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Research article

Assessment of soil micronutrients from a mango based agroecology of Malihabad, Uttar Pradesh, India

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Abstract: A sum of 250 soil samples were collected from mango based agroecology of Malihabad region, Lucknow, Uttar Pradesh to assess the status of soil micronutrients integrated with the nutrient, water, space and canopy management for improving productivity of subtropical fruits. Notable differences were observed in case of Zn, Cu, Mn and Fe content within and across mango orchards. Histogram distribution showed Zn and Cu content in the maximum frequency range of 0.5 to 1.0 and 1.5 to 3.0 mg kg^{-1} respectively while Mn was evenly distributed in 3.0 to 6.0 mg kg^{-1} range. In contrast, Fe distribution was scattered. A range of 0.45–1.23, 1.47–2.91, 2.86–11.13 and 4.9–15.2 mg kg^{-1} Zn, Cu, Mn and Fe respectively across different mango sites were estimated. In the case of major nutrients (NPK), the frequency distribution of P and K indicated widely spread while N was confined to a smaller distribution range. Soil reaction (pH) was mostly found near neutral to slightly alkaline in nature. The ecological significance of this study indicated the need for proper nutrient management. Such information may be useful for conserving the mango based agroecology for future endeavor through the adoption of optimized micronutrient management technologies.

Keywords: Subtropical agroecology - Micronutrients - Histographic distribution - Variability - Mango.

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INTRODUCTION

Nutrient imbalance in different agroecology of economic importance crops are of great concern, as their sustainability for the longer term is becoming a serious question. Such imbalance poses a serious threat on the availability of quality food products and in the case of fruit crops, its a serious matter as people get enriched through nutritive fruit sources (Rao & Swaminathan 2017). Deficiency or afficiency of any kind of nutrients in soil influences or restrict other nutrients availability as nutrients always remain in soil solution in an interaction and interdependant mode. As per the available report, Tewatia *et al*. (2017) estimated per hectare nutrient balance and opined that it is negative in all the crops grown in different agroecology. In the case of fruit ecosystem, net negative balance is 92.8 kg nutrient ha^{-1} year^{-1}. Among the fruit crops, total nutrient removal (N, P_2O_5 & K_2O) by mango was estimated at 280 Mt with a nutrient wise uptake of 124 Mt N, 31 Mt P_2O_5 and 124 Mt of K_2O. Major nutrient may thrust in supporting the longevity of an agroecology but micronutrients are essentially required owing to sustain the plant metabolism as well as nutrient richness in the fruit. Micronutrient imbalances even under salinity conditions are reported in different mango rootstocks and partitioning within the trees (Durán *et al*. 2004). Actually, micronutrients are essentially required owing to support the plant metabolism system; Zn is essential in the nitrogen metabolisms and induces the syntheses of auxin which promote cell size. Manganese is involved in oxidation-reduction process/reaction in photosynthesis and also acts as an activator for enzymes. Thus, the assessment of soil micronutrients is playing a significant role to identify ecological balances and also for nutrient budgeting for future policy.

Mango being native to Indo-Burma region, widely cultivated in tropical and subtropical parts of the country. It can withstand a vast range of soil and climatic conditions across mango growing agroecology of the country and elsewhere in the globe. Many times mango trees had to undergo the process of adaptation for sake of

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survival and maintaining its own existences under existing climatic conditions (Rajan 2012). Under conditions of low, medium and high nutrient richness across humid coastal, semiarid and subtropical areas, the adaptive capabilities and nutrient use efficiencies on long-term basis followed the trend of low>medium>high (Ganeshamurthy & Reddy 2015). Even under calcareous soils iron deficiency in mango is common to affect its yield potential (Kadman & Gazit 1984). Such incidences indicated the fact that for maintaining the diversity of mango germplasms, information on soil and climatic conditions are important in respect to micronutrient availability to plants. Thus, species richness and its survivability act as a function of nutrient contents in soil. Malihabad region of Uttar Pradesh is one of the major mango growing belts in India for conserving the mango diversity, particularly of indigenous varieties. To conserve it for future, optimum nutrient as well as micronutrient management is essentially required (Adak *et al*. 2018). The present study was thus taken up to assess the micronutrient status in orchards of mango based agroecology having a large number of soil samples under the subtropical climatic condition of Uttar Pradesh (Malihabad belt) in order to evaluate nutritional disorders across orchards.

MATERIALS AND METHODS

Study area

The study area lays in 26.54º N Latitude and 80.45º E Longitude regions of Malihabad, Lucknow, Uttar Pradesh, India. Mango based agroecology is spread over an area of about 10,000.0 ha of land in Malihabad tehsil of Lucknow. Mango growing villages of Mandauli, Tikaitganj, Rasoolpur, Kithaipara, Ramgarah, Kasmandikala, Meethenagar, Mehmoodnagar, Nejabhari, Belgarha, Kanar, Habibpur, Allupur, Dugauli, Sahilamau, MohammadNagar Talukedari, Khalispur, Ladausi, Mohammadnagar, Rahmatnagar and Naibasti Dhanewa respectively comes under the tehsil. All these villages selected under the Hon'ble Prime Minister's "*Mera Gaon Mera Gaurov*" programme. The region is recognized as subtropical zone with alluvial soil. Two hundred and fifty soil samples were collected from 0–30 cm soil depth within the tree basin after harvesting of mango in the months of September-October. The samples were air dried at room temperatures and ground by wooden pestle and mortar and sieved through 2 mm mesh size sieve. Soil pH, available nitrogen, phosphorus and K were determined by the standard analytical procedures. Soil micronutrients (Zn, Cu, Mn and Fe) were estimated as per (Lindsay & Norvell 1978) using 'Chemito' AA203D model of atomic absorption spectrophotometer.

Statistical analysis

For statistical analysis purpose, SPSS version 16.0 and Microsoft-Excel software was used. Univariate statistical analysis of soil properties and required graphs were derived from MS Excel software. Histographic presentation for frequency distribution was completed through SPSS.

RESULTS AND DISCUSSIONS

Table 1. Mean distribution of soil reaction (pH) in mango based agroecology.

S.N.	Mean	Sd	CV(%)	Var	SEm
1	7.09	0.34	4.81	0.12	0.007
2	7.53	0.23	3.03	0.05	0.005
3	7.87	0.24	3.10	0.06	0.002
4	7.00	0.24	3.40	0.06	0.006
5	6.63	0.25	3.71	0.06	0.006
6	7.40	0.48	6.48	0.23	0.023
7	6.98	0.16	2.24	0.02	0.002
8	7.79	0.32	4.14	0.10	0.005
9	7.73	0.19	2.46	0.04	0.003
10	7.91	0.16	2.07	0.03	0.003
11	7.44	0.15	2.08	0.02	0.002
12	7.48	0.16	2.19	0.03	0.003
13	7.34	0.19	2.54	0.03	0.003
14	7.63	0.28	3.72	0.08	0.008
15	7.41	0.32	4.34	0.10	0.010
16	7.58	0.40	5.25	0.16	0.016
17	7.31	0.19	2.66	0.04	0.004
18	7.52	0.48	6.43	0.23	0.023
19	8.07	0.49	6.08	0.24	0.014
20	7.59	0.31	4.09	0.10	0.009

Different soil properties were assessed from the mango based agroecology. The mean value of soil reaction (pH) across 250 soil samples of 20 mango grown villages varied between 6.63 to 8.07 (Table 1). The coefficient of variations across these mango orchards were <7%, of course in majority of cases, within the orchards smaller values of <5% CV was estimated. Histographic distribution showed maximum frequency level of N as 158.86 mg kg^{-1} with a standard deviation of 65.58 across 250 soil samples. In case of P and K, the corresponding values were 19.55 and 134.79 mg kg^{-1} (Fig. 1). The frequency distribution of major nutrients (NPK) indicated widely spread in these 20 mango agroecology based system however; N was confined to a smaller distribution range.

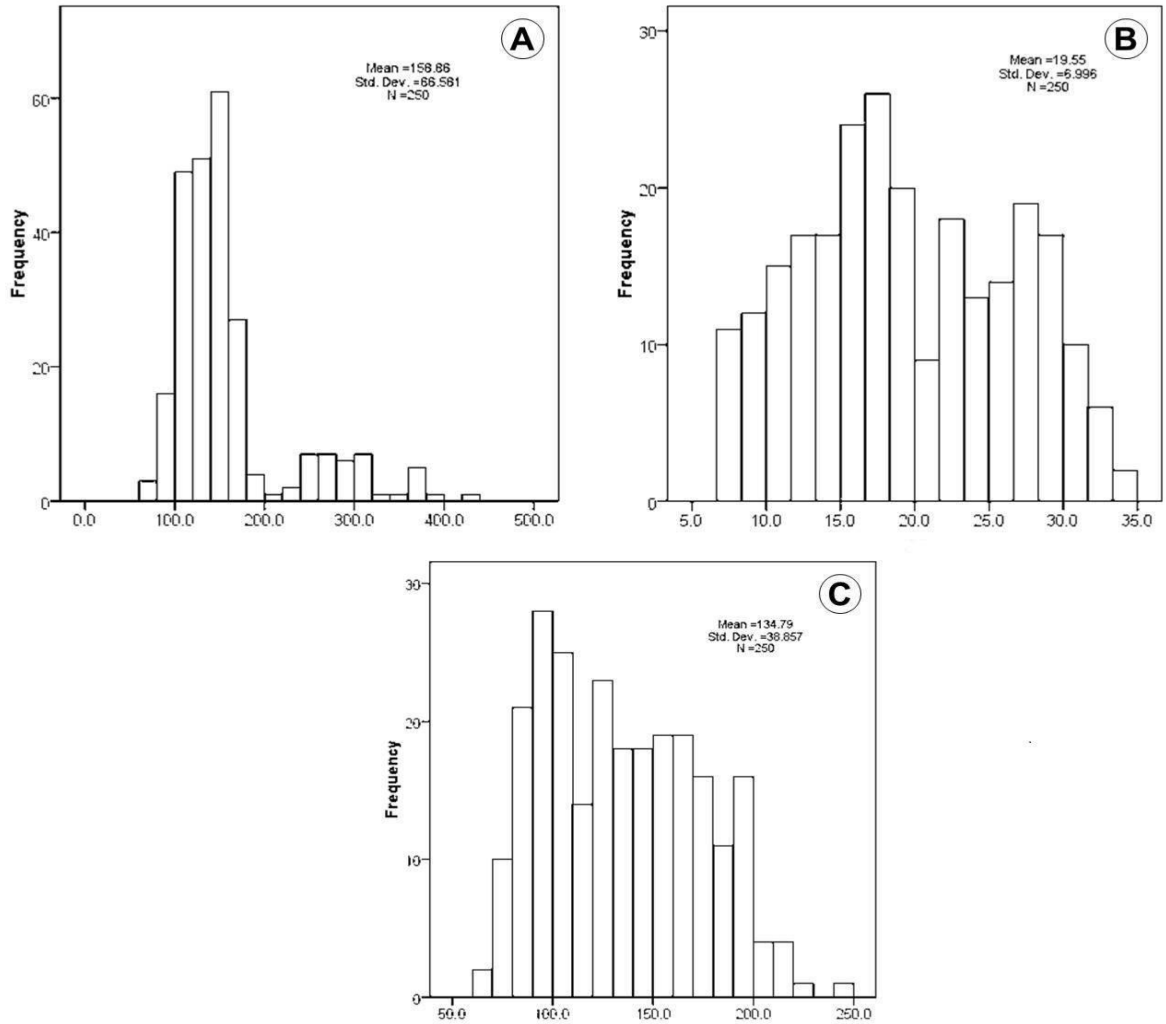


Figure 1. Histographic distribution of major nutrients in mango based agroecology: **A**, Nitrogen (N); **B**, Phosphorus (P); **C**, Potassium (K).

The micronutrients availability across the mango orchards of different villages showed wide spread variability. In case of Zn and Cu, the mean highest of 1.23 and 2.91 mg kg^{-1} were estimated respectively (Table 2). Lower value of 0.45 mg kg^{-1} Zn and 1.47 mg kg^{-1} Cu was observed. The coefficients of variations within and across the orchards were recorded and results indicated that in fact wider CV existed among the orchards. In contrast, a lower of 28 per cent variability was observed in the case of Fe content in the mango growing orchards. A range of 0.28 to 2.86 with a mean value of 0.85 mg kg^{-1} Zn was determined. Similarly, the range for Mn and Fe was 2.86 to 11.13 and 4.90 to 15.05 mg kg^{-1} respectively (Table 3). Further, it was inferred from the histographic analysis that the Fe, Mn and Cu were content widely distributed across these mango orchards with a decreasing tendency of Zn content (Fig. 2).

The variations in micronutrients (Zn) within the mango villages were higher (CV% 60.17) in Naibasti village followed by Kasmandikala (59.04%). In the case of Cu distribution, maximum variations (35.19%CV) were found in Kanar orchards followed by mango orchards of Allupur (31.03%). It was further recorded that lowest variation in Zn within the mango orchards of Tikaitganj and Meethenagar (25.11 and 26.15% CV). Similarly, maximum variations in Mn and Fe were found in mango orchards of Ladausi followed by Mahoomdnagar. The graphical representation (Fig. 3) inferred statistically higher variance of micronutrient contents within the villages of mango orchards. The highest variance in Zn content was found in the mango orchards soils of the village no 12 followed by village no 6 and lowest in the village no 7. Similarly, in case of Cu content the corresponding villages were 11, 13 and 12 respectively. The variance graph revealed that variance in the majority of mango orchards had below 5% Mn content while that of Fe was highly varied (being highest in the village no 17 followed by 11 and lowest in 2) (Fig. 3).

Table 2. Mean distribution of Zn and Cu in mango based agroecology.

S.N.	Zn				Cu			
	Mean	**Sd**	**SEm**	**CV(%)**	**Mean**	**Sd**	**SEm**	**CV(%)**
1	0.86	0.33	0.01	38.77	2.22	0.56	0.02	25.24
2	0.81	0.20	0.00	25.11	2.06	0.50	0.03	24.50
3	0.80	0.34	0.00	42.36	1.85	0.51	0.01	27.67
4	0.66	0.20	0.00	29.51	2.91	0.30	0.01	10.36
5	0.59	0.20	0.00	32.99	2.26	0.59	0.04	26.33
6	1.06	0.63	0.04	59.04	2.26	0.62	0.04	27.66
7	0.45	0.12	0.00	26.15	2.13	0.45	0.02	21.22
8	0.70	0.27	0.00	38.15	1.63	0.39	0.01	24.08
9	0.64	0.32	0.01	49.48	1.47	0.38	0.01	25.90
10	0.48	0.14	0.00	28.91	1.78	0.38	0.01	21.17
11	1.22	0.61	0.04	50.08	2.19	0.68	0.05	31.03
12	1.23	0.65	0.04	52.59	2.89	0.31	0.01	10.73
13	0.78	0.41	0.02	51.67	1.92	0.68	0.05	35.19
14	0.81	0.35	0.01	42.78	2.27	0.60	0.04	26.41
15	1.02	0.49	0.02	47.73	2.55	0.51	0.03	20.18
16	1.15	0.60	0.04	51.92	2.52	0.45	0.02	18.05
17	0.82	0.31	0.01	37.67	2.89	0.44	0.02	15.18
18	0.97	0.57	0.03	58.79	2.36	0.50	0.02	20.99
19	1.06	0.59	0.02	55.70	2.36	0.46	0.01	19.66
20	0.88	0.53	0.03	60.17	2.00	0.43	0.02	21.40

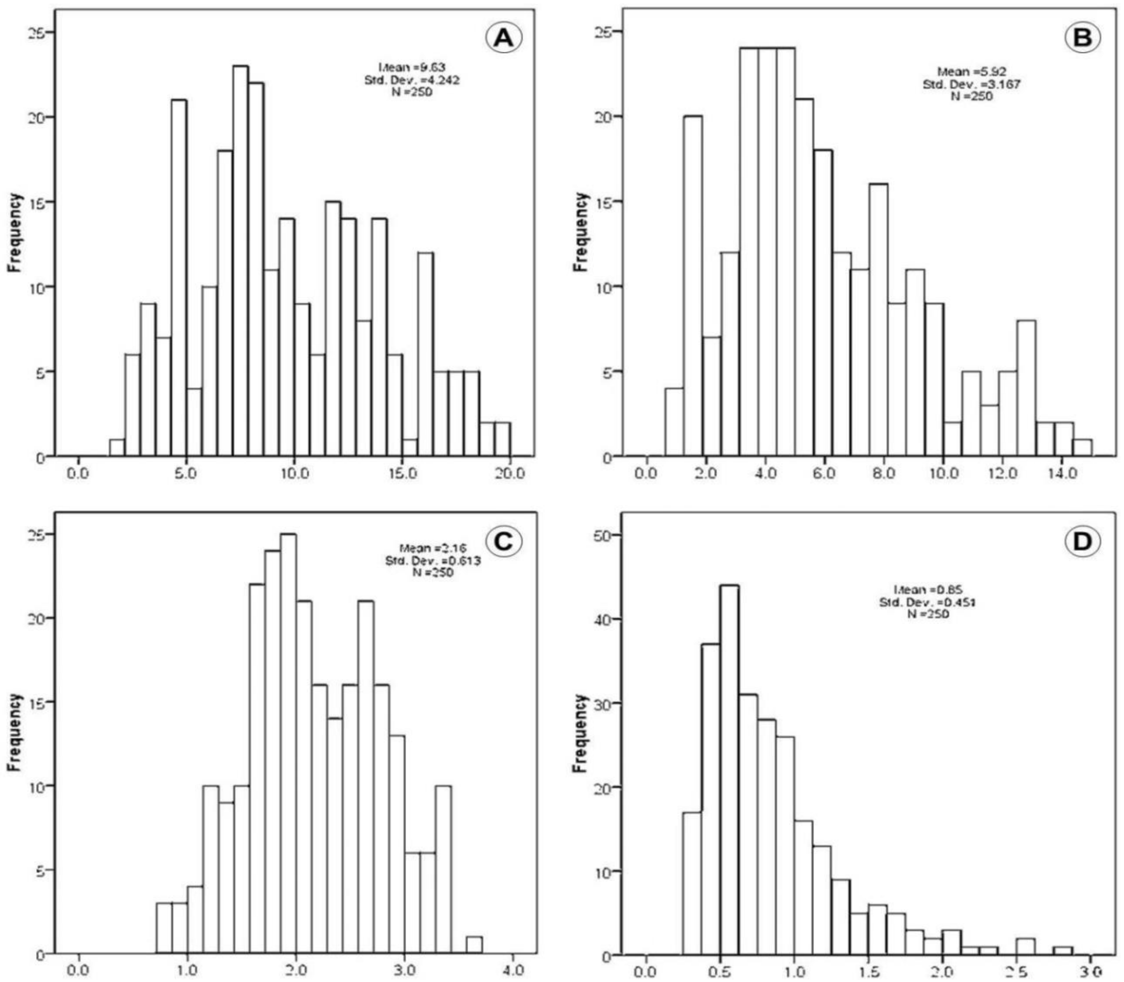
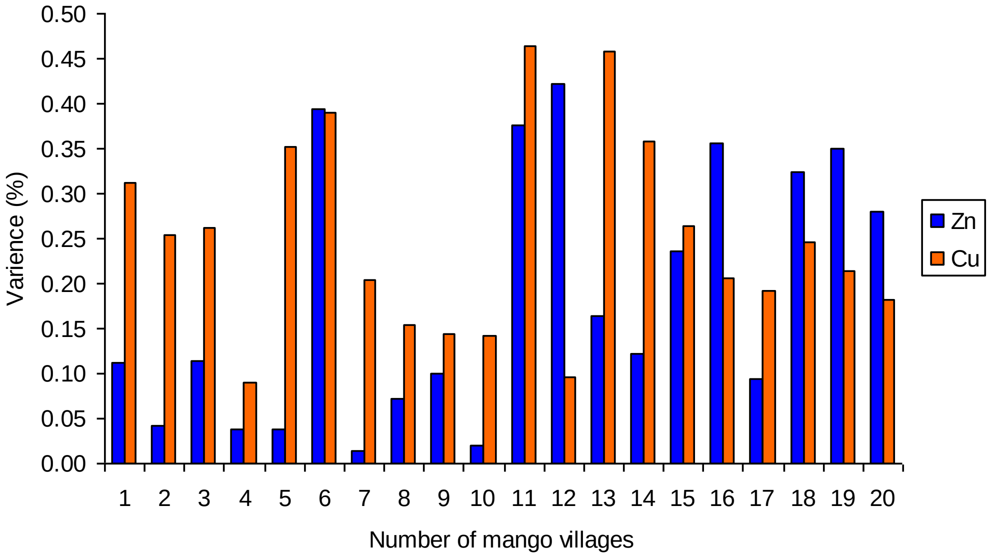


Figure 2. Histographic distribution of micronutrients in mango based agroecology: **A**, Iron (Fe); **B**, Manganese (Mn); **C**, Copper (Cu); **D**, Zinc (Zn).

Table 3. Mean distribution of Fe and Mn in mango based agroecology.

S.N.	Mn				Fe			
	Mean	Sd	SEm	CV(%)	Mean	Sd	SEm	CV(%)
1	9.20	2.75	0.47	29.92	12.67	3.44	0.74	27.17
2	7.94	2.22	0.49	27.91	7.76	1.30	0.17	16.80
3	6.28	3.41	0.33	54.27	10.30	4.07	0.47	39.52
4	11.13	2.27	0.51	20.37	15.05	2.51	0.63	16.65
5	9.74	2.40	0.58	24.64	13.83	3.86	1.49	27.93
6	6.44	3.68	1.35	57.11	9.93	3.38	1.14	34.01
7	8.24	2.82	0.79	34.21	8.34	2.82	0.79	33.82
8	4.95	2.26	0.27	45.61	6.92	2.30	0.28	33.28
9	5.81	1.70	0.26	29.22	6.04	2.27	0.47	37.67
10	6.98	1.98	0.39	28.31	8.53	2.02	0.41	23.66
11	6.36	2.30	0.53	36.07	13.81	4.66	2.17	33.76
12	4.69	1.44	0.21	30.67	15.20	3.11	0.97	20.45
13	4.65	1.67	0.28	35.94	10.96	3.26	1.06	29.71
14	5.25	2.20	0.48	41.88	7.83	1.34	0.18	17.09
15	4.66	1.30	0.17	27.89	9.09	3.94	1.55	43.38
16	4.12	0.79	0.06	19.28	10.51	2.35	0.55	22.34
17	3.33	2.15	0.46	64.60	8.66	4.91	2.41	56.65
18	2.86	1.64	0.27	57.40	8.43	4.21	1.77	49.86
19	3.20	1.81	0.19	56.41	6.45	3.39	0.68	52.57
20	3.04	1.68	0.26	55.29	4.90	2.00	0.36	40.72



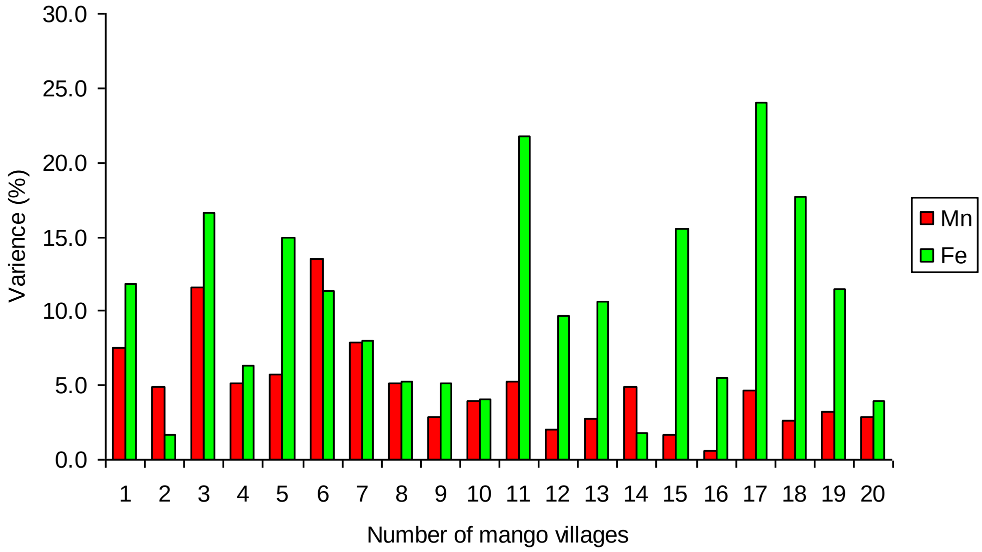


Figure 3. Variance in micronutrients within and across mango based agroecology.

Mango being widely grown in almost 80 countries in the world is one of the most important fruit crops in India (Mukherjee 1953). Malihabad region of U.P., Lucknow India is famous for its Dashehari cultivar production, being geographical Indicator (GI) of the region. The continuous mango growing belts is spread over thousands of hectare area and is maintaining over the decades (Rajan 2011). Soil nutrients particularly micronutrients plays an important role in sustaining the mango diversity and productivity in this region. The present study revealed widespread variations exited in these orchards across villages and even within the same mango growing village. Such differences may be because of un-uniformity adoption of nutrient management technologies across a different section of orchardists and prevailing socio-economic conditions. In a study conducted by Kumar *et al*. (2012) wide spread variations in soil and leaf nutrient contents were inferred from 50 mango orchards. Likewise, productivity levels were also varied immensely. Ganeshamurthy & Reddy (2015) investigated the suitability of mangoes for colonization in low fertility soils and dry-land areas by examining a number of plant traits and finally concluded that for sustaining mango trees in low fertility and dry land soils, varieties having longer leaf life span are most suited because of their adaptation to low nutrient availability. However, such adaptations may not support higher fruit productivity. Thus, proper nutrient management is obvious for maintaining the sustainability of long-term mango trees.

Soil properties are highly variable and associated in nature within and across the mango based ecology. Spatial and temporal variations of such kind and types of properties act as a function of soil chemical, physical and biological nature and inputs (types of organic matter and quantity of inorganic fertilizers) added to soils etc. Kumar *et al*. (2015) reported wide spread deficiency of micronutrients and soil organic matter across mango orchards of western Uttar Pradesh. Further, in order to sustain the high-density mango productive system, soil sustainability is an urgent issue that needs to be dealt with sensitivity and with high care (Adak *et al*. 2019). A number of soil properties like soil reaction, soil organic carbon, some of the major nutrients and micronutrients along with soil moisture play important role in biological reactions and activities which in turn decides the rate at which nutrient releasing takes place in soil (Kujur & Patel 2014). Similarly, Behera *et al*. (2016) observed spatial variability of soil properties in oil palm plantations.

Changes in soil fertility and mineral content in mango orchards of a different cultivation time span was also reported in Brazil by da Silva *et al.* (2014). Soil reaction found to be in vast range of 6.1 to 7.8 with high P and adequate K content in soil depths (0–20 and 20–40 cm). Site-specific K management, particularly for quality fruit production, was emphasized by Srivastava (2011). Based on a study at Paraipaba (3º 28′52″ S and 39º 09′52″ W; 30 m above sea level), State of Ceará, under subtropical condition of Brazil, Bernardi *et al*. (2007) 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. Likewise, soil available N was varied between 0.2–0.37 and 0.2–0.67 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} and 10 to 20 g kg^{-1} respectively. All these variations in different agroecology of mango growing regions indicated the need for optimum nutrient management to support the mango sustainability.

CONCLUSION

The present study revealed wide variations of nutrient content across 20 mango orchards of Malihabad region as evidenced by histographic distributions. Major nutrients need an optimum application in order to sustain the productivity as well as soil health. It was further inferred from the study that micronutrient distribution in these mango based agroecology was also statistically highly variable. This may be due to the fact that uneven application of proper micronutrient to mango trees. Farmers are therefore advised to adopt recommended nutrient management for sustainable soil and orchard productivity. Based on the soil analysis, it is advocated for farmers to apply 2.5 kg Urea, 3.0 kg SSP and 1.5 kg MOP in their mango orchards during the months of September to October. Special care should be taken during fruit setting to maturity periods. Potash (0.5% sulphate of potash) should be applied during peanut and marble size of fruits in order to maintain quality fruit production. Micronutrients should be sprayed at pea/marble size of fruits. In case of deficiency of Mn and Cu after soil test, farmers are also advised to apply 0.5% $MnSO_4$ or $CuSO_4$. To sustain quality fruit production by avoiding fruit carking and dropping, proper moisture content in orchards particularly during fruit setting to developmental stages having high ambient temperature and wind should be ensured. All these nutrient management modules ultimately ensure the possibility of better orchard productivity and thus opt for long-term sustainability.

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