of the oxidative metabolism in soils and thus of the metabolic activity (Nannipieri *et al.*, 2012), because being exclusively intracellular, it is linked to viable cells. Soil phosphomonoesterase (acid and alkaline phosphatase) activities play an important role in catalyzing the hydrolysis of P-ester bonds binding P to C in organic matter, thereby releasing inorganic P which are assimilable by plants (Pascual *et al.*, 2002). Soils affected by salts commonly appear in irrigated areas due to inadequate management of irrigation. Thus the soil salinization depends on the quality of irrigation water used, natural and/or artificial soil drainage, the depth of the water-bearing stratum and the original concentration of salt in the soil profile. The physico- chemical properties of the soils and their biological processes have adverse affected by huge amount of salts provided by poor quality irrigation water (Garcia and Hernandez, 1996; Rietz and Haynes, 2003; Tejada and Gonzalez, 2005).These effects include mineralization of the carbon and nitrogen and the enzymatic activity, which is crucial for the decomposition of organic matter and release of the nutrients essential for sustainability of the crop production (Azam and Ifzal, 2006; Wong *et al.*, 2008).

Irrigation is an ancient agricultural practice, generally used throughout the world, mainly in arid and semi-arid regions where the evapo-transpiration rate exceeds the rainfall throughout the year. In these areas, where there is not enough water available to supply the hydric needs of the crops throughout the whole vegetative cycle, irrigation assumes a fundamentally important role in order to guarantee good agricultural harvests. Since all natural waters contain variable amounts of soluble salts, be they of meteoric (rain), surface

(rivers, lakes, dams, etc.) or subterranean (aquifers) origin, the application of such water to the soil by irrigation implies unavoidably in the addition of salts to their profile. The total water requirement for Punjab, with the present cropping pattern and practices and industrial uses, is estimated at 4.4 Million hectare-metres (Mha-m) against the total water availability of 3.13 Mha-m (Anonymous, 2002), of which 1.45 Mha-m is from canals and 1.68 Mha-m is from rainfall and seepage. There has been a reduction of over 35 % in canal irrigated area since 1990 due to reduction in canal capacity (Anonymous, 2014) and the deficit of almost 1.27 Mha-m is met by groundwater (Miglani *et al.,* 2015). More than 93% of the arable land in Punjab is irrigated of which 67% is irrigated with groundwater. In about 42% of the total area of Punjab, the underground tube well waters contain high concentration of salts and their sustained use adversely affects soil health and agricultural production. These waters are either saline (containing chlorides and sulphates of sodium) or sodic (containing carbonates and bicarbonates of sodium). Irrigation with waters having very high concentration of salts are not recommended, but low to moderate salinity or sodicity can be used by some specific management practices. Although there is no river passing through the Bathinda district but there are two canals namely Bathinda branch and Kotla branch of Sirhind canal system which irrigates 84.6% of the total irrigated area of the district remaining 15.4% of the area is irrigated by ground water. The effects of salinity on soil physico-chemical properties and plant growth are well known, their effects on soil biological characteristics remain relatively little studied, and there is limited information and poor consistency in studies of the salt effects on soil enzyme activities due to continuous use of poor quality water for irrigation in arid soils.

Materials and Methods

The field experiment was conducted with continuous use of two quality (canal and tube well) of water on permanent fixed plots during *Kharif* 2016 to *Kharif* 2019 at Punjab Agricultural University, Regional Research Station, Bathinda (30°09′36″ N latitude, 74°55′28″ E longitude and at an altitude of 211 m above sea level). The soil is loamy sand in texture (% sand, silt and clay being 80.1, 12.2 and 7.7, respectively) non-calcareous (%$CaCO_3$- 4.15%), slightly alkaline (pH- 8.13) in reaction. The soil was low in organic carbon (OC- 0.19%), and phosphorus (P- 9.5 kg ha^{-1}) and high in potassium (K-240 kg ha^{-1}) content. The soil showed 4.67 µg TPF release g^{-1} dry soil h^{-1} as dehydrogenase activity and 3.52 and 4.21 µg p-NP produced g^{-1} dry soil h^{-1} as acid and alkaline phosphatase activity, respectively. Detailed of the different crop grown, crop growing period, number of irrigations and soil sampling time during different cropping seasons were presented in Table 1. After crop harvesting, soil samples were collected in labelled plastic bags and transferred immediately to the laboratory. The samples were passed through 2-mm sieve and divided into two fractions: one fraction for the determination of chemical fractions, which were kept at room temperature and the other fraction for measuring of soil biological parameters which was stored at 4ºC. Dehydrogenase activity (DHA) in soil was determined using the reduction of 2, 3, 5-triphenyltetrazolium chloride (TTC) method (Klein *et al.*, 1971), and the colour intensity was measured at 485 nm by spectrophotometer. The

Table 1. Detailed of the different practices conducted during the study period

S. No.	Cropping season	Crop grown	Seedling month	Total number of irrigations	Soil sampling period
1	Kharif-2016	Clusterbean	First week of July	4	November
2	Rabi-2016-17	Wheat	Second week of Nov.	4	April
3	Kharif-2017	Clusterbean	Last week of June	5	November
4	Rabi-2017-18	Gram	Second week of Nov.	3	April
5	Kharif-2018	Clusterbean	Last week of June	4	November
6	Rabi-2018-19	Vegetable cowpea	Last week of February	10	August
7	Kharif-2019	Brinjal	Second week of September	7	December

DHA was expressed as microgram (µg) triphenylformazane (TPF) produced per gram (g) dry soil per hour at 37°C. Acid and alkaline phosphatase activity were estimated following the method reported by Tabatabai and Bremner (1969), after soil incubation with modified universal buffer (pH 6.5 for acid phosphatase and pH 11.0 for alkaline phosphatase) and p-nitrophenyl phosphate (p-NP) at 37°C, the produced yellow colour intensity was measured colorimetrically at 420 nm. Acid and alkaline phosphatase activities were expressed as microgram (µg) ρ-nitro phenol produced per gram (g) dry soil per hour. The pH and EC of the soils were determined in 1:2 soil-water suspensions using a glass electrode pH meter and conductivity meter respectively (Jackson, 1973). The organic carbon was determined by wet digestion method (Walkley and Black, 1934). The available P in the soil was extracted by employing Olsen extractant (0.5M $NaHCO_3$, pH 8.5) as described by Olsen *et al*. (1954). The available K was extracted by using neutral ammonium acetate and the content was determined by aspirating the extract into flame photometer (Jackson, 1973). At the time of each irrigation water samples were collected and analyzed for salinity/sodicity parameters viz. electrical conductivity (EC), cationic concentration (Na^+, Ca^+ and Mg^+) and anionic concentration (CO_3^{2-}, HCO_3^- and Cl^-) as per standard methods outlined by Richards (1954), showed that the canal water is good quality, whereas the tube well water is saline in nature (Table 2). For statistical analysis of data, Microsoft Excel software (Microsoft Corporation, USA) was used.

Results and Discussion

Weather characteristics

The weather data during the each cropping season were recorded at meteorological weather station, PAU Regional Research Station, Bathinda. The seasonal average value of climatic parameters and total precipitation and evaporation are presented in Fig. 1. The value of T_{min} ranged from 18.3-27.9°C with mean 24.8°C in *Kharif*-2016 and 6.4-18.8°C with mean 10.6°C in *Rabi*-2016-17, 17.2-27.0°C with mean 24.0°C in *Kharif*-2017 and 4.4-18.7°C with mean 9.8°C in *Rabi*-2017-18, 17.0-26.1°C with mean 23.1°C in *Kharif*-2018 and 4.5-26.1°C with mean 14.9°C in *Rabi*-2018-19. However, the value of T_{max} ranged from 33.6-40.9°C with mean 36.5°C in *Kharif* -2016 and 18.5-37.5°C with mean 26.8°C in *Rabi*-2016-17,34.1-40.3°C with mean 36.07°C in *Kharif*-2018 and 18.9-37.0°C with mean 26.1°C in *Rabi*-2017-18, 32.3-39.7°C with mean 35.6°C in *Kharif*-2018 and 18.7-41.2°C with mean 29.8°C in *Rabi*-2018-19. As compared to *Rabi* season, the minimum temperature ($T_{min)}$ in *Kharif* was 2.35 times higher in 2016, 2.44 times higher in 2017 and 1.5 times higher in 2018. Whereas, the maximum temperature ($T_{max)}$ in *Kharif* was 1.4 times higher in 2016, 1.4 times higher in 2017 and 1.2 times higher in 2018. The morning and evening relative humidity ranged from 63.5-85.1% and 27.8- 71.4% in *Kharif* 2016, ranged from 63.5-91.7% and 39.9-61.9% in *Rabi* 2016-17, ranged from 61.0-90.3% and 31.8- 62.8% in *Kharif* 2017, ranged from 56.2-90.7% and 29.9- 56.2% in *Rabi*2017-18, ranged from 50.7-84.8% and 26.4-60.1% in *Kharif* 2018, ranged from 55.9-97.6% and 32.1-65.1- 56.2% in

Table 2. Composition of canal and tube well water used for irrigation during 2016-2019

Particulars	Canal water		Tube well water	
	Range	Mean	Range	Mean
EC (dS m^{-1})	0.30-0.34	0.32	4.20-4.40	4.33
Na^+ (me l^{-1})	0.65-1.42	0.88	32.50-36.60	34.92
$Ca^{+2} + Mg^{+2}$ (me l^{-1})	1.78-2.58	2.06	7.10-7.60	7.44
Cl^{-1} (me l^{-1})	0.40-0.80	0.53	7.20-11.80	8.46
CO_3^{-2} (me l^{-1})	Nil	Nil	Nil	Nil
HCO_3^- (me l^{-1})	1.50-1.80	1.63	6.80-7.50	7.20
RSC (me l^{-1})	Nil	Nil	Nil	Nil
SAR	0.62-1.50	0.86	17.90-19.00	18.43

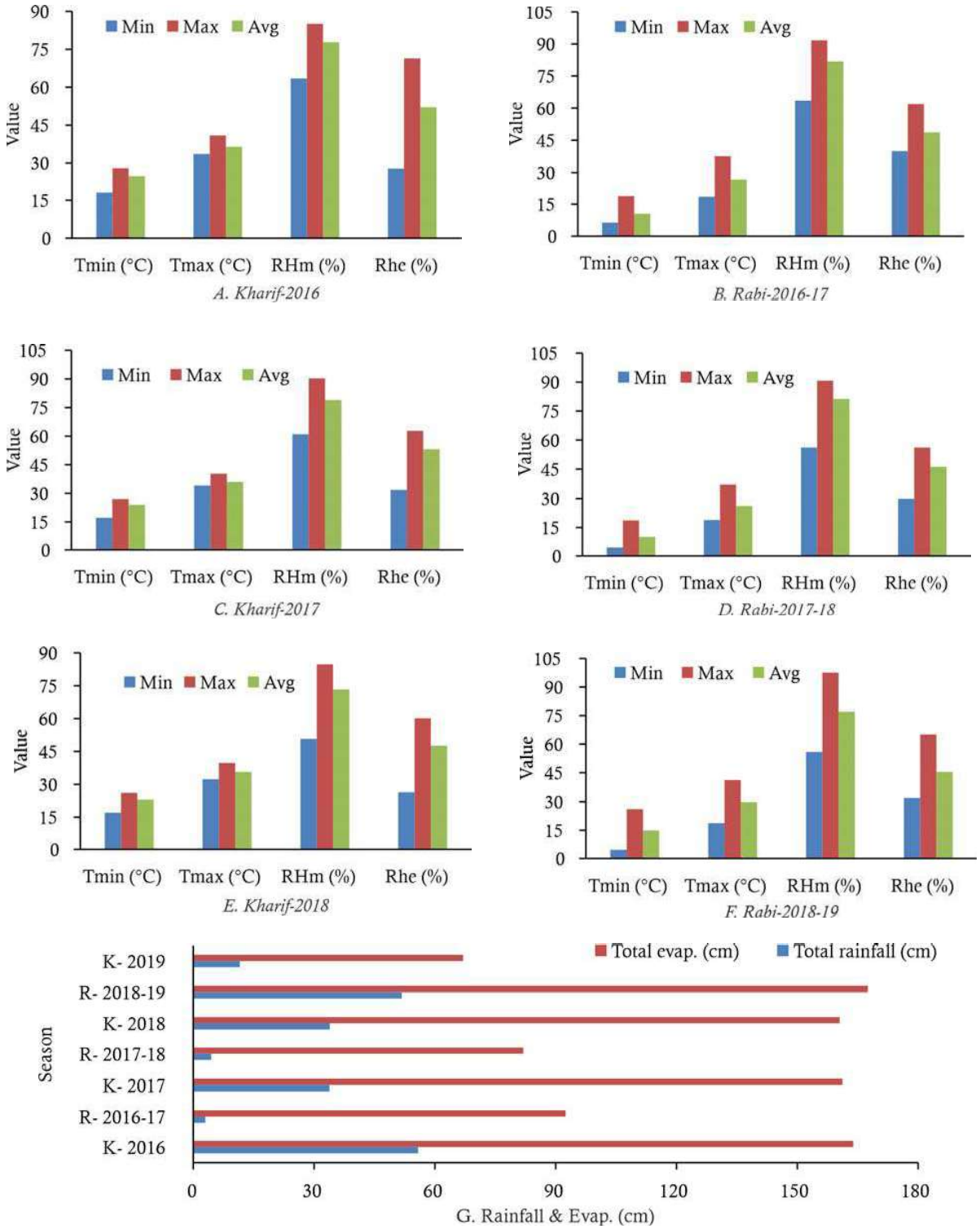

Fig. 1 Different weather parameters of study site during the experimental period (R-*Rabi*, K-*Kharif*)

Rabi 2018-19. About 88-94% rain is received during the south-western monsoon season (First week of July to mid September) and remaining during the winter season during the study period.

Soil characteristics

The soil properties of the soil exhibited variation with respect to different sampling periods and soil depths (Fig. 2). On an average, in surface (0-15cm)

soil, pH ranged from 8.28 to 8.32 and 8.33 to 8.55 with mean of 8.30 and 8.43 with canal and tube well water irrigated soils. However pH increased with increase in soil depth during all seasons and varies from 8.33 to 8.35 and 8.35 to 8.55 with mean of 8.34 and 8.46 with canal and tube well water irrigated subsurface soil (15-30 cm). The higher pH in lower layers could be due to increase in accumulation of exchangeable of cations. This finding is in agreement with Yadav *et al.* (2016) who reported increase in soil pH with increase in soil depth.

There are no seasonal variations in soil pH was observed during the study period, but slightly higher pH was observed in tube well water irrigated soils (Fig. 2), may be due to buffering capacity of soil which restrict easily changes in soil pH, moreover, higher pH of tube well irrigated soils may be due to higher accumulation of cations present in tube well water compared to canal water. Moreover, the presence of high carbonate and bicarbonate concentration in ground water of Bathinda district fall under doubtful to unfit category Sharma *et al.* (2017). The high level of carbonate and bicarbonate ions combined with calcium and magnesium will precipated as calcium carbonate ($CaCO_3$) or magnesium carbonate ($MgCO_3$). This will cause an alkalizing effect and increased the soil pH. Electrical conductivity (EC) values of the soil layers indicated the non salinity character of the soil profiles (Fig. 2). The EC varies from 0.17-0.20 dS m^{-1} in surface (0-15 cm) with mean of 0.19 dS m^{-1}, and from 0.16-0.18 dS m^{-1} in sub-surface (0-15 cm) with mean of 0.18 dS m^{-1} in canal water irrigated soils. Relatively higher soil EC was reported with tube well water irrigated soils and ranged 0.19-0.52 dS m^{-1} in surface (0-15 cm) with mean of 0.31 dS m^{-1}, and 0.19-0.51 dS m^{-1} with mean of 0.30 dS m^{-1} in sub-surface (0-15 cm). The lower values of electrical conductivity in these soils may be attributed to more macro pores, as majority of the soil samples in the area are light textured, resulting in free drainage conditions. Irrigated with tube well water soils showed higher EC in both the seasons, may be due to higher salts present in tube well water used for irrigation (Table 2). Furthermore, during *Kharif* seasons rise in temperature causes more evaporation, resulted salt accumulation in upper soil layers causes higher electrical conductivity (EC) compared to *Rabi* seasons. There are no significant seasonal variation in organic carbon was reported due to quality of irrigation water during the study period (Fig. 2). The surface (0-15 cm) soils showed higher organic carbon (0.21%) as compared to 0.18% in subsurface soils (15-30 cm). The light soil texture and high temperature prevailing in the area is responsible for the rapid burning of organic matter, thus resulting in low organic carbon content of the soil.

Dehydrogenase activity

The dehydrogenase activity ranges from 4.26-4.82 in surface (0-15 cm) with mean of 4.54 µg TPF release g^{-1} dry soil h^{-1}, and from 4.08-4.65 in sub-surface (0-15 cm) with mean of 4.24 µg TPF release g^{-1} dry soil h^{-1} in soils irrigated with canal water. However, irrigated with poor quality tube well water it varied from 4.28-4.52 with mean of 4.41 µg TPF release g^{-1} dry soil h^{-1} in surface (0-15 cm), and from 4.08-4.35 with mean of 4.24 µg TPF release g^{-1} dry soil h^{-1} in sub-surface (0-15 cm) soils (Fig. 3). Higher dehydrogenase activities were reported in surface soil (0-15 cm) as compared to subsurface soils (15-30 cm). The poor quality water slightly influence the DHA in upper soil layers and reduced the dehydrogenase activity by 2.9% in surface soil. Dehydrogenase is only produced by alive cells (Dick, 1994) and is a good indicator of microbial metabolism in soil (Tabatabai, 1982). Generally, soil enzyme activities were higher in the surface soils (0-15cm) as compared to sub surface soils (15-30 cm). The results suggest that microbial activity in surface soil was perhaps influenced by the inputs added as well as litter-fall whereas; root exudates and other root related activities were probably the principal governor of microbial activity in subsurface soil. DHA in soil depends on the content of soluble organic carbon and, the increased organic matter in the surface soil enhances the soil enzyme activities (Nannipieri *et al.*, 2012). Frankenberger and Bingham, (1982) studied under laboratory conditions, salinity influenced soil enzyme activity negatively, although the degree of inhibition varied according to the enzyme analysed and the nature and amount of soil added. The dehydrogenase

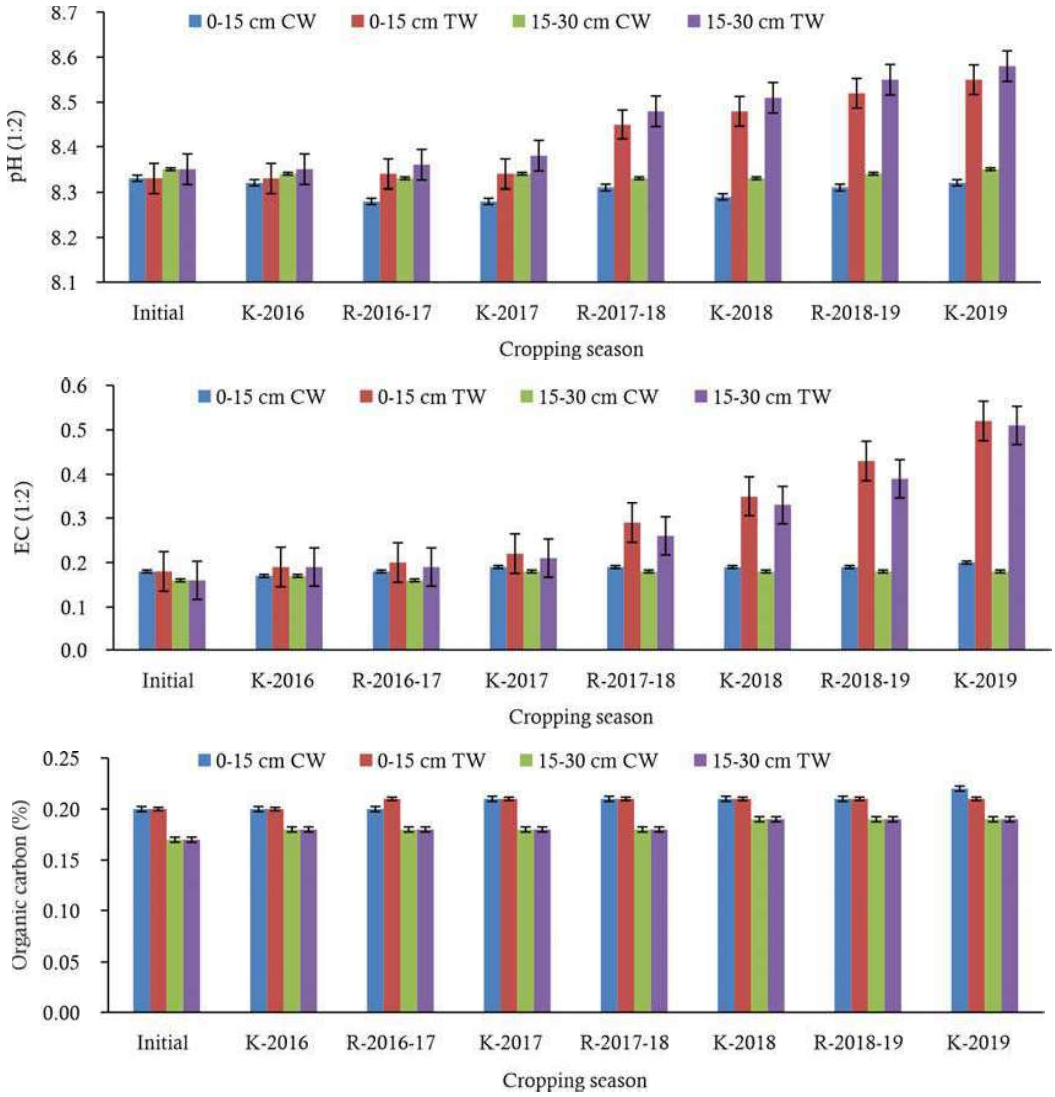

Fig. 2 Changes in soil reaction (pH), electrical conductivity (EC) and organic carbon of soils during the experimental period. Bars represent the standard error of mean

activity was severely inhibited and the reduction of enzyme activity in saline soils could be due to the osmotic dehydration of the microbial cells that liberate intracellular enzymes, which become vulnerable to the attack by soil proteases, with a consequent decrease in enzyme activity. According to Rietz and Haynes (2003) the increase in salinity due to an influx of salty water under controlled conditions, decreased the carbon content of the soil microbial biomass and enzymes.

Acid and alkaline phosphatase

The acid phosphatases varies between 3.19-3.61 with mean value of 3.41 µg p-NP produced g^{-1} dry soil h^{-1} and between 3.32-3.45 with mean value of 3.38 µg p-NP produced g^{-1} dry soil h^{-1} irrigated with canal and tube well water in surface soils (0-15cm), respectively. Similarly, it varies between 3.04-3.50 with mean of 3.30 µg p-NP produced g^{-1} dry soil h^{-1} and between 3.15-3.38 with mean value of 3.26 µg p-NP produced g^{-1} dry soil h^{-1} irrigated with canal and tube well water in subsurface soils (15-30 cm), respectively. Whereas, in surface (0-15cm) soils alkaline phosphatase varies between 4.06-4.28 with mean value of 4.17 µg p-NP produced g^{-1} dry soil h^{-1} and in subsurface (15-30 cm) soils varies from 3.92-4.16 with mean value of 4.01 µg p-NP produced g^{-1} dry soil h^{-1} in canal water irrigated soils. The variation was

between 3.83-4.11 with mean value of 3.97 µg p-NP produced g^{-1} dry soil h^{-1} in surface (0-15cm) and 3.71-4.09 with mean value of 3.91 µg p-NP produced g^{-1} dry soil h^{-1} in subsurface (15-30 cm) soils irrigated with tube well water. The surface (0-15cm) soils showed 3.3% and 3.4% higher acid phosphatase compare to subsurface (15-30 cm) soils irrigated with canal and tube well water, respectively. Whereas, in surface soils (0-15 cm) 3.4% and 1.5% more alkaline phosphatase was reported as compared to subsurface soils (15-30 cm) irrigated with canal and tube well water, respectively (Fig. 3). The alkaline phosphatase activity was more affected by poor quality water

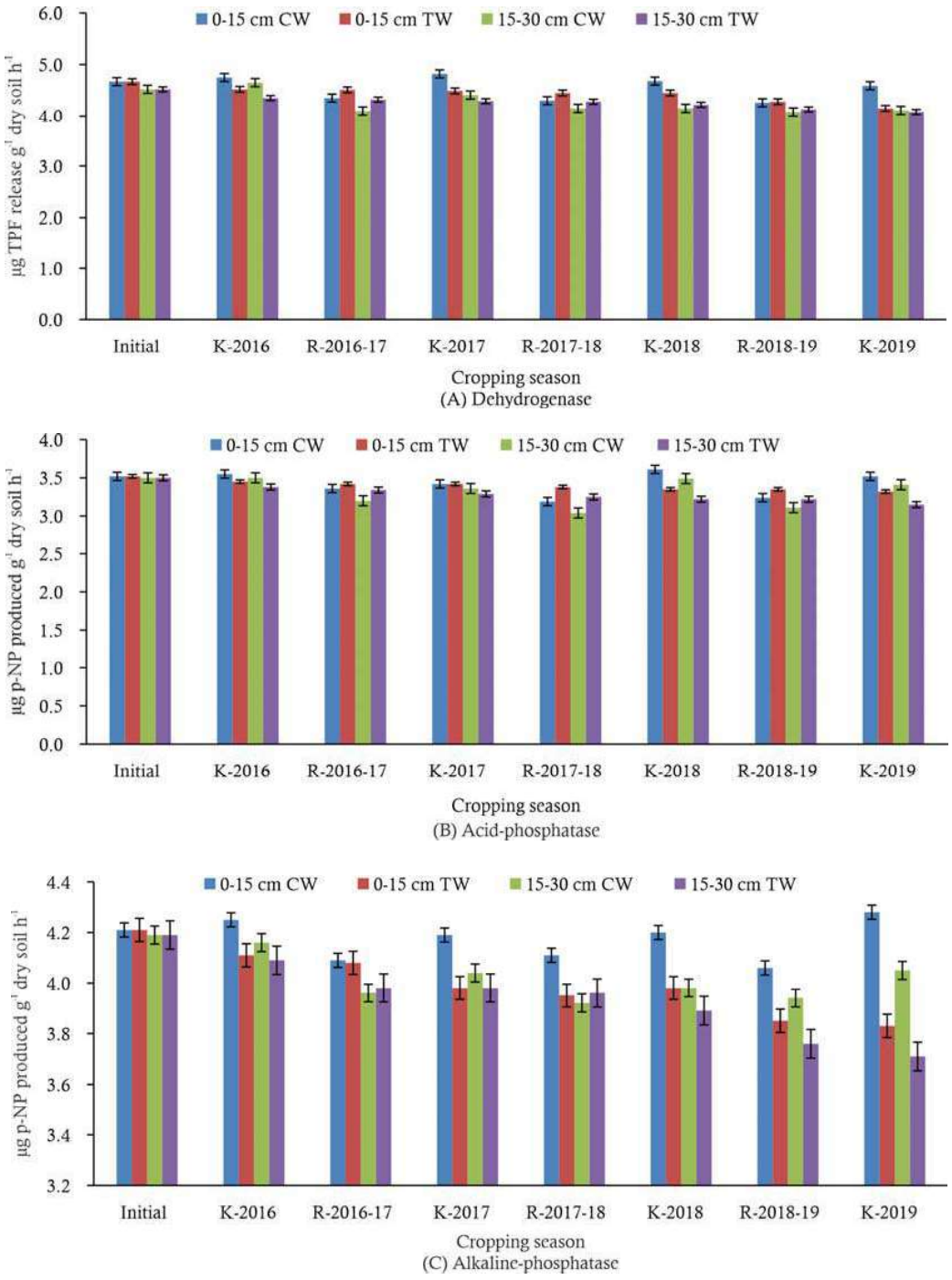

Fig. 3 Dehydrogenase, acid and alkaline-phosphatase activity of soils during the experimental period. Bars represent the standard error of mean

compared to acid phosphatase, may be due to alkaline nature of studied soils, which was higher in tube well water irrigated soils compared to canal water irrigated soils. Alkaline reaction of the soil might also have increased alkaline phosphatase activity over acid phosphatase activity. The pH of the soil solution exerts a strong control on these enzyme activities (Chhonkar *et al.*, 2007). An increase in soil salinity inhibited the enzyme activities of benzoyl argininamide alkaline phosphatase and β-glucosidase, and also microbial respiration (Ghollarata and Raiesi, 2007). Ahmed and Khan (1988) also observed a decline in amylase, catalase, phosphatase and urease activities with increasing salinity, with comparing the enzyme activities of saline soil with those of normal soil.

Conclusions

The results showed that continuous use of saline water for irrigation slightly increase the soil pH and EC and reduced the DHA, acid and alkaline phosphatase of arid soil. There are no similar trend was reported in any soil parameters during the study period, may be due to light textured soil and variation in environmental parameters specially temperature and rainfall. Therefore, it would be suggested that the farmers of the region may use such quality of water by some safety measures such as irrigate the crop with alternate furrows, the poor and good quality waters can be used together, either alternatively or by mixing with each other to mitigate the adverse effect of poor quality water. Moreover, when poor quality waters are used on a long term basis the farmers are advised to keep a watch on the build up of salts in the soil by getting the soil samples tested at regular intervals. This will help them in keeping a check on soil deterioration.

Acknowledgements

The author is highly thankful to PC unit, AICRP on Management of Salt Affected Soils and Use of Saline Water, ICAR-CSSRI, Karnal, Haryana for financial assistance and Director, PAU, Regional Research Station, Bathinda for providing all necessary facilities for this study.

References

Ahmad I and Khan KM (1988) Studies on enzymes activity in normal and saline soils. *Pakistan Journal Agricultural Research* **9(**4): 506-508.

Anonymous (2002) *Agriculture Production Pattern Adjustment Programme in Punjab for Productivity and Growth*. A Report to the Government of Punjab, Chief Ministers Advisory Committee on Agriculture Policy and Restructuring, pp.123.

Anonymous (2014) *Water Quality Issues and Challenges in Punjab*. Central Ground Water Board, Ministry of Water Resources, Government of India, Faridabad, pp. 182.

Azam F and Ifzal M (2006) Microbial populations immobilizing NH_+^4-N and NO_3^--N differ in their sensitivity to sodium chloride salinity in soil. *Soil Biology and Biochemistry* **38(8):** 2491–2494

Chhonkar PK, Bhadraray S, Patra AK and Purakayastha TJ (2007*) Experiments in Soil Biology and Biochemistry*. Westville Publishing House, New Delhi, India.

Dick RP (1994). Soil enzyme activities as indicators of soil quality. In: Doran JW, Coleman DC, Bezdicek DF and Stewart BA (eds) *Defining Soil Quality for a Sustainable Environment*. Soil Science Society of America, Madison, Wisconsin, USA, Pp. 108-123.

Frankenberger WT and Bingham FT (1982) Influence of salinity on soil enzyme activities. *Soil Science Society of America Journal* **46(6):** 1173–1177.

Garcýa C and Hernandez T (1996) Influence of salinity on the biological and biochemical activity of a calciorthird soil. *Plant and Soil* **178(2):** 255–263.

Ghollaratta M and Raiesi F (2007) The adverse effects of soil salinization on the growth of *Trifolium alexandrinum* L. and associated microbial and biochemical properties in a soil from Iran. *Soil Biology and Biochemistry* **39(7):** 1699-1702.

Jackson M L (1973) *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Klein DA, Loh TC and Goulding RL (1971) A rapid procedure to evaluate dehydrogenase activity of soils low in organic matter. *Soil Biology and Biochemistry* **3(4):** 385-387.

Miglani P, Aggarwal R and Kaur S (2015) Groundwater simulation model for Sirhind canal tract of Punjab. *Journal of Engineering and Technology* **5(1)**: 31-35.

Nannipieri P, Giagnoni L, Renella G, Puglisi E, Ceccanti B, Masciandaro G, Fornasier F, Moscatelli MC and Marinari S (2012) Soil enzymology: classical and molecular approaches. *Biology and Fertility of Soils* **48(7)**: 743-762.

Olsen SR, Cole CV, Watanabe FS and Dean LA (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDACircular 939.

Pascual JA, Moreno JL, Hernández T and García C (2002) Persistence of immobilized and total urease and phosphatase activities in a soil amended with organic wastes. *Bioresource Technology* **82(1):** 73-78.

Richards LA (1954) *Diagnosis and Improvement of Saline and Alkali Soils*. U.S.D.A. Hand Book No. 60, Oxford and IBH Publishing Co., New Delhi.

Rietz DN and Haynes RJ (2003) Effects of irrigation induced salinity and sodicity on soil microbial activity. *Soil Biology and Biochemistry* **35(6):** 845-854.

Sharma DA, Madhuri SR and Keesari T (2017) Evaluation of groundwater quality and suitability for irrigation and drinking purposes in southwest Punjab, India using hydrochemical approach. *Applied Water Science* **7(6)**: 3137-3150.

Tabatabai MA (1982) Soil enzymes. In: Page AL, Miller RH and Keeney DR (eds) *Methods of Soil Analysis* Part 2, Agronomy 9, American Society of Agronomy, Madison, Wisconsin, USA. pp. 903-947.

Tabatabai MA and Bremner JM (1969) Use of p-nitrophenol phosphate for assay of soil phosphatase activity. *Soil Biology and Biochemistry* **1(4):** 301-307.

Tejada M and Gonzalez JL (2005) Beet vinasse applied to wheat under dry land conditions affects soil properties and yield. *European Journal of Agronomy* **23(4):** 336-347.

Walkley A and Black IA (1934) An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chronic acid titration method. *Soil Science* **37(1)**: 29-38.

Wong VNL, Dalal RC and Greene RSB (2008) Salinity and sodicity effects on respiration and microbial biomass of soil. *Biology and Fertility of Soils* **44(7**): 943-953

Yadav BK, Sidhu AS and Thaman Sudhir (2016) Soil fertility status of Punjab Agricultural University seed farm, Chak Ruldu Singh Wala, Sangat, Bathinda, Punjab. *Annals of Plant and Soil Research* **18(3)**: 226-231.

Received: February 2020; Accepted May 2020