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Fertility status of soils from north konkan zone of Maharashtra

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Abstract
An investigation entitled, "Fertility status of Soils from North Konkan Zone of Maharashtra'', was conducted to study the physico-chemical properties, available macro and micronutrients of the soil samples collected from North Konkan zone of Maharashtra state. A total of 100 soil samples were collected from 10 Research Stations and farmers fields nearby the research stations of Dr. B.S.K.K.V., Dapoli using G.P.S. and were analyzed for physico-chemical properties (pH, EC and OC), available macronutrients (Nitrogen, Phosphorous, Potassium, Calcium, Magnesium and Sulphur) and available micronutrients (Iron, Manganese, Zinc and Copper) status of the soil.
The data revealed that the 100 analysed soil samples were moderately acidic to alkaline in soil reaction with normal electrical conductivity and high organic carbon. Analysis of available macronutrients revealed low to medium available nitrogen and phosphorous, low to very high available potassium, medium to very high exchangeable calcium, low to very high exchangeable magnesium and medium to high available sulphur. Further, analysis of available micronutrients showed that all the soils samples had sufficient available iron, manganese, copper and zinc, with few exceptions.

Keywords: Physico-chemical properties, macronutrients, micronutrients, north konkan region

1. Introduction
Soil is the "Soul of infinite life" and is an interface of the organic and inorganic chemistry of the terrestrial world. It is a source as well as a sink to adsorb, desorb, fix or release mineral elements and gases and grow plants and decompose crop residues incorporated into it. It is a living factory where millions of tiny organisms are ceaselessly working day and night, transforming the organic matter and participating in carbon and nitrogen cycles and many mineral elemental cycles. To understand and rationalize the use and management of soil, the soil scientists, especially pedologists, have been developing methods of soil survey and classification of soils. Soil is a reservoir of nutrients and plays a pivotal role in supporting the growth of crops and other vegetation, maintaining the earth's environment clean. It also acts as a source and sink for atmospheric gases (Sharma and Dogra, 2011) [23].
Nutrients needed by the plant to complete its' life cycle is called 'essential nutrients' and depending upon the quantity required by the plant, nutrients are classified as macronutrients and micronutrients. Nitrogen, phosphorous and potassium are called as 'primary nutrients' and are not usually available in sufficient amounts and therefore are added through fertilization for the best growth of the plant. 'Soil fertility' is the status or the inherent capacity of the soil to supply nutrients to plants in adequate amounts and in suitable proportions. It plays a key role in increasing crop production in the soil. It comprises not only supply of nutrients but also their efficient management. The fertility status of soil indicates their nutrient supplying capability (Das, 2011) [10].
Therefore, it is necessary to maintain the fertility status of soil for sustainable crop production (Ajgaonkar and Patil, 2017) [1]. In order to sustain their productivity, it is very much necessary for their proper management, which calls for determination of the fertility status of the soils. Hence, the present research work entitled "Fertility status of Soils from North Konkan Zone of Maharashtra" was undertaken.

2. Material and Methods
From the North Konkan zone of Maharashtra 100 surface soil samples were collected from different research stations and nearby farmer's fields by using GPS. Soil was collected at a depth of 0-22.5 cm by following standard method of collection of soil samples. A total of eight soil samples (Code numbers 1 to 8 given to the eight soil samples along with research station

code) were collected from each of the eight Research Stations (Research Stations coded 1 to 10) and 2 soil samples from nearby farmer's fields of each of the eight Research Stations (Coded 9 and 10).

The pH of soil was determined using pH meter having combined electrode using 1: 2.5 soil: water suspension ratio (Jackson, 1967) [11]. Electrical conductivity of soil was determined with the help of Conductivity Meter-306 using 1: 2.5 soil: water suspension ratio (Jackson, 1973) [12]. Organic carbonwas determined by following Walkley and Black wet oxidation method, as described by Black, 1965.

Available Nitrogen was determined by Alkaline Permanganate (0.32 % $KMnO_4$) method Subbiah and Asija (1956). Available Phosphorous in acidic soils was extracted by Bray's 1 extractant while that from neutral to alkaline soils was extracted by Olsen's extractant as described by Jackson (1967) [11]. Available Potassium was determined by using neutral normal Ammonium Acetate as an extractant with Flame Photometer as described by Jackson (1973) [12].

The Exchangeable Ca^{++} and Mg^{++} were determined titrimetrically by using 0.01 N Ethylenediamine tetra-acetic acid (Versenate solution) as described by Kanwar and Chopra (1978) [14]. Available Sulphur was determined turbidimetrically using soil: extractant in 1:5 proportion using 0.15 per cent $CaCl_2$ as an extractant. Turbidity developed by Barium Chloride was measured spectrophotometrically at 420 nm wavelength (Chesnin and Yein, 1950) [9].

DTPA extractable Fe, Mn, Zn and Cu were extracted from the soil by Lindsay and Norvell (1978) [15] method. The extracted solution used for this purpose consisted of 0.005 M Diethylene Triamine Penta Acetic acid (DTPA), 0.01 M $CaCl_2$ and 0.1 M Tri Ethanol Amine (TEA) buffered at 7.3 pH. The concentration of the DTPA extractable Fe, Mn, Zn and Cu Micronutrients was determined by Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978) [15].

3. Results and Discussions

3.1 Physico-chemical properties of soil

The 100 soil samples collected from various Research Stations were analysed for their physico-chemical properties, ranges and means of the soil samples Research Station wise, is presented in Table 1 and discussed under the following subheads.

Table 1: Ranges and means of physico-chemical properties in soils of north konkan region

Sr. No.	Research Stations	pH	EC (dS m^{-1})	OC (g kg^{-1})
1.	R.A.R.S., Karjat Agronomy Block	7.02-7.75 (7.48)	0.23-1.20 (0.51)	6.9-14.5 (10.3)
2.	R.A.R.S., Karjat Model Expt. Block	6.56-7.77 (7.35)	0.22-0.55 (0.33)	7.2-12.6 (10.0)
3.	R.A.R.S., Karjat, Breeding Block	6.44-7.72 (7.32)	0.13-0.51 (0.26)	9.4-15.7 (12.2)
4.	C.O.A., Saralgaon	6.35-8.47 (7.43)	0.12-0.92 (0.42)	5.7-20.7 (12.9)
5.	K.L.R.S., Panvel	6.52-7.29 (6.85)	3.24-8.92 (5.97)	4.1-9.7 (5.8)
6.	A.R.S., Sriwardhan	7.10-8.34 (7.88)	0.30-0.47 (0.36)	5.1-9.6 (7.1)
7.	A.R.S., Repoli	6.08-7.26 (6.93)	0.21-0.96 (0.45)	5.6-13.5 (9.6)
8.	C.O.A., Achaloli	5.79-6.85 (6.17)	0.14-0.82 (0.40)	5.1-11.7 (8.0)
9.	Agril. School, Roha	5.85-6.84 (6.56)	0.12-0.67 (0.33)	4.9-12.3 (9.9)
10.	A.R.S., Palghar	7.32-8.23 (7.79)	0.33-0.84 (0.50)	7.6-17.5 (11.4)
Ranges and Means of 100 soil samples		5.79-8.47	0.12-8.92	4.1-20.7
		7.15	0.98	9.7

Note: Figures in the parantheses indicate mean

3.1.1 Soil reaction (pH)

The analytical data of the soil pH is given in Table 1. The pH of the 100 soil samples ranges from 5.79 to 8.47 with a mean value of 7.15. The lowest (5.79) pH was found in the soil sample (A-4) of C.O.A, Achaloli and the soil sample (SR-7) of C.O.A., Saralgaon had highest (8.47) pH. The lowest (6.17) mean of the soil pH was found in the soil samples of C.O.A, Achaloli and the soil samples of A.R.S., Sriwardhan had the highest (7.88) mean.

The data of the soil reaction ratings as suggested by Banger and Zende (1978) [4] is presented in the Table 2. Out of the analysed 100 soil samples, majority (54) of the soil samples were neutral (6.5-7.5), 19 samples were slightly alkaline (7.5-8.0), 12 samples were slightly acidic (6.0-6.5), 10 samples were moderately alkaline (8.0-9.0) and 5 samples were moderately acidic (5.0-6.0) as presented in Table 2.

The neutral to alkaline pH may be attributed to the reaction of applied fertilizer material with soil colloids, which resulted in the retention of basic cations on the exchangeable complex of the soil. The alkaline nature may be due to the presence of sodium salts and high calcium carbonate content of black soils and coastal saline soils (Sharma *et al*., 2008) [24].

Table 2: Soil Reaction (pH)

pH	Ratings	No. of samples
Extremely acidic	< 4.0	-
Strongly acidic	4.0-5.0	-
Moderately acidic	5.0-6.0	5
Slightly acidic	6.0-6.5	12
Neutral	6.5-7.5	54
Slightly alkaline	7.5-8.0	19
Moderately alkaline	8.0-9.0	10
Strongly alkaline	9.0-10	-
Extremely alkaline	> 10.0	-

3.1.2 Electrical conductivity (EC)

The analytical data of the soil electrical conductivity is given in Table 1. The electrical conductivity of the 100 soil samples varies from 0.12 to 8.92 dS m^{-1} with a mean value of 0.98 dS m^{-1}. The lowest (0.12 dS m^{-1}) electrical conductivity was found in the soil sample (RH-4) of Agril. School Roha and the soil sample (PN-9) of farmer's field nearby Khar land Research Station, Panvel had highest (8.92 dS m^{-1}) electrical conductivity. The lowest (0.26 dS m^{-1}) mean of the soil electrical conductivity was found in the soil samples of

R.A.R.S., Karjat, Breeding Block and the soil samples of K.L.R.S., Panvel had the highest (5.97 dS m^{-1}) mean.

The data of the soil electrical conductivity ratings as suggested by Jackson (1967) [11] and Richards (1954) is presented in the Table 3. Out of the analysed 100 soil samples, majority (83) samples had normal (<0.8 dS m^{-1}) electrical conductivity while the electrical conductivity of 10 samples were rated injurious to all crops (>2.5 dS m^{-1}). Only seven samples hadthe electrical conductivity of (0.8-1.6 dS m^{-1}) which is considered critical for salt sensitive crops.

The low EC could be due to heavy rainfall resulting in leaching of soluble salts. Similar are the findings of Chavan (1977) [7]. However, the high electrical conductivity in coastal saline soils might be due to the salinity developed due to ingress of sea water, close vicinity of the creek as well as poor drainage. Similar results have been reported by Chavan and Chavan (1987) [8], Joshi and Kadrekar (1987) [13] and (Borkar *et al.*, 2018) [6].

Table 3: Electrical conductivity (EC)

Sr. No	Ratings	EC (dS m^{-1})	No. of samples
1.	Normal	< 0.8	83
2.	Critical for salt sensitive crops	0.8-1.6	7
3.	Critical for salt tolerant crops	1.6-2.5	-
4.	Injurious to all crops	>2.5	10

3.1.3 Organic carbon

The analytical data of the soil organic carbon is given in Table 1. The organic carbon of the 100 soil samples ranges from 4.1 to 20.7 g kg^{-1} with a mean value of 9.7 g kg^{-1}. The lowest (4.1 g kg^{-1}) organic carbon was found in the soil samples (PN-7 and PN-10) of K.L.R.S., Panvel and the soil sample (SR-6) of C.O.A., Saralgaon had highest (20.7 g kg^{-1}) organic carbon. The lowest (5.8 g kg^{-1}) mean of the soil organic carbon was found in the soil samples of K.L.R.S., Panvel and the soil samples of C.O.A., Saralgaon had the highest (12.9 g kg^{-1}) mean (Table 2).

The data of the soilorganic carbonratings as suggested by Banger and Zende (1978) [4] is presented in the Table 4. Out of the analysed 100 soil samples, majority (43) samples had very high (>10 g kg^{-1}) organic carbon while the organic carbon of 26 samples was high (8.1-10 g kg^{-1}), 18 soil samples had moderately high (6.1-8.0 g kg^{-1}) organic carbon and Only 13 samples had medium (4.1-6.0 g kg^{-1}) organic carbon.

The analyzed soil samples had medium to very high organic carbon which might be due to deposition of marine and vegetable residues into the soil during their formation. (Joshi and Kadrekar, 1987) [13]. The medium to high organic carbon in the soils might be attributed to the incorporation of rice stubbles, roots weeds and dried leaves of trees in the soil. Besides it might be due to low mineralization rate of organic matter because of low temperature and humid climate of the region. Almost similar findings have been reported by Mohapatra and Kibe (1973) [12], Chavan (1977) [7], Taware (1983) [27], Patil (1986) [18] and Salvi (1988) [20].

Table 4: Organic carbon

Organic carbon (g kg^{-1})		No. of samples
Class	Range	
very low	<2.0	-
Low	2.1-4.0	-
Medium	4.1-6.0	13
Moderately High	6.1-8.0	18
High	8.1-10	26
Very High	>10	43

3.2 Status of available Macronutrients of the soil viz., N, P, K, Ca, Mg and S.

The soil samples collected from different Research Stations and nearby farmer's fields of North Konkan Zone of Maharashtra state were analysed for available macronutrients of the soils viz., N, P, K, Ca, Mg and S. The analytical data, ranges and means of available macronutrients is presented in Table 5.

3.2.1 Available Nitrogen

The analytical data of the soil available nitrogen is given in Table 5. The available nitrogen of the 100 soil samples analysed ranged from 141.10 to 352.48 kg ha^{-1}, with a mean value of 233.73 kg ha^{-1}. The lowest (141.10 kg ha^{-1}) available nitrogen was found in the soil sample (PN-6) of Khar Land Research Station, Panvel and the soil sample (PL-6) of A.R.S., Palghar had the highest (352.48 kg ha^{-1}) available nitrogen. The lowest (180.46 kg ha^{-1}) mean of the available nitrogenwas found in the soil samples of K.L.R.S., Panvel and the mean was highest (276.73 kg ha^{-1}) in the soil samples of A.R.S., Palghar.

The data of the rating for available nitrogen as suggested by Banger and Zende (1978) [4] is presented in the Table 6. Out of the 100 soil samples analysed, majority (84) belonged to low (141-280 kg ha^{-1}) class and only 16 soil samplesbelonged to medium (281-420 kg ha^{-1}) class. The data clearly reveals that the soils are low to medium in available nitrogen and therefore it is necessary to apply the nitrogenous fertilizers to all the soils during cultivation of any crop for optimizing the yield. The low availability of nitrogen might be due to slow mineralization rate of organic matter (Patil, 1986) [18].

Table 5: Means and Ranges of Macronutrients in soils of North Konkan region.

Sr. No.	Research Stations	N	P_2O_5	K_2O	Ca	Mg	S
		(kg ha^{-1})			(meq 100 g^{-1})		(mg kg^{-1})
1.	R.A.R.S., Karjat Agronomy Block	159.93-317.08 (261.19)	21.22-35.92 (29.19)	156.80-256 (200.68)	15.40-39 (24.71)	8.50-32 (14)	12.51-46.24 (23.64)
2.	R.A.R.S., Karjat Model Expt. Block	169.34-321.61 (239.72)	16.89-35.59 (26.93)	147.60-258 (194.49)	17.10-25.10 (21.72)	7.90-17.30 (10.70)	11.24-33.52 (19.63)
3.	R.A.R.S., Karjat, Breeding Block	159.93-329.28 (240.25)	16.16-31.88 (25.43)	115.20-258.60 (200.74)	16.30-25.10 (21.78)	7.70-30.10 (16.26)	12.68-32.08 (18.02)
4.	C.O.A., Saralgaon	153.66-326.08 (240.20)	20.98-36.29 (26.72)	114-321.60 (207.98)	12.80-36 (22.14)	7.90-45.50 (16.73)	10.62-19.28 (14.79)
5.	K.L.R.S., Panvel	141.10-219.28 (180.46)	25.58-45.77 (32.73)	1019.20-1882 (1394.38)	10-16.52 (12.27)	7.90-15 (12.14)	11.56-212.97 (120.55)
6.	A.R.S., Sriwardhan	156.75-235.25	21.77-38.76	658-1263	12.20-24	5.70-15.60	15.01-143.65

		(191.43)	(28.64)	(884.80)	(16.61)	(10.51)	(73.69)
7.	A.R.S., Repoli	186.80-297.56 (236.39)	17.74-28.47 (23.46)	126-310.40 (233.65)	19.90-33 (25.50)	6.20-23.60 (12.03)	16.96-83.13 (40.19)
8.	C.O.A., Achaloli	185.07-297.61 (240.60)	18.38-26.18 (21.30)	105.60-385.21 (192.32)	15.50-28.10 (20.14)	4.80-15.80 (11.82)	12.72-32.73 (23.84)
9.	Agrl. School, Roha	188.16-297.92 (228.59)	16.19-43.78 (35.33)	126.80-322.60 (221.20)	14.10-31.20 (21.11)	7.70-13.70 (9.89)	12.88-68.86 (38.61)
10.	A.R.S., Palghar	185.02-352.48 (276.73)	22.72-45.23 (30.58)	229.20-357.60 (297.91)	20.20-41 (29.54)	3.50-14.90 (9.90)	10.38-23.62 (15.77)
Ranges and Means of 100 soil Samples		141.10-352.48	16.16-45.77	105.60-1882.0	10.00-41.00	3.50-45.50	10.38-212.97
		233.73	28.03	402.82	21.55	12.40	39.83

Table 6: Available Nitrogen

Available N (kg ha^{-1})		No. of samples
Class	**Range**	
very low	<140	-
Low	141-280	84
Medium	281-420	16
Moderately High	421-560	-
High	561-700	-
Very High	>701	-

3.2.2 Available phosphorus

The analytical data of the available phosphorusis given in Table 5. The available Phosphorus of the 100 soil samples analysed ranged from 16.16 to 45.77 kg ha^{-1}, with a mean value of 28.03 kg ha^{-1}. The lowest (16.16 kg ha^{-1}) available phosphorus was found in medium black soil sample (KB-7) of R.A.R.S., Karjat Breeding Block and the coastal saline soil sample (PN-8) of Khar Land Research Station, Panvel had the highest (45.77 kg ha^{-1}) available phosphorus. The lowest (21.30 kg ha^{-1}) mean of the available phosphorus was found in the soil samples of C.O.A., Achaloli and the mean was highest (35.33 kg ha^{-1}) in the soil samples of Agril. School, Roha.

The data of the available phosphorus ratings as suggested by Banger and Zende (1978) [4] is presented in Table 7. Out of the 100 soil samples analysed, 69 belonged to low (16-30 kg ha^{-1}) class and 31 samples belonged to medium (31-50 kg ha^{-1}) class. The data clearly reveals that the soils under study are low to medium in available phosphorus, which could be attributed to the low pH of the soils. According to Shivanna and Nagendrappa (2014) [25] with the increase in pH, there is an increase in phosphorous due to lowering of activities of Fe^{3+} and Al^{3+} which increase the solubility of strangle and variscite and increase the electro-negativity of colloidal complex with a consequent decrease in sorption of phosphorous.

Table 7: Available Phosphorus

Available P_2O_5 (kg ha^{-1})		No. of samples
Class	**Range**	
very low	<15	-
Low	16-30	69
Medium	31-50	31
Moderately High	51-65	-
High	66-80	-
Very High	>80	-

3.2.3 Available potassium

The analytical data of the available potassium is given in Table 5. The available potassium of the 100 soil samples analysed ranged from 105.60 to 1882.0 kg ha^{-1}, with a mean value of 402.82 kg ha^{-1}. The lowest (105.60 kg ha^{-1}) available potassium was found in the soil sample (A-8) of medium black soil from C.O.A., Achaloli and the soil sample (PN-7) of coastal saline soil from Khar Land Research Station, Panvel had the highest (1882.0 kg ha^{-1}) available potassium. The lowest (192.32 kg ha^{-1}) mean of the available potassium was found in the soil samples of C.O.A., Achaloli and the mean was highest (1394.38 kg ha^{-1}) in the soil samples of K. L. R.S., Panvel.

The data of the ratings for available potassium as suggested by Banger and Zende (1978) [4] is presented in Table 8. Out of the 100 soil samples analysed, 29 samples belonged to very high (>360 kg ha^{-1}) class, 21 samples belonged to medium (181-240 kg ha^{-1}) class, 18 samples belonged to high (301-360 kg ha^{-1}) class, 18 samples belonged to moderately high (241-300 kg ha^{-1}) class and 14 soil samples belonged to low (121-180 kg ha^{-1}) class. The higher level of potassium associated with high salinity might be from the sea water as a major source of potassium (Joshi and Kadrekar, 1987 [13]. Sufficient quantity of potassium in the soils may be attributed to presence of higher quantity of potassium bearing minerals in the parent material (Salvi *et al.*, 2017) [21].

Table 8: Available Potassium

Available K_2O (kg ha^{-1})		No. of samples
Class	**Range**	
very low	<120	-
Low	121-180	14
Medium	181-240	21
Moderately High	241-300	18
High	301-360	18
Very High	>360	29

3.2.4 Exchangeable calcium

The analytical data of the exchangeable calcium is given in Table 5. The exchangeable calcium of the 100 soil samples analysed ranged from 10 to 41 meq 100 g^{-1} of soil, with a mean value of 21.55 meq 100 g^{-1}. The lowest (10 meq 100 g^{-1}) exchangeable calcium was found in the soil sample (PN-2) of coastal saline soil from Khar Land Research Station, Panvel and the soil sample (PL-1) of medium black soil from A.R.S., Palghar had the highest (41 meq 100 g^{-1}) exchangeable calcium. The lowest (12.27 meq 100 g^{-1}) mean of exchangeable calcium was found in the soil samples of K.L.R.S., Panvel and the mean was highest (29.54 meq 100 g^{-1}) in the soil samples of A.R.S., Palghar.

The data for the ratings of exchangeable calcium as suggested by Sankaram (1966) [22] is presented in Table 9. Out of the 100 soil samples analysed, 48 soil samples belonged to high (20-30 meq 100 g^{-1}), 43 soil samples belonged to medium (10-20 meq 100 g^{-1}) and only nine belonged to very high (>30 meq 100 g^{-1}) class.

Table 9: Exchangeable Calcium

Exchangeable Ca^{++} (meq 100 g^{-1})		No. of samples
Class	Range	
Low	<10	-
Medium	10-20	43
High	20-30	48
Very High	>30	9

3.2.5 Exchangeable magnesium

The analytical data of the exchangeable magnesium is given in Table 5. The exchangeable magnesium of the 100 soil samples analysed ranged from 3.50 to 45.50 meq 100 g^{-1} of soil, with a mean value of 12.40 meq 100 g^{-1}. The lowest (3.50 meq 100 g^{-1}) exchangeable magnesium was found in the soil sample (PL-1) of medium black soil from A.R.S., Palghar and the soil sample (SR-3) of medium black soil from C.O.A., Saralgaon had the highest (45.50 meq 100 g^{-1}) exchangeable magnesium. The lowest (9.89 meq 100 g^{-1}) mean of the exchangeable magnesium was found in the soil samples of Agril. School, Roha and the mean was highest (16.73 meq 100 g^{-1}) in the soil samples of C.O.A., Saralgaon.

The data of the ratings for exchangeable magnesium as suggested by Sankaram (1966) [22], is presented in the Table 10. Out of the 100 soil samples analysed, 46 belonged to high (10-15 meq 100 g^{-1}) class, 36 samples belonged to medium (5-10 meq 100 g^{-1}) class, 16 samples belonged to very high (>15 meq 100 g^{-1}) and only two samples belonged to low (<5 meq 100 g^{-1})class.

Table 10: Exchangeable magnesium

Exchangeable Mg^{++} (meq 100 g^{-1})		No. of samples
Class	Range	
Low	< 5	2
Medium	5-10	36
High	10-15	46
Very high	>15	16

3.2.6 Available sulphur

The analytical data of the available sulphur is given in Table 5. The available sulphur of the 100 soil samples analysed ranged from 10.38 to 212.97 mg kg^{-1} of soil, with a mean value of 39.83 mg kg^{-1}. The lowest (10.38 mg kg^{-1}) available sulphur was found in the soil sample (PL-7) of medium black soil from A.R.S., Palghar and the soil sample (PN-5) of coastal saline soil from Khar Land Research Station, Panvel had the highest (212.97 mg kg^{-1}) available sulphur. The lowest (14.79 mg kg^{-1}) mean of the available sulphur was found in the soil samples of C.O.A., Saralgaon and the mean was highest (120.55 mg kg^{-1}) in the soil samples of K.L.R.S., Panvel.

The data for the ratings of available sulphur as suggested by Pal (2013) [17], is presented in the Table 11. Out of the 100 soil samples analysed, 55 belonged to high (>20 mg kg^{-1}) class and 45 samplesbelonged to medium (10-20 mg kg^{-1}) class.

Table 11: Available Sulphur

Available S (mg kg^{-1})		No. of samples
Class	Range	
Low	< 10	-
Medium	10-20	45
High	>20	55

3.3 Status of available Micronutrients in the soil

The soil samples collected from different Research Stations and nearby farmer's fields of North Konkan zone of Maharashtra state were analysed for DTPA extractable micronutrients viz., Fe, Mn, Zn and Cu in the soil. The analytical data of available micronutrients, ranges and means of available micronutrients is presented in Table 12.

3.3.1 Available Iron (Fe)

The analytical data of the available iron is given in Table 12. The available iron of the 100 soil samples analysed ranged from 9.80 to 42.20 mg kg^{-1} of soil, with a mean value of 23.70 mg kg^{-1}. The lowest (9.80 mg kg^{-1}) available iron was found in the soil sample (PN-10) of coastal saline soil from farmer's field nearby Khar Land Research Station, Panvel and the soil sample (KB-6) of medium black soil from R.A.R.S., Karjat, Breeding Block had the highest (42.20 mg kg^{-1}) available iron. The lowest (12.75 mg kg^{-1}) mean of the available iron was found in the soil samples of Khar Land Research Station, Panvel and mean was highest (31.99 mg kg^{-1}) in the soil samples of Agril. School, Roha. Similar results have been reported by Andhalkar (1984) [2] and Anonymous (1988) [3].

Table 12: Ranges and Means of DTPA extractable Micronutrients in soils of North Konkan

Sr. No	Soil sample collection spot	Fe	Mn	Zn	Cu
		(mg kg^{-1})			
1.	R.A.R.S., Karjat Agronomy Block	21.09-33.42 (26.52)	29.21-72.31 (53.84)	0.30-1.80 (1.08)	2.30-5.10 (3.55)
2.	R.A.R.S., Karjat Model Expt. Block	14.05-41.06 (26.04)	39.80-77.81 (56.89)	0.38-3.40 (1.76)	3.84-9.24 (5.53)
3.	R.A.R.S., Karjat, Breeding Block	21.89-42.20 (30.18)	38.21-61.99 (53.60)	0.40-3.65 (1.50)	2.75-8.42 (4.80)
4.	C.O.A., Saralgaon	18.90-32.74 (23.77)	55.73-74.54 (65.10)	0.16-1.16 (0.72)	3.98-7.32 (5.19)
5.	K.L.R.S., Panvel	9.80-15.90 (12.75)	23.49-36.69 (29.27)	0.98-4.60 (2.29)	6.21-13.84 (9.39)
6.	A.R.S., Sriwardhan	11.10-20.93 (15.96)	23.43-34.66 (29.06)	0.62-4.52 (2.21)	5.21-10.06 (7.44)
7.	A.R.S., Repoli	17.40-31.20 (23.61)	28.65-77.24 (48.13)	0.22-2.48 (1.22)	7.98-13.15 (10.67)
8.	C.O.A., Achaloli	21.24-35.70 (28.94)	39.52-72.25 (57.35)	0.45-0.2.34 (1.57)	2.10-10.08 (4.80)
9.	Agrl. School, Roha	22.12-41.23 (31.99)	41.12-70.24 (58.72)	0.21-3.42 (1.00)	1.85-7.54 (4.42)
10.	A.R.S., Palghar	10.52-16.85	33.34-48.84	0.56-2.34	2.21-8.56

		(14.04)	(39.64)	(1.39)	(4.44)
Ranges and Means of 100 soil samples		9.80-42.20	23.43-77.81	0.16-4.60	1.85-13.84
		23.70	49.33	1.51	6.13

The data for the ratings of available iron as suggested by Lindsay and Norwell (1978) [15] is presented in the Table 13. All the 100 soil samples belonged to the sufficient (>5.6 mg kg^{-1}) class.

Table 13: Available iron

Available Fe (mg kg^{-1})		No. of samples
Class	**Range**	
Deficient	< 4.5	-
Marginal	4.5-5.6	-
Sufficient	>5.6	100

3.3.2 Available Manganese

The analytical data of the available manganese is given in Table 12. The available manganese of the 100 soil samples analysed ranged from 23.43 to 77.81 mg kg^{-1} of soil, with a mean value of 49.33 mg kg^{-1}. The lowest (23.43 mg kg^{-1}) available manganese was found in the soil sample (SW-9) of coastal saline soil from farmer's field nearby A.R.S., Sriwardhan and the soil sample (KM-10) of medium black soil from R.A.R.S., Karjat, Model Experimental Block had the highest (77.81 mg kg^{-1}) available manganese. The lowest (29.27 mg kg^{-1}) mean of the available manganese was found in the soil samples of Khar Land Research Station, Panvel and the mean was highest (65.10 mg kg^{-1}) in the soil samples of C.O.A., Saralgaon.

The data for the ratings of available manganese as suggested by Lindsay and Norwell (1978) [15] is presented in the Table 14. All the 100 soil samples analysed, belonged to the sufficient (>3.0 mg kg^{-1}) class.

Table 14: Available manganese

Available Mn (mg kg^{-1})		No. of samples
Class	**Range**	
Deficient	< 2.0	-
Marginal	2.0-3.0	-
Sufficient	>3.0	100

3.3.3 Available zinc

The analytical data of the availablezinc is given in Table 12. The available zinc of the 100 soil samples analysed ranged from 0.16 to 4.60 mg kg^{-1} of soil, with a mean value of 1.51 mg kg^{-1}. The lowest (0.16 mg kg^{-1}) available zinc was found in the soil sample (SR-4) of medium black soil from C.O.A., Saralgaon and the soil sample (PN-6) of coastal saline soil from Khar Land Research Station, Panvel had the highest (4.60 mg kg^{-1}) available zinc. The lowest (0.72 mg kg^{-1}) mean of the available zinc was found in the soil samples of C.O.A., Saralgaon and mean was highest (2.29 mg kg^{-1}) in the soil samples of Khar Land Research Station Panvel.

The data for the ratings of availablezinc as suggested by Lindsay and Norwell (1978) [15] is presented in Table 15. Out of the 100 soil samples analysed, 57 samples belonged to sufficient (>1.0 mg kg^{-1}) class, 23 samples belonged to marginal (0.6-1.0 mg kg^{-1}) class and only 20 samples were deficient (<0.6 mg kg^{-1}) in available zinc.

Table 15: Available Zinc

Available Zn (mg kg^{-1})		No. of samples
Class	**Range**	
Deficient	< 0.6	20
Marginal	0.6-1.0	23
Sufficient	>1.0	57

3.3.4 Available Copper

The analytical data of the available copper is given in Table 12. The available copper of the 100 soil samples analysed ranged from 1.85 to 13.84 mg kg^{-1} of soil, with a mean value of 6.13 mg kg^{-1}. The lowest (1.85 mg kg^{-1}) available copper was found in the soil sample (RH-5) of medium black soil from Agril. School, Roha and the soil sample (PN-8) of coastal saline soil from Khar Land Research Station, Panvel had the highest (13.84 mg kg^{-1}) available copper. The lowest (3.55 mg kg^{-1}) mean of the available copper was found in the soil samples of R.A.R.S., Karjat Agronomy Block and mean was highest (10.67 mg kg^{-1}) in the soil samples of A.R.S., Repoli.

The data for the ratings of availablecopper as suggested by Lindsay and Norwell (1978) [15] is presented in the Table 16. All the 100 soil samples analysed, belonged to the sufficient (>0.6 mg kg^{-1}) class.

Table 16: Available Copper

Available Cu (mg kg^{-1})		No. of samples
Class	**Range**	
Deficient	< 0.2	-
Marginal	0.2-0.6	-
Sufficient	>0.6	100

4. Conclusion

From the present investigation, it can be concluded that the soil from North Konkan Zone of Maharashtra State were moderately acidic to alkaline in soil reaction with normal electrical conductivity and high organic carbon. Analysis of available macronutrients revealed low to medium available nitrogen and phosphorous, low to very high available potassium, medium to very high exchangeable calcium, low to very high exchangeable magnesium and medium to high available sulphur. Further, analysis of available micronutrients showed that all the soils samples had sufficient available iron, manganese, copper and zinc, with few exceptions.

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