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Research Article

Soil Physico-Chemical and Biological Properties *vis-à-vis* Yield Gap Analysis in Mango cv. Langra Orchards in Lucknow

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ABSTRACT

Soil physico-chemical and biological properties were assessed in Mango cv. Langra orchards of farmers' field in surrounding the ICAR-CISH, Rehmankhera, Lucknow and related with the productivity of orchards. Generally, orchards with higher productivity level had registered higher amounts of nutrients, biological activities and lower physical constraints. Soil samples at three depth (0-10, 10-20 and 20-30 cm) were collected from the tree basin were subjected to laboratory analysis during 2017-19. Data showed that enzymatic activities varied across orchards and depths. The dehydrogenase activity was estimated @ 1.14 (0-10 cm soil depth) to 0.16 (20-30 cm soil depth) µg TPF g^{-1} h^{-1} and fluorescein diacetate activity @ 386.89 (0-10 cm) to 161.11 (20-30 cm) µg fluorescein g^{-1} h^{-1} respectively. The soil reaction of the orchard indicated higher than near neutral values of 7.6; available P, K and soil organic carbon decreased down the depths (27.97 to 10.77 mg kg^{-1}, 116.95 to 76.62 mg kg^{-1} and 0.45 to 0.34%) at top soil (0-10 cm) to subsoil (20-30 cm) respectively. Wide coefficient of variations in micronutrient contents was noted. Depth wise variability in soil physical properties was estimated. The study inferred enormous scope to enhance yield in mango cv. Langra under subtropical condition of this region with improved management of soil moisture.

Key words: Physico-chemical properties, biological activity, soil depth, yield, Langra

Introduction

Quantification of soil health index is very important and essential for assessing the sustainability of fruit orchards and growers profitability (Sanchez *et al*., 2003; Aruani *et al*., 2011; Adak *et al*., 2019). Soil physico-chemical and biological properties indicates the present status of the orchard health which reveals the constraints limited to productivity (Heijden *et al*., 2008; Tolón Becerra *et al*., 2012). Soil physical properties influenced the chemical and biological activities in soil. Enzymatic activities are indicator for biological health while it also determines the rate of nutrients cycling and related chemical properties (Larsen *et al*., 2015). Depth wise micronutrient content in orchard soil is a status symbol for assuring optimum yield and requirement of future management strategy. Depth wise distribution of physical, chemical and biological properties are very much helpful to quantify the actual status of these properties for developing the relationship with fruit yield. Researchers have examined soils of fruit orchards across different agro-climatic zones and express the concern of yield gap as suggested by Bie and Rugege (2000). Limitations in effective water, nutrient, canopy, pest soil and other management may be responsible for such yield gap (Hudina and Štampar, 2005; Adak *et al*., 2018). Soil types particularly in problematic soils like gravel/sand stone/sand, salinity/sodicity etc. Compaction due

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to tillage and irrigation water qualities etc. is some of the reasons behind lower yield harvested by farmers (Özgöz *et al*., 2007; Ilie *et al*., 2017). No such information was generated on this aspect, the recent study was initiated to assess the depth wise soil physico-chemical and biological properties in mango cv. Langra orchards of Malihabad, Lucknow for establishing its relationship with productivity/yield.

Materials and Methods

The study focused on the famous mango cultivation belt of Malihabad region in Lucknow, Uttar Pradesh (Fig.1). The region is well recognized for Langra mango production along with Dashehari and Lucknow Safeda as well. Undisturbed 36 core soil samples were collected from Langra orchards of Nai Basti village of Malihabad from tree basin at 0-10, 10-20 and 20-30 cm soil depth and corresponding fruit yield was recorded from the growers/farmers during 2019. The collected soil samples were air dried and enzymatic activities -were estimated. Dehydrogenase (DHA) and fluorescein diacetate activities (FDA) in soil were assessed using spectrophotometer as per the standard methodology (Casida *et al*., 1964; Adam and Duncan, 2001). Water holding capacity, porosity, bulk and particle densities were also determined. Soil organic carbon, micronutrients and other chemical properties were determined. Univariate statistics was computed however for discussion, standard deviations and coefficient of variations (CV%) was incorporated depth wise for all the properties. The CV is an indicator of yield gap analysis as well as stability of the nutrients in orchards.

Results and Discussion

Depth wise distribution of soil physical properties in mango cv. Langra orchards is presented in Fig. 2. Higher bulk density and lower porosity in subsoil (20-30 cm) was recorded. Wider content was recorded across the orchards; with highest water holding capacity of 23.21 per cent. A range of 1.28 to 1.43 g cm^{-3} BD, 2.43 to 2.66 g cm^{-3} PD and 42.6 to 51.0% porosity across orchard depths were recorded. Soil dehydrogenase activity (DHA) was mostly <0.50 µg TPF g^{-1} h^{-1} (Table 1). Orchards with higher productivity had higher content of DHA and fluorescein diacetate activity (FDA) which varied from 0.77 to 1.14 µg TPF g^{-1} h^{-1} and 312.15 to 386.89 µg fluorescein g^{-1} h^{-1} respectively. In fact, although the FDA was in a range of 0.16 to 1.14 and 161.11 to 386.89 was determined. Soil organic carbon was low;

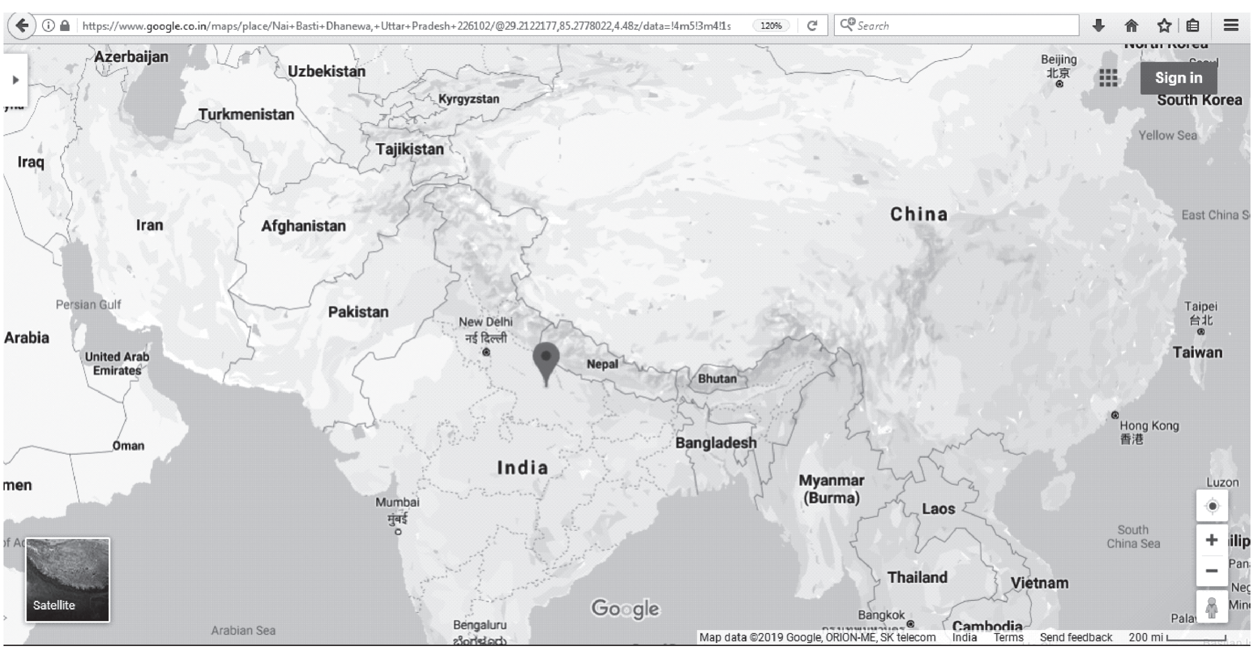

Fig. 1. The study site from where soil samples were collected

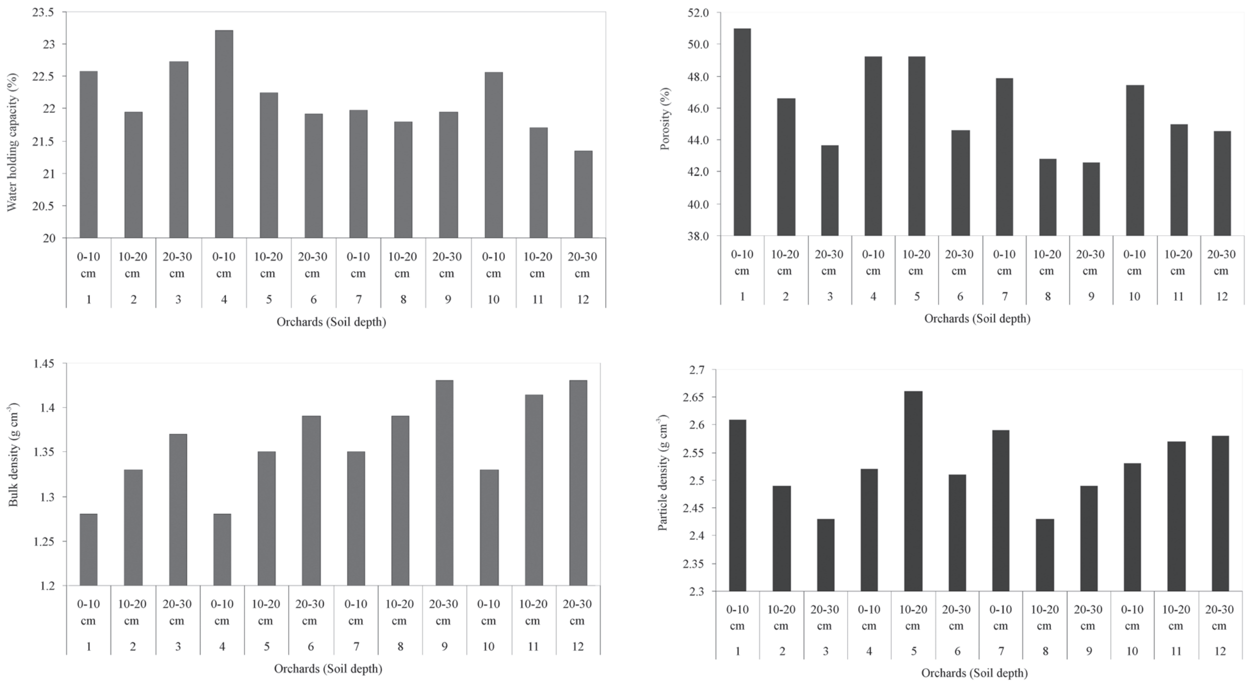

Fig. 2. Depth wise variations in soil physical properties in Mango cv Langra orchards of Malihabad region in Lucknow, Uttar Pradesh

Table 1. Depth wise distribution of soil enzymatic activities in Mango cv Langra orchards of Malihabad region in Lucknow, Uttar Pradesh

Sl. No	Soil depth (cm)	DHA (μg TPF g^{-1} h^{-1})			FDA (μg Fluorescence g^{-1} h^{-1})		
		Mean	sd	cv	Mean	sd	cv
1	0-10 cm	0.35	0.20	57.72	267.21	42.73	15.99
2	10-20 cm	0.28	0.09	33.61	224.47	70.71	31.50
3	20-30 cm	0.21	0.06	26.00	203.66	45.79	22.48
4	0-10 cm	0.56	0.36	65.07	186.56	37.45	20.07
5	10-20 cm	0.54	0.47	87.84	169.70	15.60	9.19
6	20-30 cm	0.41	0.23	55.68	161.11	9.27	5.75
7	0-10 cm	1.14	0.19	17.04	386.89	33.80	8.74
8	10-20 cm	1.10	0.26	23.97	332.18	25.23	7.59
9	20-30 cm	0.77	0.26	34.29	312.15	115.13	36.88
10	0-10 cm	0.40	0.13	33.66	231.55	53.32	23.03
11	10-20 cm	0.36	0.10	29.05	198.33	50.39	25.41
12	20-30 cm	0.16	0.06	37.85	176.35	33.24	18.85

<0.50% in all the 36 soil samples; depth wise 0.34 to 0.45% was recorded (Table 2). Soil reaction (pH) varied between 7.75 to 7.90; P and K content of 25.43 to 27.97 and 107.63 to 116.87 mg kg^{-1} in orchards of high yield was observed. Lower values of 10.77 to 12.50 and 76.62 to 78.37 mg kg^{-1} also noted. Micronutrients like Zn (0.64 to 1.32 mg kg^{-1}), Cu (1.81 to 3.29 mg kg^{-1}), Mn (3.90 to 23.88 mg kg^{-1}) and Fe (7.57 to 24.54 mg kg^{-1}) was found across orchard depths (Table 3). Productivity range of 0.5 to 2.0 t ha^{-1} was observed among the orchards with different percentage of productivity level (Fig. 3). Potential yield could be much higher than observed one

Table 2. Depth wise status of soil organic carbon, phosphorus, potassium and pH in mango cv. Langra orchards of Malihabad region in Lucknow, Uttar Pradesh

Sl.	Soil depth	SOC (%)			P (mg kg^{-1})			K (mg kg^{-1})			pH		
No.	(cm)	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv
1	0-10 cm	0.45	0.04	8.71	15.77	4.41	27.95	94.90	29.59	31.19	7.83	0.13	1.69
2	10-20 cm	0.40	0.08	19.60	15.73	3.10	19.71	89.90	30.72	34.17	7.90	0.03	0.41
3	20-30 cm	0.43	0.07	15.70	14.37	4.70	32.69	85.67	30.61	35.73	7.79	0.22	2.87
4	0-10 cm	0.38	0.06	15.84	13.53	1.75	12.93	116.95	17.74	15.17	7.84	0.12	1.57
5	10-20 cm	0.36	0.03	8.14	13.10	3.96	30.24	101.15	18.15	17.94	7.75	0.24	3.08
6	20-30 cm	0.34	0.04	11.79	12.50	1.97	15.76	78.37	11.10	14.16	7.91	0.05	0.67
7	0-10 cm	0.41	0.04	9.54	27.97	3.51	12.54	116.18	8.15	7.01	7.77	0.05	0.61
8	10-20 cm	0.40	0.03	7.47	27.70	2.56	9.25	116.87	15.52	13.28	7.80	0.14	1.76
9	20-30 cm	0.41	0.09	21.81	25.43	4.32	16.97	107.63	5.90	5.48	7.81	0.08	1.05
10	0-10 cm	0.38	0.05	12.76	14.10	4.29	30.41	88.53	27.18	30.71	7.82	0.05	0.59
11	10-20 cm	0.37	0.05	14.01	13.47	4.44	32.95	83.83	21.38	25.50	7.89	0.11	1.44
12	20-30 cm	0.34	0.02	6.55	10.77	1.71	15.88	76.62	2.82	3.68	7.88	0.05	0.65

Table 3. Depth wise distribution of micronutrients in mango cv. Langra orchards of Malihabad region in Lucknow, Uttar Pradesh

Sl.	Soil depth	Zn (mg kg^{-1})			Cu (mg kg^{-1})			Mn (mg kg^{-1})			Fe (mg kg^{-1})		
No.	(cm)	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv
1	0-10 cm	1.05	0.38	36.76	2.97	0.39	13.22	19.15	2.76	14.42	13.40	6.52	48.64
2	10-20 cm	0.81	0.11	14.04	2.91	0.38	13.22	17.73	2.90	16.39	12.16	5.61	46.17
3	20-30 cm	0.64	0.23	35.48	2.86	0.23	7.88	16.60	2.91	17.56	12.13	6.25	51.51
4	0-10 cm	1.32	0.37	28.49	3.07	0.20	6.57	22.51	2.48	11.01	24.54	5.60	22.80
5	10-20 cm	1.00	0.10	10.17	3.06	0.16	5.10	22.11	1.31	5.94	22.55	1.37	6.08
6	20-30 cm	0.94	0.19	20.63	2.81	0.56	19.96	20.07	6.25	31.16	22.24	1.47	6.59
7	0-10 cm	1.12	0.20	17.56	3.29	0.56	17.05	23.88	2.75	11.50	24.27	3.84	15.82
8	10-20 cm	1.06	0.18	17.36	2.83	0.46	16.13	23.51	2.20	9.34	22.89	2.59	11.33
9	20-30 cm	1.08	0.11	10.58	2.81	0.55	19.57	23.26	3.73	16.02	21.79	8.89	40.82
10	0-10 cm	0.80	0.20	25.52	1.98	0.29	14.58	4.62	0.61	13.10	11.00	3.36	30.59
11	10-20 cm	0.73	0.19	26.59	1.91	0.67	34.85	4.26	0.05	1.24	10.73	3.39	31.64
12	20-30 cm	0.73	0.23	31.68	1.81	0.56	31.13	3.90	0.50	12.70	7.57	2.85	37.67

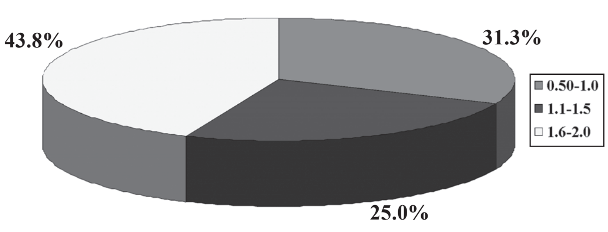

Fig. 3. Productivity range of mango cv. Langra

which further suggests narrowing down the yield gap by managing the resources.

Commonly the orchard management differs from one place to another place and variable rate of fertilization may be reason for variability in nutrients. Based on long-term study in Citrus, Colaço and Molin (2017) observed the fate of variable fertilization. Even under green house condition, mango production was tried for safe disposal to the market (Medany *et al*., 2009). As a quality component, Adak *et al.* (2018) evaluated B and K nutrient content in major mango germplasms for identifying better genetic resources and to improve the productivity. For effective orchard management, special unit based zones needs to be identified and appropriate recommendations may be developed based on soil properties (Cucunubá-Melo *et al.,* 2011; Mann *et* *al*., 2011). Similarly ecology of the orchard also plays an important role and differs from one place to another contributing towards the significant change in soil properties (Ettema and Wardle, 2002). Cropping system under semi-arid or arid in tropical or subtropical areas differs in enzymatic activities because of climate and soil mediated factors (Acosta-Martínez *et al*., 2011). Soil organic matter and associated factors like SOC, fractionation of SOC, stock variation etc. also implies the soil productivity. Ramesh *et al*. (2015) quantified SOC stocks and fractions in hilly ecosystem of N-E India involving fruit based agroforestry system. Likewise, for implication in carbon resources and its management, Chatterjee *et al*. (2018) also assessed the stocks in pasture-agroforest-agriculture-forest. Better the soil ecology better is its microbial transformation. Thus, enzymatic activities act as one of the key component in any agro-ecosystem to indicate the soil health status. Lower microbial reactions in mango cv. Langra orchard soils was therefore indicate the alarming situation in terms of low biological health and special care should immediately be taken to improve the SOC and enzymatic reactions in soil through organic sources. Nosalewicz and Nosalewicz (2011) observed the variability in dehydrogenase activity both in bulk and rhizospheric zone due to compaction. Recently, Sofo *et al*. (2019) recorded the metabolic diversity of soil micro-organisms under traditional and sustainable Olive production. The change in microbial compostion in tanglehead gradient in a semiarid region was also inferred by Grace *et al.* (2019). All these studies suggested for improving the soil health for harnessing potential yield. Decision support system should henceforth be developed and forecasted to growers for the benefit of real time based orchard management. Verma *et al.* (2018) developed DSS in mango and also suggested for management options for nutrient deficiencies. Similarly, in case of wine grape, Yau *et al*. (2014) developed DSS for Inland Pacific Northwestern United States. The productivity status of mango cv. Langra was in general low to medium as recorded in different soil types and age of trees. Datarkar *et al*. (2014) analyzed the economics and marketing statistics of mango and also observed that productivity was somewhat 5.01 MT ha^{-1}. Anu *et al.* (2015) recorded a range of 118.9 to 236.95 kg fruit $tree^{-1}$ while some others have recorded lower yield. Yadav *et al.* (2018) analyzed the benefit:cost ratio (8.24 to 11.56) along with productivity of mangoes (170 to 190 q ha^{-1}) in different age group (5-10, 11-15, 16-20 and >21 years age) of tree. Henceforth, soil related planning should be given thrust area for profit of fruit growers.

Conclusions

Soil physico-chemical properties showed variations in different mango cv. Langra orchards and depth wise distribution indicates the soil fertility status. Soil biological activity was also estimated and showed lower status. Higher coefficient of variations was recorded in case of dehydrogenase activity than fluorescein diacetate activity. This showed the need for more organic resource application to improve orchard soils for improving the microbial properties. Higher yielded orchards had higher content of soil properties; yield gap study indicates a lot needs to be done for achieving towards actual potential yield.

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