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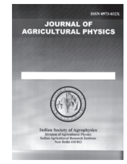

Research Article

Appraisal of Soil Properties in the Mango Growing Orchards of Malihabad, India

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ABSTRACT

Malihabad region of Uttar Pradesh in India, is one of productive mango growing hotspot occupied by famous indigenous cultivar Dashehari. Soil properties play a crucial role in the mango productivity as well as fruit quality for sustainable conservation of mango diversity and often support livelihood security of growers. A sum of 250 soil samples was collected from 20 different mango growing orchards to study different soil physical, chemical and biological properties. We observed a wide variation in soil organic carbon (SOC) content varying between 0.39-0.54 per cent, along with available N in the range of 111.44 – 332.85 mg kg^{-1}. Soil available P and K varied between 10.74-25.40 mg kg^{-1} and 106.06-185.57 mg kg^{-1} respectively. SOC and N were low in majority of the collected soil samples whereas, P and K content was sufficient. Microbial activity played a prime role in indicating soil biological health in all the agro-ecosystems that was measured in terms of dehydrogenase (DHA) and fluorescein diacetate (FDA) activity. The overall enzymatic activity was in favorable range (DHA and FDA ranged between 0.27 to 3.62 µg TPF g^{-1} h^{-1} and 410 to 850 mg fluorescin kg^{-1} h^{-1} respectively) across different mango orchards which were very much supportive to rich mango biodiversity and its conservation. SOC content had positively correlated with the DHA (r = 0.882*) and FDA (r = 0.975**). Our results will be useful for planning and implementing site specific nutrient management practices to sustain productivity of the mango orchards.

Key words: Diversity, Soil properties, SOC, Enzymatic activity, Mango, Subtropical India

Introduction

India is one of the major mango producer, exporter and consumer in Asian countries (Mukherjee, 1953; Kruijssen and Mysore, 2010). Malihabad district is one of the important mango growing region dominated by the native mango variety Sashehari. Apart from this variety, few more commertial variety *viz*. Luckow Safeda, Bombay Green, Langra, Chausa and other local selections like Jauhari Safeda, Gilas, Gulabkhas etc. are being grown.

The region is rich in mango biodeiversity; Germsplasms are scientifically conserved at farmers field (Singh *et al.,* 2012). Gajanana *et al.* (2015) explained motivation factors for conserving the mango diversity particularly of indigenous varieties. Biological traits rich in mango diversity motivated farmers to conserve the oldest mango varieties in this region. Rajan (2011, 2012) reported that subtropical climatic condition accelerated the maintenance of rich mango diversity and phenological response.

Nutrients often play a pivotal role, to sustain mango diversity. Macro- as well as micro-nutrients is important not only for quality fruit

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production but also to sustain the orchard productivity in longer run. Kadmanand Gazit (1984) observed widespread Iron deficiency in the calcareous soils of mango orchards in Israel. Ganeshamurthy and Reddy (2015) reported that longer leaf life span mango varieties can sustain more in low fertile areas with improved nutrient use efficiency. Similarly, Silva *et al.* (2014) pointed out lower soil organic carbon and higher P and K content in mango growing soils collected from 11 different places in Brazil. Thus, spatiotemporal variations in soil fertility are the important aspect in tree nutrition management strategy to optimize mango fruit production.

Soil physical and biological properties often control the process of nutrient cycling, release pattern, availability and their interaction. Sustainability of any ecological system thus become an important issue all over the world especially in agricultural ecosystems in terms of soil quality and its change óver time (Karlen *et al.,* 1997; Carrera *et al.,* 2003). Soil microbial and biochemical properties are useful indicators of soil quality that are sensitive to environmental stress and often changes with management practices (Yakovchenko *et al.,* 1996; Burylo *et al.,* 2007).

Soil enzymes showed a broad spatial variability depending on prevailed soil environmental conditions (Kandeler *et al.,* 2001). Generally, soil dehydrogenase activity reflects the total viable soil microflora that is considered to be a good indicator of microbial activity in the soil (Wlodarczyk, 2000). Similarly, fluoresce in diacetate (FDA) hydrolysis was an effective indicator of soil microbial activity (Schnürer and Rosswall 1982; Adam and Duncan 2001), as it was hydrolysed by various enzymes viz. esterases, proteases and lipases, which involved in the microbial decomposition of soil organic matter (Schnürer and Rosswall, 1982) for a wide range of soils (Green *et al.*, 2006). Several studies conducted to evaluate the potential use of enzymatic activity as the effective index for soil productivity or soil fertility (Alef and Nannipieri, 1995).Wide variability of SOC content in different orchard ecosystems undera variety of orchard management practices often influences the soil microbial activity. The present study is being initiated to study the physical, chemical and biological properties of different established mango orchard soils collected from 20 villages in the Indo-Gangetic Plains of Uttar Pradesh.

Materials and Methods

Experimental sites

The study site was in mango growing region of Malihabad, Rehmankhera, Lucknow (26.54°N Latitude, 80.45°E Longitude and 127 m above mean sea level), Uttar Pradesh, India. All the orchards were within the Malihabad region. The area is designated under subtropical climatic zone with mean annual rainfall of around 1000 mm; majority shares were received during the active south-west monsoon months (July to September). The soil is classified as mixed hyperthermic *Typic Ustocrepts* that falls under Indo-Gangetic alluvium with sandy loam texture. The mango cultivar used was Dashehari which was planted at a spacing of 10 m×10 m. Farmers used recommended doses of NPK as 1000 g N - 500 g P_2O_5- 1000 g K_2O / tree each year through urea, single super phosphate (SSP) and muriate of potash (MOP) respectively.

Sampling and observations

A total of 250 diverse soil samples were collected from 0-30 cm vertical depth within the tree basin using a soil augur from 20 villages namely Mandauli, Tikaitganj, Rasoolpur, Kithaipara, Ramgarah, Kasmandikala, Meethenagar, Mehmoodnagar, Nejabhari, Belgada, Kanar, Habibpur, Allupur, Dubauli, Sahilamau, Mohammad Nagar Tallukedari, Khalispur, Ladausi, Mahoomdnagar, Rahmatnagar and Naibasti, respectively. The soil samples were air-dried at room temperatures and ground by wooden pestle and mortar and sieved through 2 mm mesh size sieve and utilized for analytical purpose. Soil pH determined by using double distilled water suspension in the ratio of 1:2.5 (w/v). Soil organic carbon content was estimated by the standard wet digestion method. Available nitrogen was estimated by alkaline distillation with 0.32% potassium permanganate (Subbiah and Asija, 1956), Available P was estimated by the Olsen method (Olsen *et al*., 1954) using spectrophotometer and available K was estimated by extraction with ammonium acetate at pH 7.0 by 'Chemito' AA203D model of atomic absorption spectrophotometer. DTPA extracted soil micronutrients (Zn, Cu, Mn and Fe) were estimated as per standard procedures.

Soil biological properties in terms of enzymatic activity *viz.* dehydrogenase activity was estimated using 2, 3, 5 triphenyal tetrazolium chloride using 1 g air-dried soil samples (<2 mm) that are expressed as µg of triphenylformazan (TPF) formed per gram of oven dried soil per hours (Casida *et al*., 1964). General microbial activity was measured by hydrolysis of fluorescein diacetate (FDA) using the procedure of Adam and Duncan (2001) using 3, 6-diacetyl fluorescein as substrate and measuring the absorbance of released fluoresce in at 490 nm. Daily weather data of maximum and minimum temperatures, morning and evening relative humidity, rainfall, wind speed, bright sunshine hours and evaporation rates during the experimentation were recorded from the agro-meteorological observatory of ICAR-CISH experiment station based at Rehmankhera, Lucknow, India.

Statistical analysis

The data was analyzed by standard analysis of variance (ANOVA). Univariate statistical analysis and significance was concluded using SPSS version 16.0 and Microsoft-Excel software. Histogram for frequency distribution was generated through SPSS and required graphs were generated using MS Excel software.

Results

Weather conditions

The agrometeorological observations were recorded at the Institute's meteorological observatory during 2015-16 that revealed highest and lowest mean monthly maximum temperature (T_{max}) of 39.8 and 22.2°C in the month of May, 2015 and January, 2016 respectively (Table 1). The mean monthly minimum temperature(T_{min}) of 5.3°C was recorded during January 2016. A range of 63.3 to 88.3 per cent maximum relative humidity (RH) and 28.4 to 65.5 per cent minimum RH were recorded. Bright sunshine hour of 5.3 to 9.1 h were recorded along with the wind speed 1.2 to 4.3 km h^{-1} during the study period. Summer months (May-June 2015)had recorded higher pan evaporation values (7.9 and 7.3 mm d^{-1}) as compared to winter months (2.7 and 2.9 mm d^{-1} during December, 2015 and January 2016,

Table 1. Weather parameters during the study period at ICAR-CISH experimental farm, Lucknow, India

Month	Temperature (°C)		Relative humidity (%)		Bright sunshine hours (h)	Wind velocity (km h^{-1})	Total rainfall (mm)	Pan evaporation (mm)
	Tmax	*Tmin*	Max	Min				
April, 2015	34.0	17.9	73.4	33.9	7.3	3.7	41.8	5.5
May, 2015	39.8	22.2	63.3	32.5	9.1	2.7	18.0	7.3
June, 2015	36.7	25.1	70.9	42.5	8.2	4.3	71.2	7.9
July, 2015	33.3	25.1	83.1	65.5	5.9	4.0	246.2	5.4
August, 2015	33.3	24.9	84.3	65.4	5.8	2.7	136.2	5.2
September, 2015	34.8	23.6	77.9	55.5	7.6	2.7	14.4	5.0
October, 2015	33.3	17.6	73.1	49.7	7.7	1.5	0.0	5.4
November, 2015	29.4	12.5	74.7	36.4	6.2	1.2	0.0	4.4
December, 2015	22.9	6.3	86.8	47.4	5.3	1.4	7.0	2.7
January, 2016	22.2	5.3	86.2	47.6	5.3	1.3	18.4	2.9
February, 2016	27.0	8.9	87.3	39.1	7.2	2.1	0.0	3.7
March, 2016	32.9	13.5	88.3	28.4	7.7	2.7	0.0	4.8

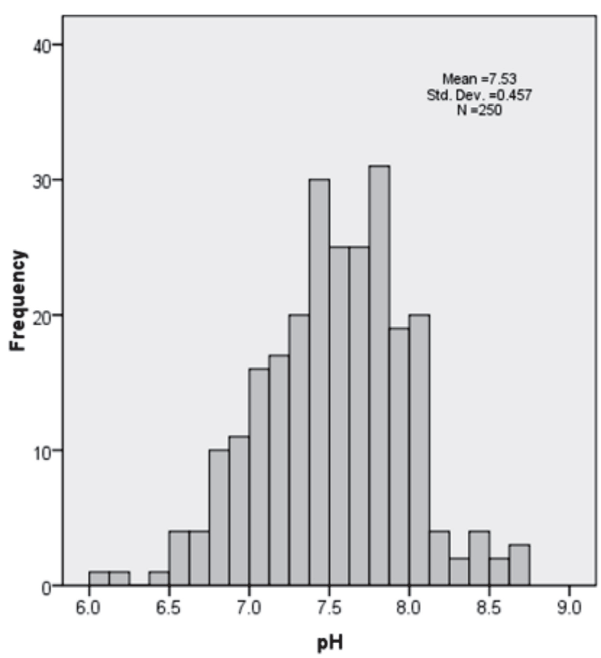
Table 2. Soil reaction and micronutrients contents in mango orchard (mean of 250 soils collected over 20 different locations)

	pH	Zn (mg kg^{-1})	Cu (mg kg^{-1})	Mn (mg kg^{-1})	Fe (mg kg^{-1})
Mean	7.53	0.85	9.63	5.92	2.16
Sd	0.46	0.45	4.24	3.17	0.61
CV(%)	6.07	53.38	44.03	53.51	28.33
max	8.66	2.86	19.46	14.48	3.62
min	6.02	0.28	1.98	0.92	0.78
SEm	0.001	0.001	0.07	0.04	0.002

respectively). The site received a cumulative annual rainfall of 553.2 mm. The highest monthly rainfall were recorded during July (246.2 mm)followed by August (136.2 mm) and June (71.2 mm), respectively; with the traces of unseasonal rainfall during December (7.0 mm) and January (18.4 mm).

Soil properties

The physicochemical properties and enzymatic activities of collected soil samples during the dry period are presented (Table 2). The soil reaction (pH) varied between 6.02 (acidic) to 8.66 (saline) although total mean value was around neutral range (7.53). Histogram distribution showed maximum frequency levels of soil pH was between 7.0 to 8.0 ranges across 250 soil samples (Fig. 1). Wide coefficient of variations were recorded in terms of micronutrients availability with around 44 to 53 percent for cationic micronutrients like Zn, Cu and Mn. In contrast, around 28 per cent variability was observed for Fe content in the mango growing orchards. A range of 0.28 to 2.86 with mean value of 0.85 ppm Zn was determined. Similarly, Cu, Mn and Fe were varied from 1.98-19.46 ppm, 0.92-14.48 ppm and 0.78-3.62 ppm respectively with the average of 9.63, 5.92 and



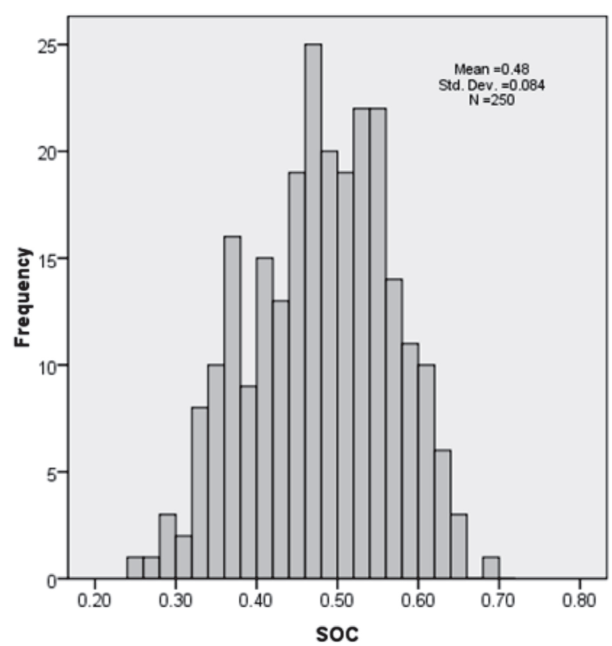


Fig. 1. Frequency distribution of pH and soil organic carbon in 250 mango orchard soils in Malihabad mango growing hotspot region of India

Table 3. Univariate statistical analysis of SOC and N (n = 250) from mango orchard ecosystem

	Soil organic carbon (%)					Available N (mg kg^{-1})				
		Range					Range			
	Mean	Max	Min	SD	SEm	Mean	Max	Min	SD	SEm
1	0.50	0.62	0.37	0.07	0.0003	332.85	422.80	260.40	50.34	158.36
2	0.40	0.64	0.25	0.13	0.0017	277.20	319.20	240.80	30.10	90.60
3	0.47	0.64	0.29	0.08	0.0002	181.11	305.20	98.00	63.86	116.50
4	0.45	0.56	0.35	0.07	0.0005	111.44	123.20	84.00	11.26	12.68
5	0.45	0.62	0.33	0.09	0.0008	117.04	156.80	95.20	21.92	48.05
6	0.51	0.58	0.39	0.06	0.0004	136.64	204.40	117.60	26.03	67.74
7	0.41	0.53	0.31	0.07	0.0005	111.72	159.60	67.20	24.78	61.40
8	0.46	0.56	0.35	0.07	0.0002	125.71	159.60	81.20	24.73	32.18
9	0.43	0.53	0.37	0.05	0.0002	121.31	173.60	72.80	24.10	52.79
10	0.39	0.55	0.27	0.07	0.0006	123.20	257.60	92.40	50.49	254.89
11	0.48	0.64	0.29	0.10	0.0010	135.24	173.60	89.60	26.50	70.22
12	0.46	0.60	0.35	0.09	0.0009	144.48	182.00	112.00	21.86	47.77
13	0.47	0.55	0.35	0.06	0.0004	141.12	162.40	126.00	12.74	16.24
14	0.51	0.68	0.37	0.11	0.0012	126.00	154.00	103.60	18.48	34.15
15	0.52	0.60	0.37	0.07	0.0005	138.88	170.80	98.00	18.95	35.92
16	0.52	0.62	0.43	0.07	0.0005	138.88	168.00	106.40	19.23	36.97
17	0.52	0.60	0.47	0.04	0.0002	154.00	179.20	100.80	24.97	62.37
18	0.48	0.58	0.41	0.05	0.0003	136.36	198.80	98.00	35.93	129.11
19	0.54	0.60	0.47	0.04	0.0001	155.81	252.00	64.40	38.17	85.72
20	0.53	0.62	0.35	0.08	0.0006	146.30	176.40	112.00	21.36	41.48

2.16 ppm respectively. The soil organic carbon (SOC) content across 20 mango orchards of villages varied between 0.39-0.54 per cent (Table 3). The mean SOC content was observed to be <0.5 per cent level only in 12 villages. The highest variability (32.74%) in SOC content was observed in Tikaitganj, and lowest (7.68%) in the collected mango orchards soil samples of Mahmood Nagar. The variability accounted between 10 to 20 per cent level in maximum number of mango growing villages (Fig. 2). Further, it was inferred from the histographic analysis with the maximum SOC content distributed widely between 0.35 to 0.6 per cent (Fig.1).

The soil available N, P and K was assessed in order to find out their sufficiency for supporting the mango diversity for its healthy vegetative growth, sustainable production and ultimately meaningful conservation. Mean available N was recorded 111.44 – 332.85 mg kg^{-1} across different mango grown villages being maximum recorded in village Mandauli and minimum in Meethenagar. Wide variations in soil available N (9.03-40.98%) were observed across the collected soil samples from different mango orchards with lower total N for all the 20 villages. Soil available P and K were in sufficient that varied between 10.74-25.40 and 106.06-185.57 mg kg^{-1} respectively (Table 4).

Soil microbial activity

Soil biological assessment measured in terms of enzymatic activities showed a widespread variation (Table 5). The dehydrogenase activity varied between 0.27 ± 0.19 to 3.62 ± 1.68 µg TPF g^{-1} h^{-1} in different villages. Highest average dehydrogenase (3.62 µg TPF g^{-1} h^{-1}) was recorded in Kanar village followed by Belgara (2.68 µg TPF g^{-1} h^{-1}). The pooled observations on mean dehydrogenase activity (1.55 µg TPF g^{-1} h^{-1}) were very low in all the 20 villages, may be due to

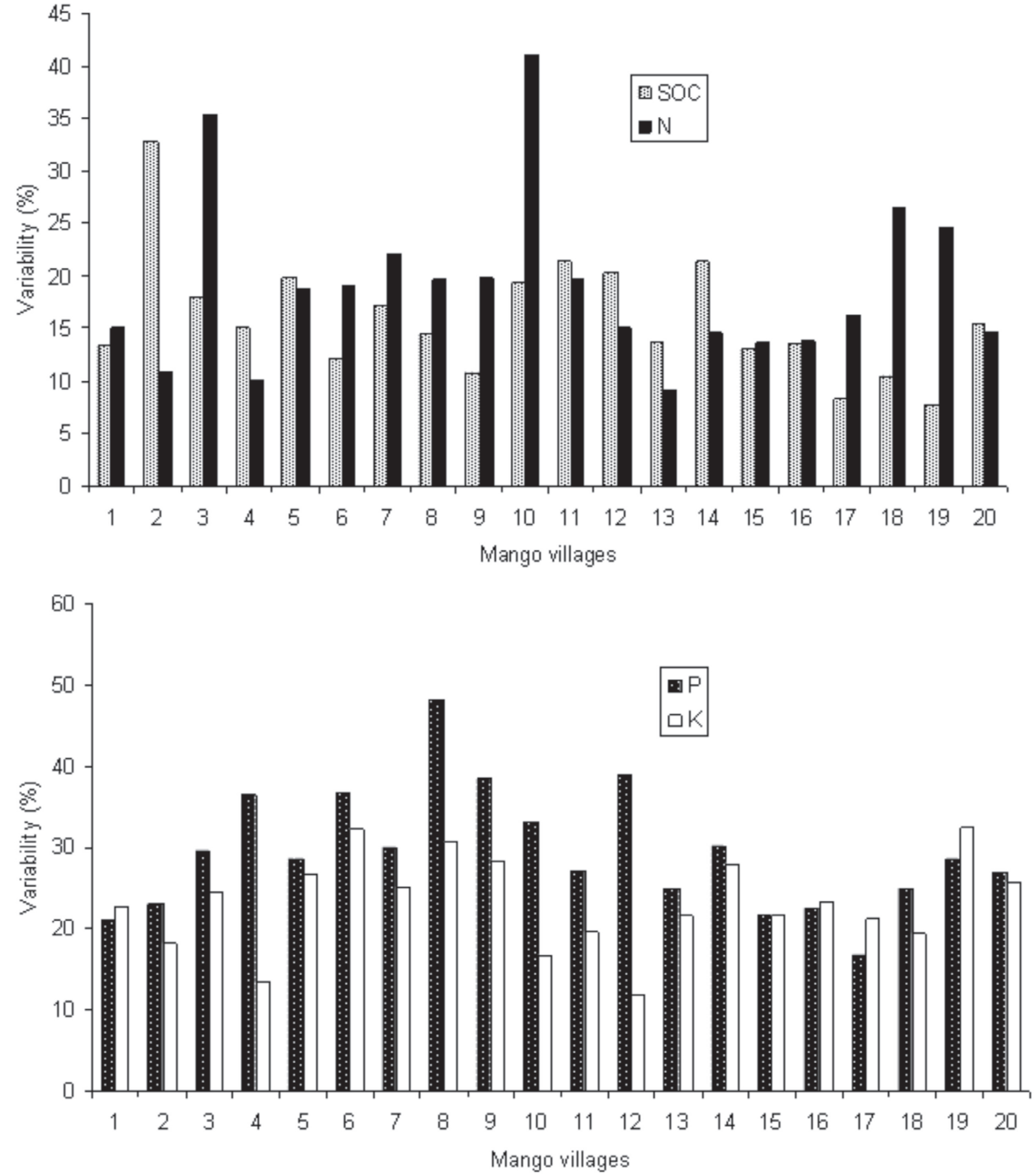


Fig. 2. Variations in SOC, N, P and K among 250 mango orchard soils from 20 diverse mango grown agroecology

intensive cultural management and low SOC content. Soil samples collected from Nejabhari, Ramgarah, Kasmandikala, showed high level of dehydrogenase activity than Kanar and Belgaha. On the other hand, Naibasti, Rasulpur, Mahmud Nagar and Dubauli, recorded reduced level of soil dehydrogenase activity.

The fluorescein diacetate activity ranged between 410.1 to 850.5 mg fluorescin kg^{-1} h^{-1}. Highest fluorescent diacetate activity (850.5 mg fluorescin kg^{-1} h^{-1}) was recorded in Kanar followed by Ramgarah (747.4 mg fluorescin kg^{-1} h^{-1}). Soil samples collected from other villages having higher level of FDA were Mahmad Nagar Talukedari (712.3 mg fluorescin kg^{-1} h^{-1}) and Kashmandikala (709.6 mg fluorescin kg^{-1} h^{-1}). Histogram distribution had explained that majority of the DHA was in the range of above 10 per cent frequency level in the range of 0.5 to 2.0 µg TPF g^{-1} h^{-1} while in case of FDA, the corresponding range was 400 to 800 mg fluorescin kg^{-1} h^{-1} (Fig. 3). Furthermore, majority

Table 4. Univariate statistical analysis of available P and K (mg kg^{-1}; n = 250) from mango growing hotspot of Lucknow, India

	Available P					Available K				
		Range					Range			
	Mean	Max	Min	Sd	SEm	Mean	Max	Min	Sd	SEm
1	20.69	27.60	12.60	4.36	1.19	108.22	154.45	79.40	24.56	37.71
2	18.13	25.20	11.60	4.17	1.74	107.32	151.15	84.50	19.60	38.42
3	18.31	30.60	8.80	5.41	0.84	122.14	185.60	75.45	29.87	25.49
4	17.29	29.30	9.40	6.32	3.99	119.94	141.15	95.35	16.18	26.19
5	14.25	21.30	7.70	4.06	1.65	108.74	149.80	74.90	29.03	84.28
6	21.20	33.60	11.30	7.79	6.08	140.75	197.40	84.40	45.32	205.39
7	10.91	16.70	7.40	3.28	1.08	106.06	155.80	74.85	26.68	71.18
8	18.22	32.50	6.90	8.76	4.03	121.12	173.40	68.30	37.14	72.61
9	12.58	20.90	6.80	4.84	2.13	120.61	185.00	82.15	34.20	106.32
10	10.74	19.20	7.10	3.55	1.26	147.97	190.45	118.80	24.79	61.46
11	25.40	32.10	11.60	6.90	4.76	175.91	220.35	115.85	34.39	118.30
12	20.87	29.50	9.70	8.12	6.59	173.45	205.10	132.90	20.56	42.29
13	21.16	31.70	12.20	5.26	2.76	132.88	167.80	94.70	28.86	83.31
14	21.02	32.20	13.20	6.34	4.02	136.22	180.70	87.80	38.18	145.75
15	25.12	31.20	11.40	5.41	2.93	174.88	216.35	108.70	37.88	143.46
16	24.03	31.70	16.70	5.38	2.89	156.99	197.40	96.70	36.46	132.92
17	24.10	28.50	17.90	4.05	1.64	185.57	247.90	102.30	39.33	154.70
18	24.83	31.40	15.40	6.16	3.80	152.14	189.50	102.40	29.57	87.42
19	23.13	34.30	13.80	6.62	2.57	133.52	198.40	69.20	43.41	110.83
20	20.70	29.60	13.90	5.58	2.83	133.73	180.55	89.70	34.46	107.95

of soil samples had medium range of DHA (1.0-2.0 µg TPF g^{-1} h^{-1}) and FDA (500-700 mg fluorescin kg^{-1} h^{-1}) (Fig. 4).

Correlation studies

Pearson's correlation studies were carried out to estimate the correlation amongst all the measured soil factors. It was inferred that majority of mango orchards soil factors were positively and significantly correlated to each other at 1 and 5 per cent level of significance (Table 6). Soil reaction (pH) was significantly correlated with soil organic carbon (SOC), N, P, K along with DHA and FDA. Our result indicated that nutrient dynamics in soil solution is a function of soil reaction existed in the soil. Soil enzymatic activities like DHA and FDA activities were also positively and significantly influenced by soil pH. SOC content had higher correlation values (r = 0.814**) with N while P and K, the values were somewhat lower (r = 0.227** and 0.144*). The SOC content had positively correlated with the DHA (r = 0.882*) and FDA (r = 0.975**). Results revealed that the soil biological health of the mango growing soils was a function of soil organic matter present. Available soil N significantly contributed towards the dynamics of DHA and FDA in mango orchard soil, while P and K had lower associations.

Discussions and Conclusion

Spatiotemporal variability analysis of soil nutrient availability are essentially required to understand the dynamics of soil processes that may vary based on adopted soil management practices by the orchard farmers. Sometimes, within the same orchards, higher degree of spatio-temporal variations in yield and soil nutrients

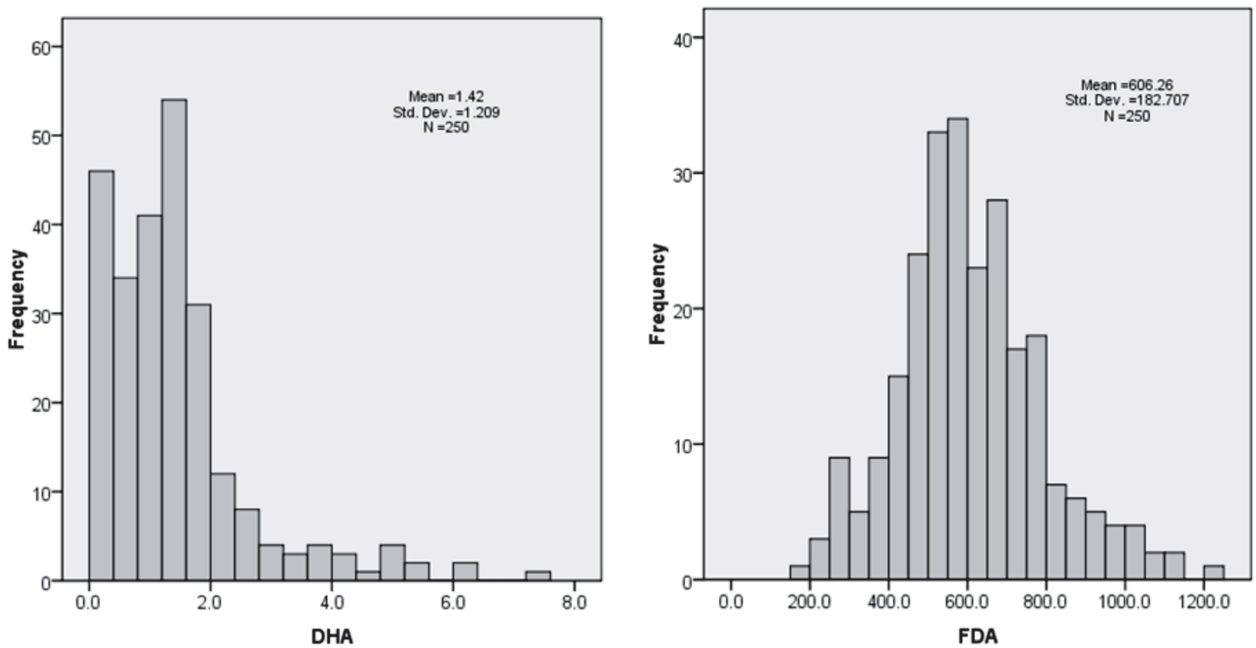


Fig. 3. Frequency distribution of dehydrogenase (DHA) andfluorescein diacetate (FDA) activities in 250 mango orchard soils of 20 different mango growing locations

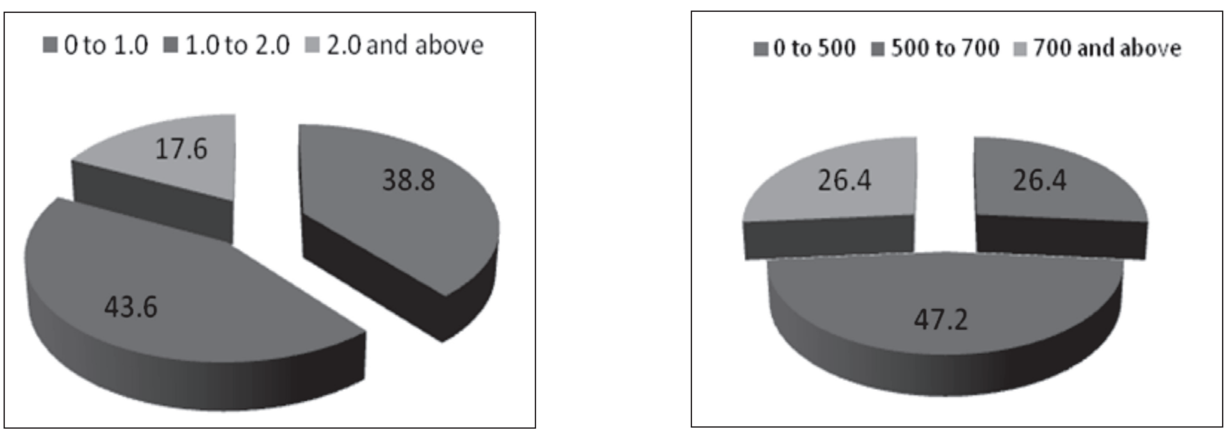


Fig. 4. Pie diagram showing distribution of soil enzymatic activity in 250 mango orchard soils of 20 different mango growing locations (a) DHA and (b) FDA

were evidenced. Kumar *et al.* (2011) reported the widespread variability of mango orchard soils ranging from acidic to alkaline pH in different districts of Uttar Pradesh. However, soil organic carbon content was less than 0.5 per cent in majority of orchards and only 25.4 per cent soils maintained optimum level of organic carbon. Srivastava and Singh (2005) identified the nutrient constraints from 108 citrus orchards in 52 different locations over 8 different states of India. They opined that nutrient diagnostics finds a place in integrated nutritional aspects for quality citrus production. Behera *et al*. (2016) observed the spatial variation in soil properties for the collected soil samples from 64 oil palm plantations in west coastal region of India. Changes in soil pH from mango orchards was evidenced than forest soils, even there was much changes in soil organic carbon (decrease), P and K content as a function of soil management practices in 11 different mango orchards in Brazil (Silva *et al.*, 2014). Bernardi *et al*. (2007)

Table 5. Soil microbial activities in 250 mango orchard soils collected from 20 different villages of Malihabad region of Uttar Pradesh

Sl. No.	Village	Dehydrogenase activity (µg TPF g^{-1} h^{-1})				Fluorescent diacetate activity (mg fluorescin kg^{-1} h^{-1})			
		Mean	SD	Range	CV(%)	Mean	SD	Range	CV(%)
1	Mandauli	1.58	0.78	0.46-3.21	49.43	584.7	80.0	482-764	13.69
2	Tikaitganj	1.65	2.01	0.38-7.30	122.44	506.2	102.0	295-634	20.16
3	Rasoolpur	0.56	0.40	0.06-1.68	72.81	625.9	162.3	391-978	25.93
4	Kithaipara	1.41	0.36	0.86-2.10	25.27	671.5	154.6	447-946	23.03
5	Ramgarah	2.08	1.37	0.66-4.86	65.84	747.4	164.5	584-1108	22.01
6	Kasmandikala	2.01	1.48	0.74-6.02	73.80	709.6	84.6	580-867	11.92
7	Meethenagar	1.48	1.10	0.34-4.16	74.45	576.3	146.7	320-807	25.46
8	Mehmoodnagar	0.94	0.92	0.02-2.58	97.96	573.8	128.4	187-774	22.38
9	Nejabhari	2.32	1.58	0.81-5.30	68.05	597.4	135.1	359-819	22.62
10	Belgaha	2.68	1.35	1.25-5.00	50.57	475.8	64.1	369-587	13.47
11	Kanar	3.62	1.68	1.04-6.22	46.45	850.5	216.8	451-1102	25.49
12	Habibpur	1.81	0.88	0.82-3.91	48.79	603.1	101.4	461-777	16.80
13	Allupur	1.23	0.76	0.01-2.38	61.53	521.7	144.7	215-718	27.74
14	Dugauli	0.98	0.44	0.39-1.78	44.99	410.1	93.5	260-558	22.79
15	Sahilamau	1.46	0.50	0.79-2.51	33.87	614.8	268.9	282-1073	43.74
16	Mohammad Nagar Tallukedari	1.22	0.65	0.53-2.49	53.11	712.3	168.2	534-1004	23.61
17	Khalispur	1.56	0.97	0.44-3.84	62.36	693.8	194.2	380-974	27.99
18	Ladausi	1.13	0.54	0.17-1.96	47.67	679.3	127.6	518-915	18.79
19	Mahamdanagar	1.07	1.05	0.14-3.25	98.59	531.0	261.2	234-1212	49.20
20	Naibasti	0.27	0.19	0.07-0.63	69.88	466.2	189.1	257-869	40.56
	Mean	1.55				607.6			
	SD	0.75				107.5			
	Range	0.27-3.62				410-850			
	CV(%)	48.33				17.69			

Table 6. Pearson's correlation coefficient among soil factors in different mango orchard soils (n = 250)

Components	pH	SOC	N	P	K	DHA	FDA
pH	1	0.992**	0.816**	0.239**	0.156*	0.895**	0.983**
SOC		1	0.814**	0.227**	0.144*	0.882**	0.975**
N			1	0.196**	0.114	0.957**	0.895
P				1	0.180**	0.189**	0.235**
K					1	0.131*	0.160*
DHA						1	0.950**
FDA							1

*Significant at 0.05 level and **significant at 0.01 level recorded a range of 1.8-4.1 and 1.90-7.27 g kg^{-1} C in wetted-bulb and non-irrigated areas in mango orchards at 0 to 40 cm soil depths in subtropical Brazil. Likewise, soil available N varied between 0.20-0.37 and 0.20-0.67 g kg^{-1} C in wetted-bulb and non-irrigated areas. Higher C and N were observed in the surface soil as compared to deeper depths. Similarly, Tiessen *et al.* (1998) surveyed NE Brazil and pointed out C content for medium and heavier textured soils ranged between 4 to 11 g kg^{-1} and10 to 20 g kg^{-1}respectively. Similarly, Yang *et al* (2015) observed the dynamics changes in mineral nutrient content and emphasized that potassium to nitrogen ratio may be considered as an important index for sustainable production litchi orchards. Site specific nutrient management particularly potassium for quality citrus production was also established (Srivastava, 2011). Wide variations in soil nutrients as a function of soil physical properties were also evidenced in fruit orchards. Such variations are primarily arises for temporal dependent soil properties as a function of soil-plant-atmospheric continuum.

Soil biological activities were correlated with the soil nutrient availability. Kujur and Patel (2014) observed that soil dehydrogenase activity (DHA) was positively correlated with water holding capacity, pH and SOC. Singha et al. (2014) reported higher variability in soil surface dehydrogenase as compared to the deeper depths (20-30 cm) in mango orchards. Adak *et al.* (2014) also observed that the dehydrogenase activity were higher in surface layers (0.71 to 1.85 µg TPF g $soil^{-1}$ h^{-1} in 0-10 cm depth) than deeper layers (0.68 to 0.96 µg TPF g $soil^{-1}$ h^{-1} in 20-30 cm depth). Debnath *et al.* (2015) reported that soil enzymatic activities decreased down towards depths in perennial fruit tree crops had deeper roots. Such dynamics in soil enzymatic activities across different ecosystem depends on the existing soil characteristics. Soil organic carbon content is an important parameters for determining soil enzymatic activity. Soil DHA reflects the total range of oxidative activity of soil microflora and, also a good indicator of microbiological activity in the soil (Skujins, 1973, 1976). Results from our study showed a wide range of soil dehydrogenase activity. The highest average dehydrogenase (3.62 µg TPF g^{-1} h^{-1}) was recorded in Kanar village followed by Belgara (2.68 µg TPF g^{-1} h^{-1}). The villages which were recorded significantly higher DHA as compared to others managed high organic inputs in soils. Similar findings were reported for different soil and crop management impacts on soil enzyme activities (Bandick and Dick, 1999; Shi *et al.,* 2008 and Zhang *et al.,* 2010). Average soil DHA value of different villages were positively correlated with the organic matter content (Wlodarczyk *et al.,* 2002) possibly due to more organic manure application in the studied villages (Furczak and Joniec, 2007). Similar trend were observed for Fluorescein diacetate activity (FDA) and soil microbial activity (Schnurer and Rosswall, 1982). It estimates a group of soil extracellular enzymes *viz*. lipases, proteases and esterases which are capable of catalyzing the hydrolysis of Fluorescein diacetate were ubiquitously present in all mango orchards soil. FDA was a reliable indicator for studying the effects of different soil management practices and inputs applied (Perucci and Scarponi 1994; Bandick and Dick, 1999), varied widely among different ecosystems as well as within similar ecosystems (Levi-Minzi *et al.,* 2002). Soil physico-chemical properties greatly influence FDA activity (Gianfreda & Bollag 1996). The highest average fluorescent diacetate activity (850.5 mg fluorescin kg^{-1} h^{-1}) was recorded in Kanar village followed by Ramgarh (747.4 mg fluorescin kg^{-1} h^{-1}). Very high FDA activity indicated that the soils were rich in organic matter.

Our present study indicated the status of different soil components in the Malihabad region, one of the hotpots of mango growing zones in India. We observed the wide variation in soil organic carbon content, soil available P and K; enzymatic activities across 20 mango growing villages, even the variations were also depicted within the mango orchards of same village. Lower microbial activities were related to low organic carbon content in the mango orchards. Thus, dissemination of appropriate technologies are essentially required for the mango growers, to marinate sustainability and conservation of diversity along with orchard productivity.

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