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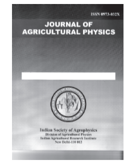

Research Article

Spatial Variability of Bio-Chemical Soil Properties under Different Land Use Systems at PAU, Regional Research Jewan Singh Wala Farm, Bathinda

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ABSTRACT

The present investigation was carried out to study the bio-chemical soil properties under different land use systems at PAU, Regional Research Jewan Singh Wala Farm. The results showed that soil was normal to marginal alkaline in reaction, and soil pH ranged from 7.44-8.45 at 0-15 cm and 7.58-8.47 at 15-30 cm soil layers. The EC of the farm ranged from 0.18-0.38 dSm^{-1} with mean of 0.27 dS m^{-1} at 0-15 cm and 0.14-0.32 dSm^{-1} with mean of 0.23 dS m^{-1} at 15-30 cm soil layer which were normal for crop production. A higher soil enzymes (dehydrogenase (DHA), acid and alkaline phosphatase) was reported in 0-15 cm soils as compared to 15-30 cm soils. The DHA ranged from 5.15-8.59 and 4.66-7.99 with mean of 7.23 and 6.20 μg TPF release g^{-1} dry soil h^{-1} in 0-15cm and 15-30 cm soils, respectively. Similarly, the surface (0-15cm) soils showed 16.2% and 12.8% higher acid and alkaline phosphatase compared to subsurface (15-30 cm) soils, respectively. The SOC of 0-15 cm soils ranged 5.33-11.98 g kg^{-1} with average of 8.78 g kg^{-1} and decreased with increased in soil depth. The P availability of the farm was low to medium category and varied from 14.65-18.54 kg ha^{-1} with average of 16.63 kg ha^{-1} in 0-15 cm and 10.96-17.12 kg ha^{-1} with average of 14.19 kg ha^{-1} in 15-30 cm soils. The average K was also higher in 0-15cm soils and ranged from 235.5-537.5 kg ha with mean of 374.4 kg ha^{-1}. DTPA-extractable Zn, Cu, Fe, and Mn showed decreasing trends with increased in soil depth, ranged from 0.52-1.65, 0.48-1.43, 5.23- 8.65 and 3.47-6.87 mg kg^{-1} with mean of 1.08, 0.88, 6.44 and 5.61 mg kg^{-1} 15-30 cm soils. The nutrient index value (NIV) revealed that the soils were higher in organic carbon, low in available P and medium in K availability and medium Zn, Fe, Mn and high Cu availability.

Key words: Dehydrogenase, Soil phosphatases, Land use pattern, Nutrients availability

Introduction

The high quality soil not only produces better food and fiber crops, but also helps to establish natural ecosystems (Griffiths *et al.*, 2010). The soil fertility changes and nutrient balances are taken as key indicators of soil quality (Jansen *et al.*, 1995). Soil fertility varies spatially from field to larger region scale, and is influenced by both land use and soil management practices (Sun *et al.*, 2003). Revealing spatial variability of soil fertility and its influencing factors are important to improve sustainable land use strategies (Qi and Darilek, 2009). It is reported that differences in fertilization, cropping system and farming practices were the main factors influencing soil fertility quality at field scale (Liu *et al.*, 2010).The different land use and management practices significantly impact soil properties (Spurgeon *et al.*, 2013), and knowledge of the variation in soil properties within farmland use is essential in determining production constraints related to soil nutrients. Sustainable land

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management practices are necessary to meet the changing human needs and to ensure long-term productivity of farmland (Hãlbac-Cotoarã-Zamfir *et al.*, 2019). Dynamics of soil properties such as texture, pH, electrical conductivity, carbon (C), nitrogen (N), available phosphorus (P), available potassium(K), and micronutrients are studied in different land use scale and dimensions (Kilic *et al.,* 2012; Jafarian *et al.*, 2014; Kharal *et al.*, 2018). At different spatial and time scales, vegetation cover helps in protecting the soil from harsh climatic conditions (Deekor *et al.,* 2012). The land use pattern causes significant modifications in soil properties. Since it is a source of energy for microbial biomass, participates nutrient ion storage and cycling, plant available water, infiltration, aggregate formation and stability, density and soil resistance, as well as influencing cation exchange capacity (Reeves, 1997). Yang *et al.* (2004) exhibited that changes in land use and management can strongly affect soil organic matter, conversion from forest to croplands, combined with conventional tillage and lack of biomass return to soil, is reported to reduce the degree of soil organic matter humification. Factors including vegetation coverage, the amount of litter fall as well as root impact and disturbance or management regime can contribute to the significant variation of surface soil SOC across different land uses (Chen *et al.,* 2007). Information on effect on different land use pattern on bio-chemical soil properties in arid soils of Punjab is lacking, so the present study was undertaken to demonstrate the effect of different land-use pattern on bio-chemical soil properties of PAU Regional Research Jewan Singh Wala farm, Bathinda.

Material and Methods

Location of study area

The Bathinda district lies between 29°30′ and 32°32′ N latitudes, 73°55′ and 76°55′ E longitudes. The annual normal rainfall of the region is about 436 mm, of which 80 percent is received during the south-west monsoon (first week of July to mid September) and remaining during the winter. The farm (Fig. 1) has well established Aonla (*Emblica officinalis* Gaertn) and Ber (*Ziziphus mauritiana* Lam.) orchard

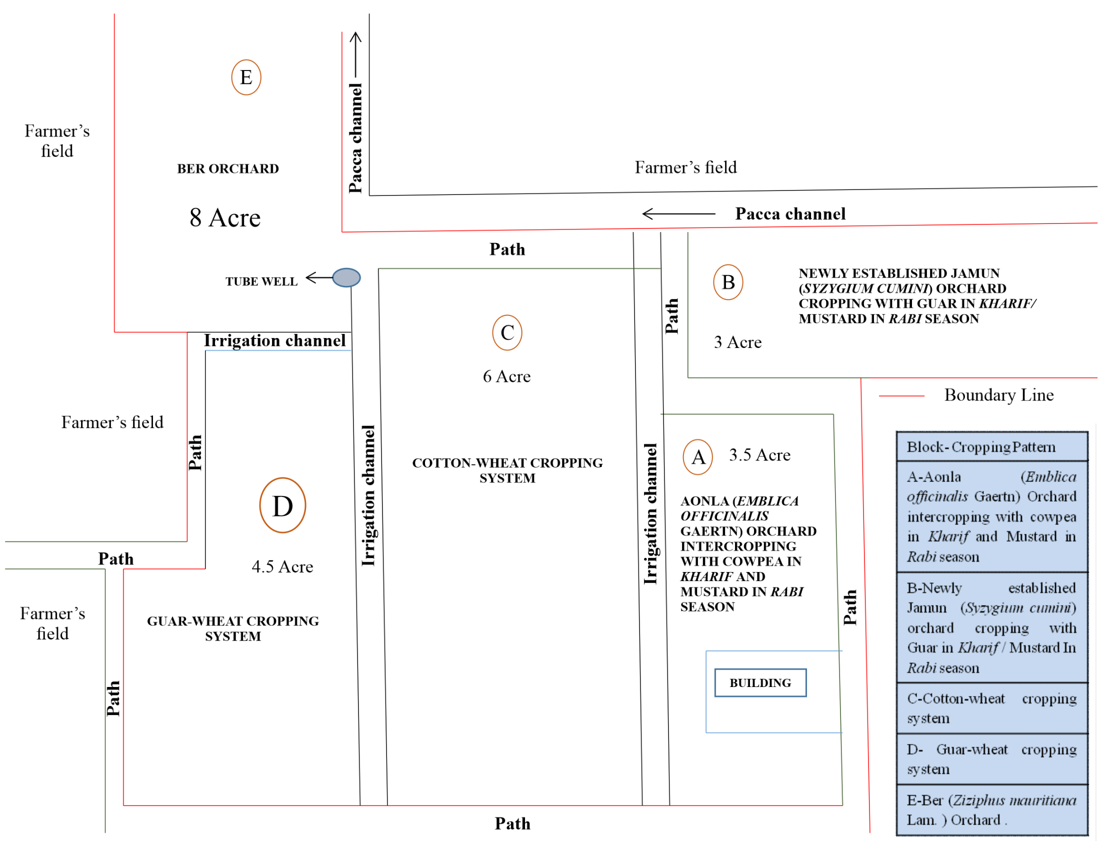

Fig. 1. Site description of soil sampling

along with newly established Jamun (*Syzygium cumini*) orchard. Similarly, the farm is used to seed production of guar and cotton in *Kharif* and mustard/ wheat in *Rabi* season.

Soil sampling and analysis

One hundred surface (0-15 cm) and sub-surface (15-30 cm) soil samples were collected from the farm under different land use pattern. All the management practices during the crop growing seasons and in orchards were applied as per Punjab Agricultural University recommendations. The collected samples were passed through 2-mm sieve and divided into two fractions: one fraction for the determination of chemical properties, which were kept at room temperature and the other fraction for analyze soil enzyme activities which was stored at 4°C. Dehydrogenase activity (DHA) in soil was determined using the reduction of 2, 3, 5-triphenyltetrazolium chloride (TTC) method (Klein *et al.*, 1971). Acid and alkaline phosphatase activities 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). Different basic soil chemical properties and available nutrients were analyzed by standard methods as described by Piper (2019). The available micronutrients (Fe, Cu, Zn and Mn) in soil samples were determined using the procedure of Lindsay and Norvell (1978). Concentration of micronutrients in the extract was determined by atomic absorption spectrophotometer. The soil samples were categorized for various classes of soil parameters as per criteria given in Table 1.

Nutrient Index Value (NIV)

Nutrient index in order to compare the levels of soil fertility of one area with those of another, it is necessary to obtain a single value for each nutrient. Here the nutrient index (NI) was calculated by the formula suggested by Parker *et al.* (1951) and nutrient index value below 1.67, in between 1.67 to 2.33 and above 2.33 has been considered as low, medium and high, respectively (Amara *et al.,* 2017). Nutrient index value (NIV) is a measure of nutrient supplying capacity of soil to plants. The healthy soils increase the capacity of crops to withstand weather variability, including short term extreme precipitation events and intra-seasonal drought.

Results and Discussion

Soil enzyme activities

Higher enzyme activities (Table 2) were reported in surface soils (0-15 cm) as compared to sub-surface soils (15-30 cm). The dehydrogenase activity (DHA) ranged from 5.15-8.59 with mean of 7.23 µg TPF released g^{-1} dry soil h^{-1} in surface (0-15cm) and 4.66-7.99 with mean of 6.20 µg TPF released g^{-1} dry soil h^{-1} in sub-surface (15-30 cm) soil. The surface (0-15 cm) soils showed 16.6% more DHA compared to sub-surface (15-30 cm) soils. Maximum DHA (6.93 µg TPF g^{-1} soil h^{-1}) was reported in ber orchard followed by newly established Jamun orchard (6.88 µg TPF g^{-1} soil h^{-1}) cropping with guar in *Kharif* / mustard in *Rabi* season. While, minimum DHA (6.39 µg TPF g^{-1} soil h^{-1}) activity was reported in cotton-

Table 1. Criteria used for categorize soil parameters into different categories

Soil characteristics	Categories		
Soil reaction (pH)	Normal (6.5-8.7)	Marginally alkaline (8.7-9.3)	Alkali or sodic (>9.3)
Electrical conductivity(EC) (dSm^{-1})	Normal (<0.8)	Critical for crop production (0.8-2.0)	Injurious (>2.0)
Organic carbon (%)	Low (<0.50)	Medium (0.50-0.75)	High (>0.75)
Available P (kg ha^{-1})	Low (<12)	Medium (12-22)	High (>22)
Available K (kg ha^{-1})	Low (<136)	Medium (136-333)	High (>333)
DTPA extractable Zn (mg kg^{-1})	Low (<0.6)	Medium (0.6-1.2)	High (>1.2)
DTPA extractable Cu (mg kg^{-1})	Low (<0.2)	Medium (0.2-0.4)	High (>0.4)
DTPA extractable Fe (mg kg^{-1})	Low (<4.5)	Medium (4.5-9.0)	High (>9.0)
DTPA extractable Mn (mg kg^{-1})	Low (<3.5)	Medium (3.5-7.0)	High (>7.0)

Table 2. Enzymes activities of soils at Jewan Singh Wala farm

Block (Sample*)	Soil depth	Dehydrogenase (µg TPF released g^{-1} dry soil h^{-1})		Acid phosphatase (µg p-NP produced g^{-1} dry soil h^{-1})		Alkaline phosphatase (µg p-NP producedg^{-1} dry soil h^{-1})	
		Range	Mean	Range	Mean	Range	Mean
A (6)	0-15 cm	5.96-8.59	7.18	4.23-6.98	5.90	4.71-6.39	5.89
	15-30 cm	5.17-7.87	6.24	3.97-6.19	4.86	4.39-6.21	5.41
B (6)	0-15 cm	5.77-8.49	7.44	4.14-5.98	5.31	4.81-6.67	5.87
	15-30 cm	5.33-7.55	6.31	3.93-5.16	4.44	4.12-5.98	4.91
C (12)	0-15 cm	5.15-8.16	6.81	4.55-6.98	6.04	4.91-6.78	5.69
	15-30 cm	4.66-7.99	5.96	3.87-5.98	5.27	4.36-6.21	4.98
D (10)	0-15 cm	5.77-8.15	7.28	4.11-6.87	5.95	4.63-6.36	5.54
	15-30 cm	4.67-7.98	6.05	3.98-5.98	5.44	4.18-6.13	5.01
E (16)	0-15 cm	6.44-8.33	7.45	4.37-6.11	5.91	4.37-6.78	5.69
	15-30 cm	5.18-7.98	6.41	3.77-5.98	4.96	4.06-6.22	5.08
Average	0-15 cm	5.15-8.59	7.23	4.11-6.98	5.88	4.37-6.78	5.71
	15-30 cm	4.66-7.99	6.20	3.77-6.19	5.06	4.06-6.22	5.06

*Figure in parenthesis ( ) denotes the number of samples collected from each block

wheat cropping system. Dehydrogenase is only produced by alive cells and is a good indicator of microbial metabolism in soil (Tabatabai, 1982). Generally, soil enzyme activities were higher in the surface soils (0-15 cm) as compared to sub surface soils (15-30 cm) and higher activity was reported in orchards as compared to sole cropping system. The results suggested 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 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).

The acid phosphatases varied from 4.11-6,98 with mean of 5.88 µg p-NP produced g^{-1} dry soil h^{-1} in surface (0-15cm) and 3.77-6.19 with mean of 5.06 µg p-NP produced g^{-1} dry soil h^{-1} in sub-surface (15-30 cm). Whereas, the alkaline phosphatase ranged from 4.37-6.78 with mean of 5.71 µg p-NP produced g^{-1} dry soil h^{-1} in surface (0-15 cm) and 4.06-6.22 with mean of 5.06 µg p-NP produced g^{-1} dry soil h^{-1} in sub-surface (15-30 cm). Like DHA, acid and alkaline phosphatase activities were also higher in surface soils (0-15 cm) compared to sub-surface soils (15-30 cm). The surface (0-15cm) soils showed 16.2% and 12.8% higher acid and alkaline phosphatase compared to sub-surface (15-30 cm) soils, respectively (Table 2). Higher acid phosphatase (5.69 µg p-NP g^{-1} soil h^{-1}) and alkaline phosphatase (5.65 µg p-NP g^{-1} soil h^{-1}) was reported in guar-wheat cropping system and Aonla (*Emblica officinalis* Gaertn) orchard intercropping with cowpea in *Kharif* and mustard in *Rabi* season. Acid and alkaline phosphatases are mainly higher in the surface layers (0-15 cm). Alkaline phosphatase activity is derived from micro-organisms only, while acid phosphatase is contributed both by plant roots and soil-inhabiting microbes (Chhonkar *et al.*, 2007). George *et al.* (2002) reported a higher rhizospheric phosphatase activity in some agro forestry species.

Soil chemical properties and nutrient availability

The data presented in Table 3 revealed that pH of soil ranged from 7.44-8.45 at 0-15 cm and 7.58-8.47 at 15-30 cm soil layers. The higher pH was recorded in C block (8.16) followed by block D (8.15) and block B (8.14) at 0-15 cm, whereas minimum pH was recorded in block A. The data regarding pH of the soils revealed that the soils were neutral to alkaline in reaction. These high values might be due to presence of soluble and exchangeable sodium along with HCO_3^- ions, which precipitates

Table 3. Macro and micro-nutrients availability of the farm soils

Soil parameters	A (6)*		B (6)		C (12)		D (10)		E (16)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
	Depth									
Soil pH (1:2)	7.75-8.18	7.79-8.24	7.76-8.32	7.78-8.47	7.65-8.45	7.58-8.32	7.95-8.26	8.11-8.37	7.44-8.22	7.86-8.37
	7.85	7.92	8.09	8.19	8.21	8.10	8.08	8.22	8.01	8.20
Soil EC (1:2)	0.18-0.32	0.17-0.29	0.21-0.31	0.17-0.28	0.18-0.36	0.14-0.31	0.21-0.32	0.18-0.28	0.22-0.38	0.17-0.32
dSm^{-1}	0.22	0.21	0.27	0.22	0.28	0.23	0.26	0.22	0.3	0.25
Organic carbon	7.16-10.55	5.86-9.53	5.33-9.43	5.19-9.21	6.32-9.65	5.13-8.54	6.87-11.87	5.98-9.35	7.65-11.98	5.45-9.43
(g kg^{-1})	9.15	8.16	7.49	6.62	7.67	6.68	9.23	7.7	9.67	7.62
Available P	14.65-18.54	10.96-17.12	12.56-18.23	11.43-16.36	8.11-19.54	7.33-18.56	8.43-19.54	7.94-18.66	7.98-25.54	6.58-24.89
(kg ha^{-1})	16.63	14.19	15.53	14.1	13.00	11.36	13.7	11.81	13.79	11.6
Available K	265.5-537.5	212.21-485.80	243.50-432.50	201.54-382.50	235.54-411.54	201.43-398.70	283.8-471.90	276.98-515.10	354.80-476.87	255.70-411.87
(kg ha^{-1})	351.62	311.96	346.41	306.97	359.50	306.68	356.20	331.18	416.11	346.45
DTPA-Zn	0.62-1.65	0.46-1.14	0.61-1.61	0.51-1.25	0.87-1.62	0.71-1.21	0.52-1.55	0.49-1.17	0.53-1.55	0.44-1.11
(mg kg^{-1})	0.99	0.72	0.91	0.70	1.19	0.90	1.13	0.84	1.08	0.76
DTPA-Cu	0.58-1.32	0.34-1.21	0.67-1.43	0.38-0.99	0.48-1.22	0.38-1.01	0.76-1.26	0.45-1.13	0.56-1.05	0.42-0.94
(mg kg^{-1})	0.82	0.61	0.89	0.62	0.85	0.63	0.97	0.73	0.87	0.69
DTPA-Fe	5.23-8.43	4.54-7.83	5.33-8.24	4.33-7.66	5.27-7.43	4.17-7.34	5.38-8.18	4.55-6.98	5.38-8.65	4.31-7.48
(mg kg^{-1})	6.52	5.69	6.62	5.77	6.43	5.83	6.41	5.55	6.36	5.36
DTPA- Mn	3.65-6.44	3.23-5.37	3.47-6.87	3.14-6.12	3.55-6.39	3.55-5.43	3.87-6.58	3.02-5.85	3.65-6.76	3.18-6.19
(mg kg^{-1})	5.34	4.62	5.91	5.05	5.51	4.64	5.29	4.59	5.87	4.95

*Figure in parenthesis ( ) denotes the number of samples collected from each block calcium and magnesium carbonates during evaporation. Alkalinity problem in soils is due to the indigenous calcareous parent material with typical low organic matter content. Yadav *et al.* (2018a) and Yadav and Gupta (2018) observed neutral to alkaline pH in soil of Bathinda district, and soil pH was increased with increased in soil depth. Further, Yadav (2020) and Kahlon *et al.* (2021) reported that lower soils layers (15-30 cm) were slightly more alkaline than upper soils layers (0-15cm). Table 3 revealed that soil EC of the farm ranged from 0.18-0.38 dS m^{-1} with mean of 0.27 dS m^{-1} at 0-15 cm and 0.14-0.32 dS m^{-1} with mean of 0.23 dS m^{-1} at 15-30 cm soil layer which were normal for crop production. The upper soil layers (0-15 cm) showed higher EC as compared to lower (15-30 cm) soil layers, and observed 0.22, 0.27,0.28, 0.26 and 0.30 dS m^{-1} in block A, B, C, D and E at 0-15 cm. However, it was 0.21, 0.22, 0.23, 0.22 and 0.25 dS m^{-1} in block A, B, C and D at 15-30 cm soils. The average mean values of electrical conductivity (EC) indicated that salinity was not a problem in any area of the farm. 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. Yadav and Gupta (2018) observed higher EC in 0-15 cm soils compared to 15-30 cm soils of ber orchard. The EC ranged from 0.11-0.84 dS m^{-1} with mean of 0.28 dS m^{-1} in 0-15 cm and from 0.10-1.22 dS m^{-1} with mean of 0.31 dS m^{-1} in 15-30 cm soils under cotton-wheat cropping system in Sangat block of Bathinda district (Yadav, 2020).

Nitrogen requirements of crops are usually recommended by the soil testing laboratories based on the soil organic matter contents (Cooke, 1982). The SOC of 0-15cm soils ranged 5.33-11.98 g kg^{-1} with average of 8.78 g kg^{-1} and 5.13-9.53 g kg^{-1} with average of 7.36 g kg^{-1} in 15-30 cm soils (Table 3). The upper soil (0-15 cm) layers contain more SOC compared to lower (15-30 cm) soil layers in all blocks. The higher SOC was observed in A block (8.65 g kg^{-1}) followed by E (8.64 g kg^{-1}) and D block (8.46 g kg^{-1}). It was also reported that 26% and 74 % soils were medium and high in OC content in upper 0-15 cm soils. However, it ranged by 54% medium and 46% high in sub surface (15-30 cm) soils. The block wise perusal of the data indicates that 83% soil samples of A block contains higher OC followed by block E (75%) and block D (70%). The medium (26%) to higher (74%) organic carbon content in surface soils may be attributed to the proper vegetation, leaf fall of orchard plants and avoid crop residue burning and incorporation into the soil under cropping system. Yadav *et al.* (2018a) observed mean value of OC varied between 0.31 to 0.62% in different blocks of Bathinda and showed that 61 to 70% samples were deficient in organic carbon. The available P of soil varied from 14.65-18.54 kg ha^{-1} with average of 16.63 kg ha^{-1} in 0-15 cm soils and 10.96-17.12 kg ha^{-1} with average of 14.19 kg ha^{-1} in 15-30 cm soils (Table 3). The P availability of the farm was low to medium category with higher availability in block B (15.36 kg ha^{-1}) followed by block A (14.86 kg ha^{-1}), whereas others blocks contains comparable amount of available P. Likewise, data presented in Table 3 indicated that 17, 8, 58, 45, 63% and 83, 92, 42, 55, 38 % soil samples were low and medium in available P in block A, B, C, D and E respectively. These results were in conformity with the findings of Verma *et al.* (2005), who reported that available P content in soils of Mansa district of Punjab varied from 1.8 to 59.6 kg ha^{-1} with a mean value of 18.46 kg ha^{-1}. Similar results were also reported by Pathak (2010) and Singh *et al.* (2016), who concluded that available phosphorus ranged from medium to high category in India and Kapurthala district of Punjab, respectively. Similar to P, K was also higher in 0-15 cm soils compared to 15-30 cm which ranged from 235.5-537.5 kg ha^{-1} and 201.4-515.1 kg ha^{-1} with a mean of 374.4 kg ha^{-1} and 325.0 kg ha^{-1} in 0-15 cm and 15-30 cm, respectively. The block wise distribution of K showed that E block soils contained more K (381.3 kg ha^{-1}) followed by block D (343.7 kg ha^{-1}) and block C (333.1 kg ha^{-1}). It was also reported that 30% and 70% soil samples were medium and high at 0-15 cm, whereas at 15-30 cm 62 % and 38% soil samples were medium and high. The K distribution in different blocks showed that 67%, 50%, 25%, 50% and 33%, 50%, 75% and 50% surface (0-15cm) soil samples were medium and high in A, B, C and D blocks, respectively. However, in E block 100% soil samples were in high range. Similarly at lower (15-30 cm) soil layers 67%, 67%, 75%, 70%, 44% and 33%, 33%, 25%, 30%, 56% soil samples were medium and high in A, B, C, D and E blocks. Medium to high K in soil was because of K rich minerals such as illite and feldspars (Sharma *et al.,* 2008). Ground waters of Bathinda district have substantial amount of dissolved K and irrigation with such waters results into higher amounts of available K in these soils (Patel *et al.,* 2000). The results were in line with findings of (Verma *et al.,* 2005), Yadav *et al.* (2018a) and Yadav (2020) who concluded medium to high K content in south-west districts of Punjab.

Soil micronutrient availability

Distribution of DTPA- extractable Zn, Cu, Fe and Mn in soil profiles of different blocks have been given in Table 3. The concentration of DTPA –Zn ranged from 0.52-1.65 with average of 1.08 mg kg^{-1} in 0-15 cm soils. However, it ranged from 0.44-1.25 with average of 0.80 mg kg^{-1} in 15-30 cm soils. Similarly, DTPA- Cu ranged from 0.48-1.43 mg kg^{-1} with average of 0.88 mg kg^{-1} in 0-15 cm soils and 0.34-1.21 mg kg^{-1} with average of 0.66 mg kg^{-1} in 15-30 cm soils (Table 3). The surface (0-15 cm) and sub-surface (15-30 cm) soil layers contain 5.23-8.65 mg kg^{-1} and 4.17-7.83 mg kg^{-1} with mean of 6.44 mg kg^{-1} and 5.60 mg kg^{-1} DTPA- Fe, respectively. The DTPA extractable- Mn ranged from 3.47-6.87 with mean of 5.61 mg kg^{-1} and 3.02-6.19 with mean of 4.77 mg kg^{-1} in 0-15 cm and 15-30 cm soil depth, respectively across the farm (Table 3).The higher amount of Fe (6.19 mg kg^{-1}) and Mn (5.48 mg kg^{-1}), Cu (0.85 mg kg^{-1}) and Zn (1.04 mg kg^{-1}) were reported in B, D and C block followed by 6.13 mg Fe kg^{-1} in C block, 5.41 mg Mn kg^{-1} in E block, 0.78 mg Cu kg^{-1} in E block and 0.98 mg Zn kg^{-1} in D block. The soils contain sufficient amount of micro-nutrients, however, on the basis of soil test ratings, only 4% and 2% upper (0-15 cm) soil fall under low category in available Zn and Mn. While, lower (15-30 cm) soils showed 8%, 18% and 1% deficiency in Fe, Zn and Mn.

The decline in DTPA-extractable Zn, Cu, Fe and Mn may be ascribed to decline in soil organic C content down the soil profile as organic carbon content significantly correlated with DTPA-extractable micronutrients in surface soil as reported by Behera *et al.* (2011). Moreover, the Mn content in 0-15 cm soils were higher than 15-30 cm soils and showed a decreased trend with increased in soil depth might be due to low pH and high organic matter in 0-15cm layers. The adequacy of available Mn might be attributed to the positive effect of organic matter and suitable soil pH for Mn availability. Similar results were obtained by Malik *et al*. (2017) where low Fe content was observed because of sandy soil, low organic matter and alkaline pH. Sadana *et al.* (2010) reported that12% and 22% soils of Punjab soils were deficient in iron and zinc. The micronutrients (Fe, Cu, Zn and Mn) were observed to be higher in surface soil than sub-surface soil which was in line with the findings of Yadav *et al.* (2018b) and Yadav and Gupta (2019), who observed higher micronutrient content in 0-15 cm soils than 15-30 cm soils of Bathinda district.

Nutrient index value (NIV)

According to number of samples low, medium and high in OC, available phosphorus and available potassium, nutrient index value (NIV) was calculated and presented in (Fig. 2) revealed that all block were

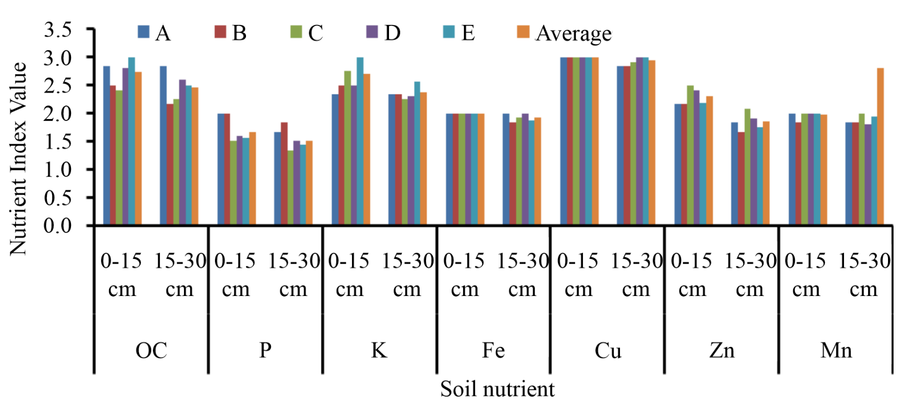

Fig. 2. Soil nutrient index value (NIV) for macro and micronutrients

medium to high in all macro and micronutrients. At 0-15cm soils NIV for OC, P and K was 2.74, 1.66 and 2.70 indicated that soils were higher in available N (OC <0.5 %), low in available P and medium in K availability. The NIV for OC, P and K was 2.46, 1.50 and 2.38 indicated that soils were medium in available N, P and K in 15-30 cm soil layers. The NIV for Zn (2.30), Fe and Mn (2.0), Cu (3.0) in 0-15 cm soils indicated that soils were medium in Zn, Fe and Mn availability and high in Cu availability. However, the NIV of 1.86, 1.92, 2.80 and 2.94 for Zn, Fe and Mn, Cu in 15-30 cm soils indicated that soils were medium in Zn, Fe and Mn availability and high in Cu availability in 15-30 cm soil.

Conclusion

The soils of the farm are non-saline and alkaline in reaction with medium to high organic carbon. Higher microbial activity was reported in orchard soil due to higher SOC as compared to cereal or legume based cropping system. The availability of P in soil was medium, whereas high in K content. Sufficient availability of micronutrients such as Fe, Cu, Zn and Mn were found in the soil. All the macro and micro-nutrients analysed decreased with increase in soil depth, however, no deficiency were observed in sub-surface layer. The soils of the farm has sufficient amount of nutrients for sustainable crop production.

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