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Correlation of soil properties with quality parameters of mango in mango research sub-centre, Rameshwar, Devgad

Chavan AR, Wahane MR, Dodake SB, Khobragade NH, Damodhar VP, Galande AV, Jagtap PS, Shinde NS and Thorat AT

Abstract
The present survey was conducted at Mango Research Sub-Centre, Rameshwar, Devagd under the jurisdiction of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra during May 2022, where 90 soil samples for physico-chemical analysis and 54 mango samples for quality parameter analysis collected from eighteen mango orchards of Mango Research Sub-Centre, Rameshwar, Devgad. The result revealed that, soils were acidic in nature with low EC due to leaching of free soluble salts and very high organic carbon content. In case of available nutrient status, the soils found to be "moderate" in available nitrogen, "moderate to high" in available phosphorus, low in exchangeable Ca^{2+} and Mg^{2+} with high amount of DTPA extractable micronutrients *i.e.,* Fe, Mn, Zn and Cu. The quality parameters of mango showed that the total sugar ranged from 13.99 to 15.42 per cent, reducing sugar ranged from 4.00 to 6.10 per cent, non-reducing sugar ranged from 8.65 to 10.33 per cent, titratable acidity ranged from 0.22 to 0.37 per cent, total soluble solids (TSS) ranged from 14.40 to 22.40 ^{0}Brix, ascorbic acid ranged from 31.42 to 53.35 mg $100g^{-1}$ and β-Carotene ranged from 1779 to 3440 µg $100g^{-1}$. Mango quality and properties of soil showed both positive and negative relationships, indicating an equilibrium between them.

Keywords: Mango, fertility, quality parameters, nutrients, correlation

Introduction
Mango (*Mangifera indica* L.) is popularly known as the 'King of Fruits', 'Nector of God' belongs to the family Anacardiaceae and considered as 'National fruit of India'. It is a most cultivated fruit in tropical regions. Mango is originated in South East Asia, Indo Burma region (Mukherjee, 1953). In India, mango is cultivated in both tropical and sub-tropical regions in an area of 2350.30 thousand hectares with an annual production of almost 20772.30 thousand tonnes and productivity is 8.8 MT ha^{-1} which accounts for more than 55 percent of the world's total production (Anonymous, 2023) [4]. However, Maharashtra produces 459.15 thousand tons from an area of 164.40 thousand hectares and having productivity of 2.79 MT ha^{-1} (Anonymous, 2022a) [5]. The Konkan region, particularly Ratnagiri and Sindhudurg, is popularly known as basket of Alphonso mango. It produces 0.32 million tons of mango from an area of 0.12 million hectares with a productivity of 2.56 MT ha^{-1} which is meager to the national productivity (Anonymous, 2022b) [3].

Mango fruit is very popular with the masses due to its wide range of adaptability, high nutritive value, richness in variety, delicious taste and excellent flavour. It is a rich source of vitamin A and C. Macro and micro nutrients in soil plays an important role on production and quality of Mango. The lateritic hard rock areas are nearby sea-coast and some of these pockets are directly exposed to the sea, which favours very early flowering and development of excellent quality fruits to fetch premium market rates.

Alphonso is the king of mangoes and Alphonso Mangoes from Konkan region are always delicious ever and has earned fame at local market as well as at foreign market. The most significant tell-tale sign is the aroma. Sindhudurg and Ratnagiri district known as "Mango Basket". Laterite and lateritic soils formed from basalt during the laterization process, cover an area of about 10.73 lakh ha (Kadrekar *et al.*, 1981) [17] having low native fertility and nitrogen retention capacity, where additionally, some macro- and micronutrients are losing possibly as a result of the terrain's undulations and heavy rainfall.

Materials and Methods

The present study was conducted at 18 mango orchards of Mango Research Sub-Centre, Rameshwar, Devgad, Dist. Sindhudurg, situated at latitude 16^0 52' 83.32" N and 73^0 34' 63.29"E longitude with an area 36.07 ha in the Southwest region of Maharashtra State on the Arabian sea coast. Climatic conditions in the Sindhudurg district are strongly influenced by its geographical condition. May is the hottest month, with a temperature of more than 33 ºC, whereas December is the coldest month with mean daily maximum temperature at 32.7 °C and the mean daily minimum temperature at 18.7 °C. Humidity during June to October is more than 80 per cent. Laterite and lateritic soil cover an area of about 10.73 lakh hectors in Southern Raigad and whole of Ratnagiri and Sindhudurg districts. The soils are sandy clay loam to clay in texture. The soils are developed on granite and gneiss materials contain more sand and less clay as compared to the soil derived from the basalt.

Five representative surface soil samples (up to 22.5 cm) from each orchard were taken by following the standard method of collection of soil samples (Tandon, 1993) [29]. The samples of mature fruit were collected, ripened and analyzed for various quality parameters *viz*., total soluble solids, titratable acidity, reducing sugar, total sugar, β- carotene and ascorbic acid content.

pH and electrical conductivity (EC) were determined in 1**:**2.5 soil water suspension using combined electrode of pH meter and ELICO Conductivity Bridge, respectively (Jackson, 1973) [14]. Wet oxidation method (Walkley and Black, 1934) and alkaline permanganate (0.32% $KMnO_4$) method (Subbiah and Asija, 1956) [28] were used for determination of organic carbon and available nitrogen. Available phosphorus in soil was determined by Bray II method by developing blue colour with ammonium molybdate and stannous chloride. Phosphorus in the extract was determined colorimetrically by using Spectrophotometer at 660 nm wavelength as outlined by Black (1965) [10]. The Ca^{2+} and Mg^{2+} were determined titrimetrically by using 0.01 N Ethylene diamine tetra-acetic acid (Versenate solution) as given by Chopra and Kanwar (1978) [11]. The Fe, Mn, Cu and Zn in 0.005 M DTPA extract were then estimated with the help of Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978) [18].

Total Soluble Solids in fruit were determined with the help of Hand Refractometer (Atago Japan, 0 to 32 ^{0}Brix) as given in A.O.A.C. (1975) [1]. Titrable acidity was determined by titrating pulp sample with 0.1 N sodium hydroxide (NaOH) using phenolphthalein indicator. Reducing sugar and total sugar were quantified by titrating against standards (Feling's A and B) using methylene blue indicator to a brick red end point (Ranganna, 1977) [26]. According to A.O.A.C. (1975) [1] the 2, 6, dichlorophenol indophenol dye method was used to measure ascorbic acid. The determination of beta-carotene content was done by simple and rapid method given by Roy and Susantha (1973) [27].

Results and Discussion

pH, EC and OC of soils

The pH and EC of soil collected from eighteen orchards of Mango Research Sub-Centre, Rameshwar ranged from 4.36 to 5.99 with an average value of 5.17 and from 0.314 to 0.882 dS m^{-1} with an average value of 0.598 dS m^{-1} (Table 1). The data indicated that the soils are acidic in nature and devoid of soluble salts, which might be attributed to leaching of the soluble salts due to heavy precipitation (Anonymous, 1990) [2]. The organic carbon content ranged from 14.16 to 26.86 g kg^{-1} with an average value 20.51 g kg^{-1} (Table 1) indicating "very high" content in the Konkan region's humid climate (Bangar and Zende, 1978), which may be to blame for the extremely high organic carbon content of the soils (Anonymous, 1990) [2].

Available nutrient status of soils

The available nitrogen, available phosphorus and available potassium content in soil varied from 286.00 to 376.32 kg ha^{-1} with an average value 331.16 kg ha^{-1}, from 30.52 to 72.13 kg ha^{-1} with an average value 51.32 kg ha^{-1} and from 363.73 to 682.09 kg ha^{-1} with an average value 512.92 kg ha^{-1} indicating moderate, moderate to high and very high content as per the ranges proposed by Bangar and Zende (1978), respectively. In general, the available P_2O_5 content in lateritic soils ranges from 0.35 to 74.14 kg ha^{-1} with an average value of 14.14 kg ha^{-1} (Anonymous, 1990) [2]. The higher phosphatase activity under the trees, as the organic anion exudation and acid phosphatase activity of tree roots has resulted to increase mobilization of phosphorus in the rhizosphere (Tisdale *et al*., 1995) [32]. According to Tandon (1987) [30], the addition of organic matter may have increased the amount of available P because the organic matter breaks down and releases significant amounts of CO_2, which dissolves in water to form carbonic acid, which can break down and dissolve some primary minerals. Additionally, the organic matter covers the sesquioxides, rendering them dormant. This lowers the soil's ability to fix phosphate, which eventually aids in the release of a sufficient amount of phosphorus. Similar values of available NPK were reported by Mahajan (2001) [19] and Patil (2010) [22].

The exchangeable Ca^{2+} and Mg^{2+}content in soil ranged from 3.62 to 8.76 cmol (p^+) kg^{-1} with an average value of 6.19 cmol (p^+) kg^{-1} and 1.68 to 4.28 cmol (p^+) kg^{-1} with an average value of 2.97 cmol (p^+) kg^{-1} (Table 2), indicating low content as the lateritic soils are highly leached soils (Raghupathi and Bhargava, 1997) [25]. Similar values were also observed by Thakare (2016) [31].

DTPA extractable Micronutrients (mg kg^{-1})

The exchangeable Fe, Mn, Zn and Cu content in soil ranged from 28.11to 64.10 mg kg^{-1} with an average value of 46.11 mg kg^{-1}, 31.54 to 63.27 mg kg^{-1} with an average value of 47.41 mg kg^{-1}, 1.59 to 4.90 mg kg^{-1} with an average value of 3.26 mg kg^{-1} and 2.68 to 7.54 mg kg^{-1} with an average value of 5.11 mg kg^{-1}, respectively (Table 2). The low pH and greater organic matter content of lateritic soil may also contribute to the sufficient amount of accessible Fe in lateritic soil (Diwan, 1982) [12]. The region's warm, humid environment may have contributed to the decomposition and mineralization of organic debris, which would explain the high concentration of accessible Mn and Cu (Mehta and Patil, 1967) [20]. The high levels of organic matter and hydrous oxides of Fe, Al, or Mn may indicate an appropriate level of available zinc in lateritic soils (Tandon, 1993) [29]. Similar values of micronutrients in mango orchards were also observed by Raghupathi and Bhargava (1997) [25], Pawar (2012) [23] and Mahajan (2001) [19].

Table 1: Physico-chemical properties and nutrient status of soils of Mango Research Sub-Centre, Rameshwar

Orchards	pH	EC (dS/m)	OC (g/kg)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
1	4.47	0.418	29.12	376.32	30.52	363.73
2	4.90	0.334	18.92	344.33	46.67	426.11
3	5.01	0.454	23.80	364.12	42.57	441.95
4	4.57	0.424	26.86	336.81	32.46	314.62
5	5.36	0.384	16.78	287.88	37.18	442.65
6	5.46	0.882	19.68	315.48	44.11	476.91
7	5.48	0.684	18.18	298.55	39.75	428.67
8	5.49	0.756	20.34	321.75	41.80	499.77
9	5.19	0.732	17.50	313.60	68.22	682.09
10	5.85	0.610	18.60	331.16	51.55	509.44
11	5.81	0.528	15.78	286.00	52.57	439.35
12	5.52	0.630	18.56	325.52	65.14	612.35
13	5.94	0.530	19.26	339.94	56.17	457.54
14	5.59	0.678	19.56	331.79	63.09	556.63
15	5.47	0.438	14.16	304.19	60.27	523.08
16	5.26	0.774	20.34	329.28	47.96	492.95
17	5.35	0.806	19.80	355.00	61.55	506.93
18	5.81	0.362	18.24	302.94	72.13	453.62

Table 2: Exchangeable Ca and Mg and DTPA extractable micronutrients in soils of Mango Research Sub-Centre, Rameshwar

Orchards	Ca	Mg	Fe	Mn	Zn	Cu
	(Cmol. (p^+) kg^{-1})		(mg/kg)			
1	3.62	1.68	41.14	38.95	4.05	3.28
2	6.44	3.32	44.67	48.02	3.16	5.78
3	6.86	3.36	64.10	54.70	4.00	7.54
4	2.92	0.74	53.69	31.54	1.59	2.68
5	6.76	2.86	56.95	37.37	4.11	6.59
6	6.82	3.80	50.54	46.06	2.15	7.06
7	6.04	3.08	38.06	34.31	3.37	5.81
8	7.24	3.72	37.30	42.62	3.29	4.89
9	8.76	4.28	53.05	46.53	2.84	5.78
10	7.26	3.10	28.69	38.03	4.90	6.78
11	6.84	2.40	32.59	42.52	4.32	7.20
12	8.64	3.60	31.91	38.44	1.71	4.26
13	7.32	3.24	29.28	49.78	3.84	5.25
14	7.24	3.82	28.11	63.27	4.72	5.68
15	6.12	2.54	35.21	34.79	4.08	5.62
16	6.66	3.90	41.12	57.16	2.84	6.53
17	6.94	3.22	35.25	59.83	4.00	5.81
18	6.34	2.88	37.41	33.88	4.39	6.31

Quality parameters of mango

Various quality parameters of mango (Table 3.) indicated that total sugar, reducing sugar and Non-reducing sugar ranged from 13.99 to 15.42 per cent with an average value of 14.71 per cent, 4.00 to 6.10 per cent with an average value of 5.05 per cent and 8.65 to 10.33 per cent with an average value of 9.49 per cent, respectively. Titratable acidity ranged from 0.22 to 0.37 per cent with an average value of 0.30 per cent. Total soluble solids ranged from 14.40 to 22.40 ^{0}Brix with an average value of 18.40 ^{0}Brix. Ascorbic acid and β-Carotene ranged from 31.42 to 53.35 mg $100g^{-1}$ with an average value of 42.39 mg $100g^{-1}$ and 1779 to 3440 µg $100g^{-1}$ with an average value of 2609.50 µg $100g^{-1}$, respectively.

Similar values were also observed by Thakare (2016) [31], Prabhudesai *et al*. (2019) [24], Jadhav *et al*. (2019) [15], Yadav *et al.* (2013) [34], Jha *et al.* (2010) [16] and Dutta *et al.* (2011) [13].

Table 3: Quality parameters of Mango

Orchards	Total Soluble Solids (^{0}Brix)	Titratable Acidity (%)	Ascorbic Acid (mg/100 g)	Reducing Sugar (%)	Non-reducing Sugar (%)	Total Sugar (%)	β-Carotene (µg $100g^{-1}$)
1	20.73	43.97	0.35	5.16	9.22	14.87	1103.00
2	20.67	44.87	0.37	6.10	8.65	15.20	2287.67
3	19.97	44.27	0.25	4.97	9.93	15.42	1866.67
4	17.90	41.62	0.29	5.73	8.63	14.82	2479.67
5	20.53	37.12	0.27	4.14	10.33	15.02	3440.33
6	15.83	39.13	0.31	4.86	9.24	14.58	3223.00
7	14.83	38.15	0.29	4.92	9.10	14.50	1361.67
8	22.40	53.35	0.25	4.74	10.12	15.40	3228.00
9	15.77	33.57	0.32	4.68	8.96	14.11	2291.00
10	19.33	31.42	0.26	5.17	8.98	14.62	1779.00
11	15.53	37.26	0.24	4.51	9.48	14.49	1391.67

12	18.67	39.12	0.27	4.11	9.64	14.25	1346.33
13	15.97	36.71	0.22	4.24	9.56	14.30	1750.67
14	15.37	37.14	0.30	4.00	9.49	13.99	1529.67
15	14.80	37.32	0.27	4.22	9.66	14.38	1422.67
16	15.40	37.02	0.26	4.74	9.36	14.59	1123.67
17	14.43	36.57	0.27	4.12	9.41	14.03	1566.00
18	17.53	32.26	0.30	4.18	9.49	14.17	2584.00

Correlation

A negative and significant correlation found in case of soil pH with titratable acidity (r=-0.589) and reducing sugar content (r=-0.625); exchangeable Ca with reducing sugar (r=-0.501); total soluble solid (r=-0.471), reducing sugar (r=-0.600) and total sugar (r=-0.750) with available P_2O_5. Organic carbon with reducing sugar (r=0.488) as well as DTPA extractable Fe with total sugar (r=0.539) and β-carotene (r=0.490) showed positive and significant correlation. (Table 4).

Table 4: Correlation between soil properties and quality parameters of mango

	TSS	Ascorbic Acid	Titratable acidity	Reducing sugar	Total sugar	Non reducing sugar	β- Carotene
pH	-0.353	-0.411	-0.589*	-0.625**	-0.455	0.344	0.008
EC	-0.420	-0.323	-0.195	-0.248	-0.327	-0.001	-0.026
Organic Carbon	0.393	0.176	0.284	0.488*	0.375	-0.252	-0.078
Available N	0.289	0.338	0.232	0.359	0.227	-0.230	-0.309
Available P_2O_5	-0.471*	-0.255	-0.119	-0.600**	-0.750**	0.041	-0.193
Exch. Ca	-0.150	-0.101	-0.306	-0.501*	-0.302	0.337	0.051
Exch. Mg	-0.146	0.042	-0.083	-0.336	-0.185	0.243	0.089
Fe	0.300	0.385	0.237	0.375	0.539*	0.040	0.490*
Mn	-0.261	0.291	-0.087	-0.202	-0.158	0.102	-0.224
Zn	-0.006	0.158	-0.180	-0.323	-0.092	0.308	-0.198
Cu	-0.215	0.046	-0.279	-0.227	0.008	0.288	0.119

Significant at 5%- *
Significant at 1%- **

Conclusion

The soils of Devgad were found to be acidic in nature and free of soluble salts with very high organic carbon, moderate to high in available nitrogen and phosphorous. Whereas available micronutrients were also found to be in high range category and low calcium and magnesium content. Soil properties exhibited the positive and negative relationship with quality parameters of mango thereby indicating the equilibrium between them.

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