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Full Research Article

Nutrients Status of Cultivated Soils of Ganga Canal Area of Meerut District of Uttar Pradesh

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Abstract

Incidence of nutrient deficiency in soils and plants has been reported worldwide including India. The present study was conducted to characterize their chemical properties and accordingly to develop optimum land use plan to realize maximum agricultural productivity. The surface (0–15 cm) and sub-surface (15–30) soil samples were collected from cultivated soils representing the six location of Meerut district namely, Kaili (Sakoti), Milak (Sardhana), Nanu (SP), Pooth (Rohata), Bhola (Jhal) and Jani, Meerut, Uttar Pradesh, India, respectively. The status of available macro, micro nutrient in soils and other soil properties like pH, electrical conductivity (EC) and organic carbon (OC) content were assessed. Results revealed that the soil of study area were neutral to strongly alkaline in reaction and non-saline in nature. Nutrient status regarding to the available macro and micro nutrient in surface (0–15 cm) and subsurface (15–30 cm) depth of soil indicate that soils are low in available N and medium in available P and K in surface and subsurface soil and in general sufficient in available Zn, Cu, Fe and Mn in the surface and subsurface layer of the soil. The Nutrient Index (NI) values were low for available nitrogen (1.16) and medium with respect to phosphorus (2.34) and potassium (1.91). in the soils of study area. A positive and significant correlation of NPK and micronutrients was found with organic matter content while significant and negative correlations exist between micronutrients and soil pH.

1. Introduction

Soil is the most important natural resources which need to be properly and scientifically utilized for improving the productivity and economic condition of the rural area. The National Commission on Agriculture recommended that land use policy should be such that land is utilized in accordance with the ecology, capability and the need of the land in different region and area. This is especially true for coarse texture soil area where irrigation facilities are meager. Macronutrients (N, P, K) and micronutrient (Zn, Fe, Cu, Mn) are important soil elements that control its fertility. Soil fertility is one of the important factors controlling yield of the crops. Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agriculture production. Because of imbalance and inadequate fertilizer use coupled with low efficiency of their inputs, the response (Production) efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years Meena et al. (2006). The results of numerous field experiments in different part of India have, therefore indicate "fertilizer–induced sustainability of crop productivity" (Yadav, 2003). Variation in nutrient supply is a natural phenomenon and some of them may be sufficient where other deficient.

The stagnation in crop productivity cannot be boosted without judicious use of macro and micronutrients fertilizers to overcome existing deficiencies/imbalances. A widespread macro-and micronutrient deficiency has been observed in the soils of Rajasthan, especially zinc (46%) and iron (51.5%) (Sharma et al., 2003). Deficiencies of many plant nutrients are emerging fastly in intensively cultivated sandy alkaline soils of Haryana (Narwal, 2006). Since the quality of produce is significantly influenced by the nutrient supplying capacity of soils coincidently with time, crops and their economic product become significantly suboptimal. Therefore to have sound information about the nutrient status of these soils this study was undertaken.

2. Materials and Methods

2.1. Description of the study sites

The study area falls in Meerut district of western Uttar Pradesh and Ganga canal was considered as base line of the study area. In the left side hand (LHS) of Ganga canal from Kaili (Sakoti) to Jani was taken as the study area. Each bridge on the canal between these two end points (Kaili Sakoti to Jani) was selected for sampling location. Samples were taken from the distance of 1000, 2000, 3000, 4000, and 5000 meter away from canal.

2.2. Sampling and analyses

Soil samples from two depths (0–15 and 15–30 cm) from six locations of Meerut district under different cropping pattern were collected with the help of auger and stored in polythene bags. Collected soil samples were air dried in shade, crushed gently with a wooden roller and then pass through 2.0 mm sieve to obtain a uniform representative sample. Samples were properly labeled with the aluminum tag and stored in polythene bags for analysis. The processed soil samples were analyzed by standard methods for pH and electrical conductivity (1:2 soil water suspensions), organic matter (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1956), available phosphorus, available potassium (Jackson, 1973) and cationic micronutrients (Fe, Mn, Cu and Zn) in soil samples extracted with a Diethylene triamine pentaacetate (DTPA) solution (0.005 M) DTPA+0.01 M $CaCl_2$+0.1 Mtriethanolamine, pH 7.3 as outlined by Lindsay and Norvell (1978). The nutrient index (NI) values for available nutrients were calculated using the formula suggested by Parker et al., (1951). The concentration of micronutrients was determined by atomic absorption spectrophotometer (GBC Avanta PM). All the analysis of soil samples was carried out in the laboratory of Department of Soil Science, SVPUA & Tech, Modipuram, Meerut (U.P), India.

3. Results and Discussion

3.1. General soil properties

Data regarding the soil chemical properties of surface and subsurface presented in (Table 1). The soil samples of surface and subsurface were usually found normal to alkaline reaction and it varied from 6.15 to 8.49 and 7.12 to 8.92, respectively (Table 1). Similar finding was observed by Rajeswar et al., (2009). The minimum pH 6.15 at surface was observed in Bhola Jhal location, while maximum pH 8.49 was observed in

Table 1: Chemical properties in soils of along with Ganga canal of Meerut district of Uttar Pradesh

Location	D*(m) from Ganga canal	Depth (cm)	EC (dS m^{-1})	pH	OC (g kg^{-1})
Kaili (Sakoti)	1000	0–15	1.07	7.31	13.45
		15–30	0.43	7.45	9.90
	2000	0–15	0.79	7.57	11.38
		15–30	0.41	7.85	7.24
	3000	0–15	0.75	7.25	13.15
		15–30	0.31	7.30	8.13
	4000	0–15	0.79	7.40	8.87
		15–30	0.62	7.52	6.06
	5000	0–15	0.89	7.80	11.53
		15–30	0.39	7.76	7.54
Milak (Sardh-ana)	1000	0–15	1.59	7.85	9.02
		15–30	0.67	7.95	6.65
	2000	0–15	1.03	7.40	10.20
		15–30	0.62	7.83	6.65
	3000	0–15	0.21	7.75	8.42
		15–30	0.35	7.88	5.32
	4000	0–15	0.38	7.51	11.97
		15–30	0.21	7.76	7.83
	5000	0–15	0.49	7.74	11.23
		15–30	0.25	7.97	7.24
Nanu (SP)	1000	0–15	0.46	7.61	10.79
		15–30	0.47	8.44	5.62
	2000	0–15	0.46	7.31	10.20
		15–30	0.21	7.57	7.54
	3000	0–15	0.34	7.60	11.38
		15–30	0.20	7.80	7.83
	4000	0–15	0.34	7.67	7.54
		15–30	0.15	7.85	5.32
	5000	0–15	0.26	7.74	8.28
		15–30	0.25	8.05	5.76
Pooth (Rohata)	1000	0–15	0.28	7.12	9.75
		15–30	0.21	7.80	6.06
	2000	0–15	0.25	7.64	7.54
		15–30	0.18	7.70	4.29
	3000	0–15	0.42	7.34	10.20
		15–30	0.43	8.28	6.21
	4000	0–15	4.90	7.10	9.31
		15–30	0.22	7.60	5.32
	5000	0–15	0.33	7.66	7.83
		15–30	0.13	8.46	3.55

Continue...

Location	D*(m) from Ganga canal	Depth (cm)	EC (dS m^{-1})	pH	OC (g kg^{-1})
Bhola (Jhal)	1000	0–15	0.11	6.15	11.08
		15–30	0.44	7.12	6.95
	2000	0–15	0.91	6.83	9.02
		15–30	0.37	7.45	4.88
	3000	0–15	0.66	7.60	12.27
		15–30	0.81	7.75	5.62
	4000	0–15	1.77	7.78	9.16
		15–30	0.94	8.30	5.91
	5000	0–15	0.88	8.05	8.28
		15–30	0.66	8.45	6.95
Jani	1000	0–15	1.10	8.07	7.09
		15–30	0.89	8.20	4.43
	2000	0–15	1.10	8.22	6.95
		15–30	0.54	8.92	4.14
	3000	0–15	0.57	7.70	9.02
		15–30	0.73	8.13	5.76
	4000	0–15	0.74	8.49	9.46
		15–30	0.74	8.50	6.06
	5000	0–15	1.04	8.17	6.50
		15–30	0.63	8.48	3.40

*D: Distance

Jani location. Similarly in subsurface, minimum pH 7.12l and maximum pH 8.92 was observed at both the same locations. This may be due to the influence by parent material, rainfall and topography (Thangaswamy et al., 2005). The organic carbon in surface and subsurface varied from 6.502 to 13.448 and 3.399 to 9.901 g kg^{-1}. The highest value of organic carbon content 13.448 and 9.901 g kg^{-1} soil at surface and subsurface was found in Kaili Sakoti, while lowest 6.502 and 3.399 g kg^{-1} soil in Jani location. Higher content of organic carbon at surface soil could be attributed to additions of FYM and plant residues and crop management to surface horizon. Similar result was reported by Rajeswar et al. (2009) and Leelavathi et al. (2009). The electrical conductivity of surface and subsurface soil varied from 0.109 to 1.59 dS m^{-1} and 0.150 to 0.939 dS m^{-1}, respectively. On the basis of the limits suggested by Muhar et al., (1963) for judging salt problem of soils, most of the samples (88.33%) were found normal (EC<1.0 dS m^{-1}) and remaining 11.67% samples were found in the category of soluble salt content critical for germination (EC 1 to 2 dS m^{-1}). Sangwan and Singh (1993) also noticed the similar trend.

3.2. Available macronutrient

3.2.1. Available nitrogen

The available nitrogen content in surface (0–15 cm) and subsurface (15–30 cm) soils varied from 158.38 to 430.85 kg ha^{-1} and 131.53 to 284.55 kg ha^{-1}, respectively (Table 2). The maximum available nitrogen 430.85 and 284.55 kg ha^{-1} was found in Kaili Sakoti and minimum 158.38 and 131.53 kg ha^{-1} Jani location at surface and subsurface. On the basis of the rating suggested by Subbiah and Asija (1956) 80% samples were low (<250 N kg ha^{-1}) and 20% samples were medium (250–500 N kg ha^{-1}) for available nitrogen. However, available nitrogen content was found to be maximum in

Table 2: Macronutrient in soils of study area along with Ganga canal of Meerut district of Uttar Pradesh

Location	D*(m) from Ganga canal	Depth (cm)	Available macro-nutrient kg ha^{-1}		
			N	P	K
Kaili (Sakoti)	1000	0–15	431	35.0	204
		15–30	285	21.5	143
	2000	0–15	370	23.3	90
		15–30	274	19.7	73
	3000	0–15	411	34.1	189
		15–30	225	20.2	119
	4000	0–15	274	17.6	85
		15–30	170	11.6	68
	5000	0–15	379	33.2	111
		15–30	204	19.3	76
Milak (Sardhana)	1000	0–15	228	31.9	118
		15–30	181	20.6	90
	2000	0–15	231	33.2	169
		15–30	188	22.1	139
	3000	0–15	220	24.7	159
		15–30	164	19.7	129
	4000	0–15	258	40.9	580
		15–30	220	26.0	515
	5000	0–15	236	34.6	847
		15–30	196	22.4	745
Nanu (SP)	1000	0–15	285	35.2	287
		15–30	176	17.6	221
	2000	0–15	260	33.5	260
		15–30	166	15.2	184
	3000	0–15	293	38.5	618
		15–30	212	27.0	534
	4000	0–15	223	23.8	162
		15–30	153	12.7	129
	5000	0–15	263	26.6	209
		15–30	174	12.3	153

Continue...

Location	D*(m) from Ganga canal	Depth (cm)	Available macro-nutrient kg ha^{-1}		
			N	P	K
Pooth (Rohata)	1000	0–15	234	34.8	405
		15–30	215	27.4	208
	2000	0–15	204	12.7	202
		15–30	199	8.6	156
	3000	0–15	244	38.0	996
		15–30	223	33.1	514
	4000	0–15	220	29.9	340
		15–30	217	18.8	187
	5000	0–15	217	18.4	213
		15–30	200	11.9	156
Bhola (Jhal)	1000	0–15	231	29.1	400
		15–30	177	24.6	226
	2000	0–15	215	18.0	150
		15–30	156	16.8	140
	3000	0–15	244	31.1	484
		15–30	193	25.4	287
	4000	0–15	217	28.2	225
		15–30	172	20.2	174
	5000	0–15	199	16.0	214
		15–30	153	6.6	156
Jani	1000	0–15	183	25.0	319
		15–30	154	11.1	212
	2000	0–15	177	23.7	177
		15–30	137	10.7	124
	3000	0–15	234	26.2	482
		15–30	153	12.7	246
	4000	0–15	239	30.3	528
		15–30	188	14.3	267
	5000	0–15	158	14.3	130
		15–30	132	9.0	111

*D: Distance

surface horizons and decrease regularly with soil depth, which might possible be due to the accumulation of plant residues, debris. These observations are in accordance with the findings of Prasuna Rani et al. (1992). Correlation studies shows that significant positive correlation (r=+0.843) was found between organic carbon and available nitrogen. This might be because most of the soil nitrogen found in organic forms. Similar results were also reported Kanthalia & Bhatt (1991); Paliwal (1996).

3.2.2. Available phosphorus

The available phosphorus content in the surface (0–15 cm) and subsurface (15–30 cm) varied from 12.708 to 40.899 and 6.579 to 27.418 P_2O_5 kg ha^{-1}, respectively (Table 2). The maximum available phosphorus 40.899 P_2O_5 kg ha^{-1} was found in Milak Sardhana location and minimum 12.708 P_2O_5 kg ha^{-1} in Pooth Rohata at surface (0–15 cm) , whereas, at subsurface (15–30 cm) maximum 27.418 P_2O_5 kg ha^{-1} was found in Pooth Rohata location and minimum 6.579 P_2O_5 kg ha^{-1} in Bhola Jhal location. The range is quite large which might be due to variation of soil properties viz., pH, calcareousness, organic matter content, texture and various soil management and agronomic practices. On the basis of limit suggested by muhr et al., (1968) 40% samples were rated low (<20 P_2O_5 kg ha^{-1}), and 60% samples were medium (20–50 P_2O_5 kg ha^{-1}). However, the highest available phosphorus was observed in the surface horizons and decreased regularly with depth. Higher phosphorus in the surface horizons might be due to the confinement of crop cultivation to this layer and supplement of the depleted phosphorus through external source i.e. fertilizers (Rajeswar et al., 2009). Similar results were reported by Thangaswamy et al. (2005).

3.2.3. Available potassium

Available potassium status of surface (0–15 cm) and subsurface (15–30 cm) ranged between 85.12 to 995.68 and 68.32 to 744.80 K_2O kg ha^{-1} (Table 2). The maximum available potassium 995.68 K_2O kg ha^{-1} was found at Pooth Rohata and minimum 85.12 K_2O kg ha^{-1} in Kaili Sakoti location at surface (0–15 cm). Similarly maximum available potassium 744.80 K_2O kg ha^{-1} was found in Milak Sardhana and minimum 68.32 K_2O kg ha^{-1} Kaili Sakoti location at subsurface (15–30 cm). The use of K fertilizers in the valley were low in contrast to its removal from soils by crops, leading to a lower K content in cultivated soils (agriculture land use). In grass lands, wastes land and forest soils, probably loss K removal by plants, maintained a comparatively higher K in soils (Choudhary Ram 2005). According to muhr et al. (1963) 18.33% samples were found in low range (<125 K_2O kg ha^{-1}), 55% medium (125–300 K_2O kg ha^{-1}) and 26.67% samples were high (>300 K_2O kg ha^{-1}) of potassium content at surface (0–15 cm) and Subsurface (15–30 cm). A significant positive correlation (r=+0.365) was observed between organic carbon and available potassium content. This might be due to creation of favorable soil environment with presence of high organic matter. Similar results were also reported by Paliwal (1996); Chouhan (2001).

3.3. Nutrients index

Considering the concept of "soil nutrient index" suggested by Parker et al., (1951), the soils of study area were also

Table 3: Nutrient index and fertility status class of study area soils

Sl. no.	NON*	Percent sample			NI**		FSC***
		L#	M##	H###	O$	P$$	
1.	Nitrogen	93.33	6.67	nil	1.06	<1.5	Low
2.	Phosphorus	6.11	48.88	45.00	2.34	1.5–2.5	Medium
3.	Potassium	18.88	69.44	11.66	1.91	1.5–2.5	Medium

Low (<1.5), Medium (1.5-2.5) and High (>2.5); *NON: Name of Nutrient; **NI: Nutrient Index; ***FSC: Fertility status class; #L: Low; ##M: Medium; ###H: high; $O: Observed; $$P: Proposed

classified. The Nutrient Index Values (Table 3) were low for available N (1.06), Medium for available phosphorus (2.34) and Potassium (1.91) in the soils of study area. These are close agreement with those reported by Marsonia et al. (2008) for Porbandar and Rajput and Polara (2012) for Bhavnagar district.

3.4. Cationic micronutrient

3.4.1. Available zinc

DTPA-extractable available Zn in the soil at various depth viz., 0–15 and 15–30 cm of six different locations was found to be sufficient.. DTPA-extractable Zn (mg kg^{-1} soil) in surface (0–15 cm) and subsurface (15–30 cm) varied from 0.656 to 3.61 and 0.220 to 2.013 mg kg^{-1} soil, respectively (Table 4). The maximum available Zn 3.61 mg kg^{-1} soil was found in Jani and minimum 0.656 mg kg^{-1} soil in Pooth Rohata locations at surface (0–15 cm) soils. In case of subsurface soils (15–30 cm) maximum DTPA-extractable Zn 2.013 mg kg^{-1} soil was found in Pooth Rohata location and minimum 0.220 mg kg^{-1} soil was found in Nanu (SP) location. Similar results were reported by Leelavathi et al. (2009). The DTPA extractable Zn ranged from 0.86 to 1.30 mg kg^{-1} soil in surface and 0.20 to 1.21 mg kg^{-1} soil in sub-surface horizons. The vertical distribution of Zn exhibited little variation with depth. Relatively high content of available Zn in surface horizons may be attributed to more complexing with organic carbon which resulted in chelating of Zn. Similar views were also expressed by Vankatesu et al., (2002); Rao et al. (2008) in soils of Nellore district, Andhra Pradesh. Considering 0.6 mg kg^{-1} as critical levels proposed by Lindsay and Norvell (1978), all the soil samples were sufficient in available Zn content.

3.4.2. Available copper

DTAP-extractable available Cu in soil at the various depth viz., 0–15 cm and 15–30 cm of six different locations was found to be sufficient. The data presented in Table 4 indicated that the DTPA-extractable (Cu mg kg^{-1} soil) in surface (0–15 cm) and subsurface (15–30 cm) soils varied from 0.952 to 4.86 and 0.482 to 3.11 mg kg^{-1} soil, respectively. The maximum available Cu 4.86 mg kg^{-1} soil was found in Kaili Sakoti location and minimum 0.952 mg kg^{-1} soil in Milak Sardhana location at surface (0–15 cm) soil. While subsurface soil (15–30 cm) maximum and minimum available Cu 3.11 to 0.48 mg kg^{-1} soil was found in Milak Sardhana location. A decreasing

Table 4: Micronutrient status in soils of study area along with Ganga canal of Meerut district of Uttar Pradesh

Location	D*(m) from Ganga canal	Depth (cm)	Available micro-nutrient Mg ha^{-1}			
			Zn	Cu	Fe	Mn
Kaili (Sakoti)	1000	0–15	1.86	4.16	69.30	39.24
		15–30	1.27	2.31	51.56	30.41
	2000	0–15	1.00	3.74	56.50	30.52
		15–30	0.52	2.28	30.52	20.47
	3000	0–15	1.97	4.86	65.90	39.02
		15–30	1.35	2.85	44.22	22.82
	4000	0–15	1.06	1.94	20.58	19.42
		15–30	0.37	1.24	17.14	13.11
	5000	0–15	1.16	1.90	64.90	29.05
		15–30	0.76	0.85	33.56	18.84
Milak (Sardhana)	1000	0–15	1.08	1.25	15.77	16.24
		15–30	0.41	0.69	10.68	11.94
	2000	0–15	1.37	1.67	16.24	16.94
		15–30	0.52	1.25	13.43	12.42
	3000	0–15	0.79	0.95	14.07	24.51
		15–30	0.36	0.48	8.50	18.51
	4000	0–15	1.77	1.84	37.50	10.44
		15–30	0.76	1.35	24.64	7.24
	5000	0–15	1.19	4.56	18.62	12.42
		15–30	0.46	3.11	14.63	10.44
Nanu (SP)	1000	0–15	2.16	2.75	40.24	18.93
		15–30	0.98	1.97	17.84	13.64
	2000	0–15	1.31	2.27	20.87	28.62
		15–30	0.54	1.63	17.26	24.59
	3000	0–15	3.03	2.94	49.11	27.04
		15–30	1.25	2.22	18.45	20.18
	4000	0–15	0.42	1.78	12.97	19.29
		15–30	0.22	1.36	8.80	17.41
	5000	0–15	1.30	2.28	17.40	17.49
		15–30	0.41	1.93	9.06	11.97

Continue...

Location	D*(m) from Ganga canal	Depth (cm)	Available Micro nutrient Mg ha^{-1}			
			Zn	Cu	Fe	Mn
Pooth (Rohata)	1000	0–15	1.72	1.92	20.96	23.11
		15–30	0.90	1.29	14.05	17.09
	2000	0–15	0.66	1.31	12.80	14.85
		15–30	0.52	1.21	8.64	11.69
	3000	0–15	2.10	2.24	81.82	24.38
		15–30	1.31	1.89	43.62	20.51
	4000	0–15	1.52	1.51	19.83	23.46
		15–30	0.82	1.28	13.02	18.11
	5000	0–15	1.44	1.43	17.92	20.15
		15–30	0.79	0.62	12.39	12.43
Bhola (Jhal)	1000	0–15	1.66	1.90	34.41	72.47
		15–30	0.90	1.73	26.93	44.31
	2000	0–15	1.22	1.70	19.28	44.99
		15–30	0.61	1.54	12.80	30.56
	3000	0–15	1.77	2.45	50.79	90.82
		15–30	1.20	2.16	41.91	51.44
	4000	0–15	1.51	1.64	23.05	61.05
		15–30	0.86	1.31	15.52	38.65
	5000	0–15	0.89	1.46	12.21	17.26
		15–30	0.46	0.94	11.46	13.12
Jani	1000	0–15	1.55	2.04	18.68	32.50
		15–30	0.88	1.08	14.03	27.77
	2000	0–15	1.03	2.30	18.21	24.95
		15–30	0.78	1.00	12.16	19.15
	3000	0–15	1.74	2.79	20.65	32.26
		15–30	1.29	1.33	14.65	23.16
	4000	0–15	3.61	4.07	22.90	52.51
		15–30	2.01	1.71	17.37	32.28
	5000	0–15	0.98	1.56	17.59	20.43
		15–30	0.57	0.96	11.12	16.00

*D: Distance

trend in available Cu content with depth was noticed in all six different locations. Similar results were observed by Rajeshwar et al., (2009). A decreasing trend with depth was noticed in all the pedons except in 2, 7 and 8 which showed irregular trend with depth. An increasing trend with depth was noticed in pedon 6. The availability of Cu content was more in surface layer and decreasing with depth, which might be due to its association with organic carbon. All the soil samples of six different locations were found to be sufficient in available Cu by considering the critical limit 0.20 mg kg^{-1} soil as suggested by Lindsay and Norvell (1978). A positive and significantly correlation between Cu and organic carbon (r=+0.670) indicates that the organic matter increased the availability of soil Cu. This has also been reported by several other workers (Sakal et al., 1988; Singh and Chaudhari, 1990; Katyal & Sharma, 1991; Dhane and Shukla, 1995).

3.4.3. *Available iron*

The DTPA-extractable available Fe in soil at surface (0–15 cm) and subsurface (15–30 cm) of six different locations was in high (Table 4). The data revealed that the DTPA-extractable Fe in surface (0–15 cm) as well as subsurface (15–cm) varied from 12.97 to 81.82 ad 8.50 to 51.56 mg kg^{-1} soil, respectively. The highest available Fe content 81.82 mg kg^{-1} soil was found in Pooth Rohata location and lowest 12.97 mg kg^{-1} soil in Nanu (SP) location at surface (0–15 cm) soil, while maximum 51.56 mg kg^{-1} soil in kaili Sakoti location and minimum 8.50 mg kg^{-1} soil Milak Sardhana location at subsurface (15–30 cm) soil. According to the critical limit 4.5 mg kg^{-1} soil as proposed by Lindsay and Norvell (1978) all the soil samples (surface and subsurface) were sufficient in available Fe. The amount of available Fe decreased with increasing soil depth. A decreasing trend with depth was noticed in the 2, 3, 5, 6, 7 and 9 pedons. It might be due to accumulation of humic materials in the surface layer besides prevalence of reduced condition in the subsurface layers. The findings are agreement with the findings of Prasad and Sakal (1991). The correlation coefficient ® values between available Fe and soil characteristics indicated a positive and significant relationship between available Fe and organic carbon (r=+0.680). The increases availability of the DTPA Fe with increase in organic matter content was also reported by Dhane and Shukal (1995).

3.4.4. *Available Mn*

The data presented in Table 4 revealed that the DTPA-extractable available Mn in soil at various depth viz., 0–15 cm and 15–30 cm in six different locations was sufficient to high because these value are well above the critical limit (1.0 mg kg^{-1} soil). The maximum and minimum extractable Mn in surface (0–15 cm) and subsurface (15–30 cm) varied from 10.38 to 90.82 and 7.24 to 51.44 mg kg^{-1} soil, respectively. The maximum available Mn content 90.82 to 51.44 mg kg^{-1} soil was found in Bhola Jhal same location of surface and subsurface soils. and minimum 10.43 to 7.24 mg kg^{-1} soil was found in Milak Sardhana same location of surface and subsurface soils. Almost similar range of available Mn has been reported for medium black and deep black soils of Marathwada and by Katyal and Sharma (1991). It was high in the surface horizons and gradually decreased with depth 2 and 5 pedons; and increasing trend with depth was noticed in pedons 3 and 9. Rest of the pedons showed in irregular trend with depth, which might be due to its presence in the reduced forms in the surface soils. These observations are in agreement with the finding of and Nayak et al. (2000).

3.5. *Relationship of pH and OC with soil properties*

Relationships of pH and Organic carbon with some soil properties like Available N, P, K and DTPA extractable micronutrient (Zn, Cu, Fe and Mn) were established by determination of correlation coefficient values (Table 5). The analysis indicates that pH was negatively correlated with Available N, P, K and DTPA extractable micronutrient Zn, Cu, Fe and Mn (r=-0.424, -0.439, -0.115, -0.236, -0.364 and -0.331) similar results were observed by Tisdale et al., 1997, Similar results were also noticed by Singh 1988 in the soils of Udaipur. OC significantly and positively correlated with the above discussed soil properties (r=0.808, 0.781, 0.365, 0.670, 0.680 and 0.381, respectively. Katyal and Sharma, 1991 reported a highly significant correlation coefficient between DTPA extractable Zn and organic carbon content in soil. A higher organic carbon content in soil results in a higher production of complexing agents which promote better extractability of Zn. Whereas, Ghosh et al. (2009) observed negative and significant relation of DTPA-Zn with soil pH. Similar relation was also observed by several workers (Sakal et al., 1988; Chatterji et al., 1999; Sharma et al., 2003).

Table 5: Correlation studies between OM and pH with available N, P, K, Cu, Fe, Mn and Zn under different locations

	Av. N	Av. P	Av. K	Zn	Cu	Fe	Mn
pH	-0.42	-0.43	-0.11	-0.17	-0.23	-0.36	-0.3
	411	882	486	324	754	384	312
OM	0.807	0.781	0.365	0.607	0.67	0.68	0.38
	981	321	119	699	0153	0708	131

*Significant at (p=0.05)

4. Conclusion

Physico-chemical characteristics and nutrient status of soil indicates that soil of study area were neutral to strongly alkaline in reaction and non-saline in nature. Nutrient status for macro and micro nutrient in surface and subsurface depth of soil indicate that soils are low in available N and medium in available P and available K in surface and subsurface soil and in general sufficient in available Zn, Cu, Fe and Mn in the surface and subsurface layer of the profiles.

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