



Research Article

STATUS OF AVAILABLE PHOSPHORUS, POTASSIUM AND MICRONUTRIENTS AND THEIR CO-RELATIONS IN SURFACE SOILS OF UNDULATING TERRAIN OF DANGS DISTRICT, GUJARAT

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Abstract- Thirty (30), twenty (20) and twenty three (23) numbers of GPS- referenced representative surface soils (0 - 15 cm) were collected respectively from Motidabdar, Chikhaldar and Daguniya villages situated in undulating hilly terrain of Dang district (Gujarat). Samples were analyzed for the status of available phosphorous, potassium and DTPA- extractable micronutrients (Fe, Mn, Cu and Zn) including some basic soil properties (PH, EC and organic carbon) following standard procedures. The result revealed that soil pH varied widely from 5.30 to 6.80, 6.00 to 7.70 and 5.80 to 6.80 respectively in Motidabdar, Chikhaldar and Daguniya villages, while soil EC values indicated that all surface soils were normal. Soil organic carbon (SOC) varied widely from low to high showing 30, 6.7 and 4.5 per cent samples with low status and 35, 26.6 and 21.7 per cent samples with medium status respectively in Motidabdar, Chikhaldar and Daguniya village. Both available phosphorus and potassium varied widely from low to high, while with respect to available P_2O_5 , 73.3, 65.0 and 69.6 per cent samples were found to belong under low status and 23.3, 30.0 and 30.4 per cent samples with medium status respectively in Motidabdar, Chikhaldar and Daguniya villages and only 10.0 per cent soils of Motidabdar, 70.0 and 5.0 percent soils respectively from Chikhaldar and Daguniya villages, came under medium status of available K_2O . DTPA- Fe and Mn exhibited high status in all soils and 53.3, 30 and 30.4 per cent soils depicted low status with respect to DTPA-Zn respectively in Motidabdar, Chikhaldar and Daguniya villages. However, >90 % soils of these villages were high in DTPA- Cu status. Soils with deficient/ low in available nutrient status in all three villages call for management of these nutrients for higher crop yield and sustaining soil health. Some important significant simple correlations (r) among different parameters were worked out and discussed.

Keywords- Available phosphorous, Potassium, DTPA- micronutrients, Surface soils, Undulating terrain

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Introduction

Dangs district consists of a series of foot hills between flat alluvial planes and high mountains and it is the smallest district of Gujarat state and situated in the southern part of the state between the parallels of latitude $20^{\circ} 33'40''$ and the meridians of longitude $73^{\circ} 27' 58''$ and $73^{\circ} 56' 36''$. The district receives an average annual rainfall of > 2500 mm, but owing to its high undulating topography major rainfall goes downstream as runoff which creates water-scarcity from December-January onwards [3]. There are 311 villages in this district and > 95 per cent populations of these villages are tribal. Soils of all villages suffer from many crop- productions related constraints like, sandy to gravelly texture, shallow to medium depth, sloppy land with high erosion, medium to poor soil fertility, medium to low moisture holding capacity and rain-dependent mono-cropped agriculture. Thus, farming is not a much remunerative occupation to the tribal farmers and thus their socio-economic status is poor. Only 38% land in the district comes under cultivated area. Crop production has large bearing on the fertility of soil as among several factors, soil fertility status determines to a high extent the ultimate yield, even if all the above factors are optimum for crop production. Determining 'Soil fertility' i.e. available major and micro nutrients status of coarse -textured and erosion -prone soils of villages of this district would be of highly importance in relation to proper soil nutrient management of hilly undulating terrain for higher crop production. Further, information relating to available nutrients especially micro-nutrients in surface soils of undulating hilly terrain with varying slopes from

different villages of Dangs district is scanty.

Material and Methods

An overview of study area

Study area confined to three villages namely, Chikhaldar, Motidabdar and Daguniya villages of waghai taluka in Dangs district of South Gujarat Heavy Rainfall Zone. Details of these villages relating to Location, rainfall, temperature, geology, land use pattern, surface soil texture, soil depth, slope of soil/ land, type and degree of erosion etc. had already been narrated by [3- 5].

Collection of Soil samples and analysis

Representative surface soils (0-15 cm) from Motidabdar, Chikhaldar and Daguniya villages were collected from farmers' field having elevations from 279 to 352 m above MSL in Motidabdar, 217 to 257 m above MSL in Chikhaldar and 320 to 380 m above MSL in Daguniya village. However, depending upon slope, relief, organic matter and other minerals present in different field, colour of these samples varied widely both under dry and wet conditions. Thirty (30), twenty (20) and twenty three (23) numbers of representative geo-referenced surface soils (0-15 cm) were collected respectively from Motidabdar, Chikhaldar and Daguniya villages by using GPS device. Latitude, longitude and elevation of all samples are given in Appendix 1. All the samples were air-dried, sieved (<2 mm), processed and were analyzed for chemical parameters like, Soil pH, EC, organic carbon,

available P_2O_5 and K_2O and DTPA-extractable Fe, Mn, Zn and Cu, following standard procedures as described by [1, 13]. Organic carbon was determined following [20] method, while DTPA-micronutrients were determined following [9] method. Results of analyzed data were interpreted and analytical parameters were subjected to simple correlation analysis and then interpreted accordingly. All the results were given in tabular form.

Results and Discussion

pH, EC, organic carbon, available P_2O_5 , K_2O , Fe, Mn, Zn, and Cu of surface soils of Motidabdar, Chikhaldar and Daguniya village are presented in [Table-1 to 3], while simple correlation co-efficient among different parameters are presented in [Table-4 to 6].

Soil pH and EC

So far as soil pH is concerned, the result revealed that in Motidabdar Village pH varied widely from 6.8 to 5.30 with a mean value of 6.11 (slightly acid) i.e. neutral to strongly acid in reaction. However, out of 30 samples, only 3 (10%) samples exhibited neutral in reaction, whereas 2 samples (6.6%), 11 samples (36.6%) and 14 samples (46.6%) came under the category of strongly acid, medium and slightly acidic in reaction respectively [Table-1]. Similarly, in Chikhaldar Village soil pH ranged from 6.0 to 7.70 with a mean value of 6.70 i.e. from mildly alkaline to medium acid in reaction. However, out of 20 samples, only 1 sample (5%)

exhibited mildly alkaline in reaction, whereas 2 samples (10%), 14 samples (70%) and 3 soil samples (15%) came under the category of medium acid, slightly acid and neutral in reaction respectively [Table-2]. However, in Daguniya Village, the same varied from 5.80 to 6.80 (Neutral to medium acid) with a mean value of 6.3. However, out of 23 samples, only 6 (26%) exhibited neutral in reaction [Table-3], whereas, 4 samples (17.39%) and 13 soil samples (56.52%) came under the category of medium acid and slightly acid in reaction respectively. The variation of acidity of surface soils of varying elevations and slopes of these villages might be attributable to the leaching loss of basic cations at varying degree from surface layers due to prevailing high rainfall of these villages. Neutral to strongly acidic soil reaction in surface soils of Sarvar village of Dangs district was earlier reported by [4]. Results were also supported by [17] for soils of hill areas in Haryana. So far as soil EC (salinity) is concerned, the result revealed that in Motidabdar, Chikhaldar and Daguniya villages all the soils came under normal category with values ranging from 0.009 to 0.161 $dS\ m^{-1}$ with a mean value of 0.085 $dS\ m^{-1}$ in Motidabdar, from 0.040 to 0.180 $dS\ m^{-1}$ with a mean value of 0.090 $dS\ m^{-1}$ in Chikhaldar and from 0.020 to 0.340 $dS\ m^{-1}$ with a mean value of 0.117 $dS\ m^{-1}$ in Daguniya [Table-1 to 3]. The reason for low EC of surface soils was good / free drainage condition which favored the removal of released bases by percolating and drainage water. Results were supported by the findings of [10] for soils of Kashmir region and [17] for soils of hill areas in Haryana.

Table-1 pH, EC, organic carbon, available P_2O_5 , K_2O , Fe, Mn, Zn, and Cu of surface soils of Motidabdar village.

Sr. No.	Elevation (m)	pH (1:2.5)	EC ($dS\ m^{-1}$) (1:2.5)	O.C. ($g\ kg^{-1}$)	P_2O_5 ($kg\ ha^{-1}$)	K_2O ($kg\ ha^{-1}$)	DTPA-extractable available micronutrients($mg\ kg^{-1}$)			
							Fe	Mn	Zn	Cu
1	279	5.80	0.118	11.72	39.00	114.24	26.02	24.14	0.56	1.38
2	283	6.00	0.065	5.30	20.09	161.28	17.63	23.43	0.28	0.39
3	283	6.30	0.059	10.46	69.73	204.96	28.28	22.99	0.63	1.48
4	286	6.10	0.032	9.86	15.36	174.72	20.84	22.12	0.43	0.49
5	287	6.40	0.104	7.00	10.64	164.64	30.52	22.51	0.41	0.96
6	292	6.40	0.100	11.40	11.82	188.16	23.86	22.77	0.71	1.57
7	293	6.10	0.111	16.91	18.91	540.96	48.88	23.87	0.37	1.81
8	294	6.40	0.092	11.31	31.91	161.28	33.06	22.77	0.41	1.36
9	295	5.60	0.161	6.32	11.82	168.00	12.61	20.47	0.33	0.53
10	295	5.90	0.060	11.25	28.36	137.76	33.48	23.77	0.62	1.67
11	296	5.80	0.098	14.52	36.64	178.08	24.90	23.48	0.46	1.09
12	297	6.70	0.124	15.72	14.18	181.44	22.74	22.70	1.00	1.51
13	298	6.40	0.101	5.57	10.64	309.12	18.58	22.51	0.56	1.32
14	298	6.30	0.147	13.65	27.18	339.36	33.48	23.54	0.61	1.94
15	299	6.00	0.090	4.11	14.18	131.04	27.84	21.72	0.37	0.40
16	300	6.70	0.077	6.80	23.64	204.96	34.00	23.46	0.39	0.14
17	300	6.30	0.077	6.44	8.27	356.16	21.18	21.39	0.46	1.04
18	301	6.10	0.058	8.45	26.00	181.44	26.12	24.02	0.44	1.17
19	301	6.30	0.101	4.50	15.36	231.84	21.36	22.68	0.43	0.68
20	302	5.80	0.009	7.97	15.36	235.20	23.16	24.02	0.44	1.17
21	302	6.30	0.096	13.67	13.00	278.88	32.70	23.27	0.69	1.61
22	305	6.00	0.085	11.97	26.00	332.64	25.42	23.00	0.64	0.89
23	306	6.10	0.084	12.02	23.64	211.68	32.52	23.98	0.55	1.68
24	309	6.50	0.066	11.67	31.91	520.80	22.30	21.70	0.80	1.21
25	317	5.80	0.106	12.36	14.18	154.56	25.16	23.81	0.44	1.43
26	328	6.00	0.062	11.55	50.82	141.12	27.16	24.19	0.51	1.40
27	329	5.50	0.053	10.88	23.64	157.92	27.06	23.22	0.51	1.08
28	340	5.30	0.084	14.72	17.73	151.20	27.94	23.68	0.54	1.27
29	351	6.80	0.083	5.34	29.55	245.28	15.20	17.89	0.39	0.50
30	352	5.70	0.043	6.99	14.18	161.28	31.66	18.54	0.41	0.67
S.D.		0.361	0.032	3.559	13.23	105.09	7.02	1.52	0.15	0.47
Range		5.30-6.80	0.009-0.161	4.11-16.91	8.27-69.73	114.24-540.96	12.61-48.88	17.89-24.19	0.28-1.00	0.14-1.94
Mean		6.11	0.085	10.01	23.13	224.00	26.52	22.72	0.51	1.13
Soil status: Low		-	-	2	22	3	0	0	16	1
Medium		-	-	8	7	21	0	0	14	2
High		-	-	20	1	6	30	30	0	27

Soil organic carbon (SOC)

Soil organic carbon (SOC) in surface soils of Motidabdar village varied widely from low to high status i.e. from 4.11 to 16.91 $g\ kg^{-1}$ with a mean value of 10.01 $g\ kg^{-1}$ i.e. high status in mean value. Out of 30 soil samples of this village, only 2 samples (6.6%) and 8 soil samples (26.6%) exhibited low and medium status

respectively and rest of the samples showed high status of organic carbon [Table-1]. Similarly, the same in Chikhaldar village was found to vary widely from low to high status i.e. from 2.43 to 16.23 $g\ kg^{-1}$ with a mean value of 7.44 $g\ kg^{-1}$. Out of 20 samples, only 6 samples (30%) and 7 samples (35%) exhibited low and medium status respectively and the rest showed high status of SOC [Table-2]. In

Daguniya village, SOC also varied widely from low to high status i.e. from 1.41 to 14.73 g kg⁻¹ with a mean value of 9.50 g kg⁻¹. Out of 23 samples, only 1 sample (4.3%) and 5 samples (21.7%) exhibited low and medium status respectively and the rest came under high status of SOC [Table-3]. The higher status of SOC in major soils can be attributed to high leaf-litter fall / decay, vegetation, tree/ plant coupled with heavy rainfall in these three villages. The results further indicated that Chikhaldia, Motidabdar and Daguniya village exhibited respectively about 30, 6.7 and 4.3 per cent surface samples under low and about 35, 26.6 and 21.7 per

cent respectively under medium status of SOC and as a result need proper management of SOC of these soils through addition of more organic matters/ manures for possible improvement of crop yield. Results were supported by the findings of [11] for soils of Loktak catchment area in Manipur region. Low organic carbon content in piedmont plain and coastal plain of Southern Saurashtra region of Gujarat was also found by [15].

Table-2 pH, EC, organic carbon, available P₂O₅, K₂O, Fe, Mn, Zn and Cu of surface soils of Chikhaldia village.

Sr. No.	Elevation (m)	pH (1:2.5)	EC (dS m ⁻¹) (1:2.5)	O.C. (g kg ⁻¹)	P ₂ O ₅ (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)	DTPA-extractable available micronutrients(mg kg ⁻¹)			
							Fe	Mn	Zn	Cu
1	217	6.80	0.075	2.43	11.82	470.67	21.94	17.50	0.57	1.19
2	224	6.40	0.049	6.92	7.18	363.15	26.40	18.52	0.51	1.63
3	225	7.70	0.144	3.05	17.73	269.07	8.39	4.05	0.11	0.26
4	227	6.00	0.095	7.37	22.46	699.15	33.89	18.68	0.95	1.36
5	227	6.60	0.081	6.96	39.00	685.71	25.19	16.86	0.46	0.94
6	228	6.50	0.122	11.07	17.73	665.79	28.35	17.26	0.93	1.18
7	228	6.50	0.099	11.43	55.55	645.39	30.39	16.10	1.25	1.53
8	229	6.50	0.151	16.23	54.37	800.19	31.21	16.95	1.73	2.17
9	230	6.00	0.058	9.38	7.09	443.79	16.10	15.17	0.44	0.24
10	232	6.40	0.181	12.63	49.64	853.95	21.94	16.46	2.19	0.83
11	232	6.50	0.052	6.23	14.18	712.59	20.34	16.47	0.39	0.28
12	234	6.10	0.073	4.55	10.64	497.55	22.98	17.96	0.56	0.69
13	234	6.30	0.056	4.13	12.18	658.83	22.20	18.21	0.51	1.04
14	236	6.50	0.115	8.99	79.18	940.19	28.91	17.72	0.83	1.23
15	248	6.30	0.044	4.49	8.27	833.55	25.75	16.45	0.64	0.88
16	248	6.40	0.069	5.87	34.27	927.63	29.52	17.58	0.44	1.42
17	250	6.50	0.071	6.51	39.00	934.87	31.60	18.83	0.67	1.54
18	253	6.40	0.063	6.05	10.18	961.75	28.26	18.50	0.82	2.33
19	255	6.10	0.040	4.80	8.18	443.79	22.72	17.81	0.45	0.88
20	257	6.80	0.084	9.78	11.18	808.63	19.69	14.59	0.69	1.30
S.D.		0.37	0.04	3.49	20.77	207.67	6.03	3.16	0.49	3.16
Range		6.00-7.70	0.04-0.18	2.43-16.23	7.09-79.18	269.07-961.75	8.39-33.89	4.05-18.83	0.11-2.19	4.05-18.83
Mean		6.47	0.09	7.44	25.49	680.81	24.79	16.58	0.76	16.58
Soil status: Low				6	13	0	0	1	6	1
Medium				7	6	1	1	0	11	0
High				7	1	19	19	19	3	19

Available phosphorus and potassium

In case of available phosphorus, its content in surface soils of Motidabdar, Chikhaldia and Daguniya villages varied widely from low to high status i.e. from 8.27 to 69.73 kg P₂O₅ ha⁻¹ with mean value of 23.13 kg P₂O₅ ha⁻¹ (low status) in Motidabdar, from 7.09 to 79.18 kg P₂O₅ ha⁻¹ with mean value of 25.49 kg P₂O₅ ha⁻¹ (low status) in Chikhaldia and from 7.09 to 79.18 kg P₂O₅ ha⁻¹ with mean value of 25.49 kg P₂O₅ ha⁻¹ (low status) in Daguniya [Table-1 to 3]. Out of 30 soil samples from Motidabdar village, 22 samples (73.3%), 7 samples (23.3%) and only 1 (3.3%) sample exhibited low, medium and high status respectively and out of 20 soil samples from Chikhaldia village, 13 samples (65%), 6 samples (30%) and only 1 (5%) sample exhibited low, medium and high status of available phosphorus respectively. In Daguniya village, out of 23 samples, 16 samples (69.5%) and 7 samples (30.4%) samples exhibited low and medium status of available phosphorus respectively [Table-1 to 3]. When surface samples from three villages were compared, it was observed that Motidabdar village depicted the highest percentage (73.3%) of low status of available phosphorus followed by Daguniya (69.6%) and Chikhaldia (65.0%) i.e. major soils were of low status of available phosphorus and as a result appropriate measures are required to be taken up for P- management of these soils in order to fulfill crop demand and achieve higher crop yield.

In case of available potassium, its content in surface soils of these villages varied widely from low to high status i.e. from 114.24 to 540.96 kg K₂O ha⁻¹ with mean value of 224 kg K₂O ha⁻¹ (high status) in Motidabdar, from 269.07 to 961.75 kg K₂O ha⁻¹ with mean value of 680.81 kg K₂O ha⁻¹ (high status) in Chikhaldia and from 65.18 to 887.71 kg K₂O ha⁻¹ with mean value of 338.16 kg K₂O ha⁻¹ (high status) in Daguniya village [Table-1 to 3]. In Motidabdar village, 3 samples (10%), 21 samples (70%) and 6 (20 %) samples, out of 30 total, exhibited low, medium and high status respectively, in Chikhaldia village. Only 1 sample (5%) and 19

(95%) samples (out of 20 total) portrayed medium and high status respectively in Daguniya village. Similarly, 4 samples (17.4 %), 8 samples (34.7 %) and 11 samples (47.82 %) (out of 23 total) belonged to low, medium and high status respectively. When surface samples from three villages were compared, it was observed that Daguniya village depicted the highest percentage (17.4 %) of low status of potassium followed by Motidabdar (10 %) and Chikhaldia (0%) [Table-1 to 3]. The result indicated that appropriate measures for K- management are required to be taken up in Daguniya and Motidabdar in case of soils with low and medium status of Available-K in order to fulfill the crop demand and achieve possible higher crop yield. Results of phosphorus and potassium were supported by the findings of [16] for soils of Amritsar district of Punjab, for pear orchard soils of Kashmir [2] and for ravenous land in Chambal region of Madhya Pradesh [17].

DTPA-extractable available micronutrients (Fe, Mn, Zn and Cu) status

DTPA- extractable micronutrients (Fe, Mn, Zn and Cu) status of surface soils from Motidabdar village is presented in [Table-1]. The results of Motidabdar village revealed that the status of DTPA- extractable available Fe and Mn of soils were high, whereby Fe and Mn varied from 12.61 to 48.88 ppm (mean 26.52 ppm) and 17.89 to 24.19 ppm (mean 22.72 ppm) respectively. Available Zn content of surface soils varied widely from 0.28 to 1.00 ppm i.e. low to high status with a mean value of 0.50 ppm. However, 16 samples (53.3%) out of 30 total, exhibited low status of available Zn and the rest belonged to medium status. In case of available Cu, it varied widely from low to high status (0.14 to 1.94 ppm) with a mean value of 1.13 ppm. Out of 30 soil samples, only 1 sample (3.3 %), 2 samples (6.6 %) and 27 (90%) samples exhibited low, medium and high status respectively with respect to available Cu. The results clearly indicated that the soils of Motidabdar village were in general sufficient with available Fe, Mn and Cu, but about 53 % and 47% soils of this village were low / deficient and medium

respectively with respect to available Zn. Thus, proper management of available Zn in soils with low / deficient and/or medium status is highly needed for improvement of their status to fulfill the crop demand and possible higher crop yield. In Chikhaldia village [Table-2] also available Fe and Mn of soils, though varied widely, depicted high status barring one sample. DTPA- Fe varied from 8.39 to 33.89 ppm with a mean value of 24.79 ppm, while DTPA- Mn ranged from 4.05 to 18.83 ppm (mean 16.58 ppm). Available Zn content varied widely from low to high (0.11 to 2.19 ppm) with a mean value of 0.76 ppm. Out of 20 soil samples, 6 samples (30%), 11 samples (55%) and 3 samples (15%) samples , exhibited low, medium and high status of available Zn respectively. Available Cu of soils varied widely from medium to high status from (0.24 to 2.33 ppm) with a mean value of 1.14 ppm and out of 20 soil samples, only 3 samples (15%) exhibited medium and the rest were of high status. Similar trend of results were also found in Daguniya village [Table-3] in case of DTPA- Fe and Mn of soils. Fe ranged from 20.06 to 41.18 ppm with a mean value of 29.63 ppm and Mn spanned from 17.47 to 19.90 ppm with a mean value of 19.16. Available Zn content of soils

like other two villages, varied widely from low to high status (0.19 to 1.21 ppm) with a mean value of 0.62 ppm. However, 7 samples (30.4 %), 14 samples (60.8 %) and 2 (8.7 %) samples out of 23 samples, exhibited respectively low, medium and high status of available Zn. However, available Cu of soils ranged widely from medium to high status (0.29 to 2.90 ppm) with a mean value of 1.30 ppm. But, out of 23 soil samples of this village, only 1 sample (4.3%) exhibited medium status and the rest was of high status. Results of Chikhaldia and Daguniya village clearly indicated that about 30 % soils of these villages were deficient in available Zn and for which proper management of soil available Zn would be needed in regard to possible improvement in crop yield and soil health. The results were corroborated with the findings of [8] for Jharkhand plateau and [12] for soils of Patiala District Punjab, whereby they observed higher percentage of Zn deficient soils. However, deficiency of both available Fe and Zn in soils of Karnataka was reported by [14]. The results further revealed that Motidabdar village exhibited the highest Zn deficiency followed by Chikhaldia / Daguniya. Thus, Zn deficient soils require proper Zn management for possible improvement in crop yield and soil health.

Table-3 pH, EC, Organic carbon, available P_2O_5 , K_2O , Fe, Mn Zn, and Cu of surface soils of Daguniya village.

Sr. No.	Elevation (m)	pH (1:2.5)	EC (dS m ⁻¹) (1:2.5)	O.C. (g kg ⁻¹)	P_2O_5 (kg ha ⁻¹)	K_2O (kg ha ⁻¹)	DTPA-extractable available micronutrients			
							Fe	Mn	Zn	Cu
							(mg kg ⁻¹)			
1	320	6.00	0.143	13.73	35.46	606.82	36.55	19.9	1.21	2.25
2	322	6.80	0.146	10.77	44.91	887.71	27.55	17.47	0.84	0.78
3	324	6.50	0.121	12.81	29.55	784.49	32.48	19.62	1.14	2.70
4	325	6.30	0.087	12.89	33.09	433.57	28.46	19.39	0.53	1.23
5	326	6.30	0.142	14.33	29.55	702.37	29.5	19.39	0.56	1.49
6	327	6.20	0.099	11.04	26.00	199.58	36.38	19.27	0.61	2.68
7	327	6.40	0.055	5.39	14.18	171.36	20.06	18.29	0.19	0.91
8	328	6.00	0.181	7.71	28.36	328.07	29.45	19.87	0.29	0.69
9	330	6.60	0.017	7.55	52.00	852.90	34.21	19.23	0.97	2.90
10	332	6.40	0.054	7.46	43.73	65.18	26.08	19.42	0.47	1.41
11	333	6.50	0.335	7.80	31.91	142.06	41.18	19.75	0.89	0.65
12	338	6.30	0.095	11.34	13.00	133.59	25.04	18.24	0.45	0.65
13	339	6.20	0.133	11.69	13.00	336.67	34.52	19.44	0.91	0.87
14	339	6.70	0.094	6.14	15.36	150.39	24	17.95	0.32	1.27
15	342	6.30	0.077	9.75	14.18	153.48	23.22	19.24	0.50	0.84
16	345	6.50	0.138	7.05	14.18	449.43	31.88	19.27	0.50	0.94
17	351	6.60	0.062	1.41	34.27	205.90	26.08	18.66	0.64	1.19
18	356	6.20	0.081	10.17	14.18	160.34	29.32	19.37	0.44	0.29
19	359	6.60	0.111	9.69	46.09	242.59	28.98	19.44	0.64	1.36
20	366	6.00	0.187	14.73	14.18	339.36	30.14	19.52	0.72	2.21
21	378	6.50	0.065	9.50	13.00	121.63	30.58	18.87	0.51	1.09
22	378	5.80	0.115	11.18	15.36	170.69	27.76	19.52	0.57	0.62
23	380	6.60	0.146	5.30	49.64	139.51	28.15	19.52	0.26	0.94
S.D.		0.25	0.06	3.29	13.46	255.52	4.81	0.63	0.27	0.74
Range		5.80-6.80	0.02-0.34	1.41-14.73	13.00-52.00	65.18-887.71	20.06-41.18	17.47-19.90	0.19-1.21	0.29-2.90
Mean		6.36	0.117	9.54	27.18	338.16	29.63	19.16	0.62	1.30
Status: Low		-	-	1	16	4	0	0	7	0
Medium		-	-	5	7	8	0	0	14	1
High		-	-	17	0	11	23	23	2	22

Simple Correlations

Simple correlations among different parameters of surface soils of Motidabdar village

Simple correlations among different parameters (pH, EC, O.C, available P_2O_5 , available K_2O and micro nutrients) of surface soils of Motidabdar village were worked out and are presented below in [Table-4]. As far as available Macro nutrients are concerned, no significant correlation was observed. In case of DTPA extractable micronutrients, the results revealed [Table-4] that DTPA-Fe was positively and significantly correlated with O.C., DTPA-Cu and Mn, while the DTPA-Mn was positively and significantly correlated with O.C., DTPA-Fe, Cu and Zn. DTPA-Zn was positively and significantly correlated with only O.C. and DTPA-Mn, DTPA-Cu was either positively or negatively and significantly correlated with soil sample elevation, O.C and DTPA-Fe and Mn. Similar kind of co- relations were also observed by [12, 19, 7].

Simple correlations among different parameters of surface soils of Chikhaldia village

Simple correlations among different parameters (pH, EC , O.C , available P_2O_5 , available K_2O and micro nutrients) of surface soils of Chikhaldia village were worked out and are presented below in [Table-5]. As far as available major nutrients are concerned, the results revealed [Table-5] that available P_2O_5 was positively and significantly correlated with EC and O.C. and available K_2O was positively and significantly correlated with soil sample elevation and available P_2O_5 . So far as available (DTPA-extractable) micronutrients are concerned, the results revealed that DTPA-Fe was positively and significantly correlated with pH, available P_2O_5 , DTPA-Mn and Cu while, the DTPA-Mn was positively and significantly correlated with pH, available K_2O and DTPA-Fe and Cu. DTPA-Zn was positively and significantly correlated with EC, O.C. and available P_2O_5 . DTPA-Cu was positively and significantly correlated with available K_2O , DTPA-Fe and Mn. So far as other parameters are concerned, O.C. was positively and significantly correlated with EC. Similar kind of co- relations were also observed by [12, 19, 7].

Table-4 Simple correlations among different parameters of surface soils of Motidabdar village

Elevation	Elevation 1	pH	EC	O.C.	P ₂ O ₅	K ₂ O	DTPA-Fe	DTPA-Mn	DTPA-Zn	DTPA-Cu
pH	-0.220	1.000								
EC	-0.242	0.112	1.000							
O.C.	-0.037	0.256	0.207	1.000						
P ₂ O ₅	-0.051	0.042	0.169	0.243	1.000					
K ₂ O	-0.052	0.100	0.106	0.226	0.077	1.000				
DTPA-Fe	-0.056	0.241	0.007	0.514**	0.134	0.240	1.000			
DTPA-Mn	-0.135	0.296	0.224	0.737**	0.223	0.260	0.474**	1.000		
DTPA-Zn	-0.072	0.278	0.135	0.549**	0.143	0.205	0.019	0.560**	1.000	
DTPA-Cu	-0.472**	0.080	0.007	0.492**	0.215	0.057	0.397*	0.505**	0.175	1.000

Table-5 Simple correlations among different parameters of surface soils of Chikhaldia village

Elevation	Elevation 1.000	pH	EC	O.C.	P ₂ O ₅	K ₂ O	DTPA-Fe	DTPA-Mn	DTPA-Zn	DTPA-Cu
pH	-0.200	1.000								
EC	-0.357	0.412	1.000							
O.C.	-0.096	-0.155	0.604**	1.000						
P ₂ O ₅	-0.129	0.093	0.600**	0.568**	1.000					
K ₂ O	0.519*	-0.211	0.127	0.344	0.494*	1.000				
DTPA-Fe	0.132	0.502**	-0.030	0.356	0.436*	0.600	1.000			
DTPA-Mn	0.186	0.795**	-0.384	0.135	0.080	0.445*	0.753**	1.000		
DTPA-Zn	-0.108	-0.189	0.691**	0.790**	0.559**	0.427	0.406	0.244	1.000	
DTPA-Cu	0.221	-0.122	0.067	0.349	0.284	0.494*	0.739**	0.481*	0.399	1.000

Table-6 Simple correlations among different parameters of surface soils of Daguniya village

Elevation	Elevation 1.000	pH	EC	O.C.	P ₂ O ₅	K ₂ O	DTPA-Fe	DTPA-Mn	DTPA-Zn	DTPA-Cu
pH	-0.091	1.000								
EC	-0.039	-0.145	1.000							
O.C.	-0.171	-0.509*	0.199	1.000						
P ₂ O ₅	-0.200	0.430*	0.005	-0.182	1.000					
K ₂ O	-0.508*	0.174	0.013	0.389	0.401	1.000				
DTPA-Fe	-0.157	-0.141	0.547**	0.312	0.209	0.295	1.000			
DTPA-Mn	0.111	0.552**	0.334	0.290	0.125	-0.029	0.560**	1.000		
DTPA-Zn	-0.326	-0.022	0.236	0.444*	0.283	0.629	0.682**	0.270	1.000	
DTPA-Cu	-0.302	0.015	-0.193	0.286	0.338	0.496*	0.386	0.233	0.555**	1.000

Appendix-1 Details of surface soil sampling from Motidabdar, Chikhaldia and Daguniya village with GPS reading

Motidabdar village				Chikhaldia village				Daguniya village			
Sample No.	Elevation (mmsl)	Latitude(N)	Longitude(E)	Sample No.	Elevation (mmsl)	Latitude(N)	Longitude(E)	Sample No.	Elevation (mmsl)	Latitude(N)	Longitude(E)
1	295	20° 43' 30.4 "	73° 36'14.6"	1	217	20° 41' 28.5"	73° 35' 26.2"	1	325	20° 38' 52. " "	73° 35'83.0"
2	296	20° 43' 32.6 "	73° 36'8.9"	2	224	20° 41' 25.5"	73° 35' 39.5"	2	330	20° 38' 52.6 "	73° 35'88.0"
3	298	20° 43' 34.2 "	73° 36'40"	3	225	20° 41' 18.1"	73° 35' 32.5 "	3	320	20° 38' 58 "	73° 35'95.0
4	302	20° 43' 33.1 "	73° 35'45.4"	4	227	20° 41' 34.4"	73° 35' 30.2"	4	322	20° 38' 60.2 "	73° 35'97.8"
5	299	20° 43' 31.3 "	73° 56'91.9"	5	227	20° 41' 33.9"	73° 35' 35.1 "	5	326	20° 38' 59.6 "	73° 36'26.0"
6	328	20° 43' 26.1 "	73° 35'85.8"	6	228	20° 41' 33.6"	73° 35' 34"	6	327	20° 38'59.5 "	73° 36'42.0"
7	351	20° 43' 24.3 "	73° 35'76.4"	7	228	20° 41' 26.6"	73° 35' 37.4"	7	328	20° 38' 59.6 "	73° 36'66.0"
8	352	20° 43'2.5 "	73° 85'70.6"	8	229	20° 41' 32.2"	73° 35' 35.5"	8	366	20° 38'63.8 "	73° 36'22.0"
9	340	20° 43' 27 "	73° 35'73.2"	9	230	20° 41' 26.6 "	73° 35' 37.4"	9	359	20° 38'62.7 "	73° 36'77.0"
10	329	20° 43' 1.8 "	73° 35'73.9"	10	232	20° 41' 30.1 "	73° 35'36.4"	10	351	20° 38'61.5 "	73° 36'15.7"
11	317	20° 42' 92.7 "	73° 35'73.3"	11	232	20° 41' 24.7"	73° 35' 29.6"	11	345	20° 38'59.9 "	73° 36'13.7"
12	295	20° 42' 84 "	73° 35'79.6"	12	234	20° 41' 22.5 "	73° 35' 36.3 "	12	339	20° 38'59.9 "	73° 36'13.7"
13	287	20° 42' 80.4 "	73° 35'78.7"	13	234	20° 41' 32.7 "	73° 35' 30.5"	13	333	20° 38'59.6 "	73° 36'11.1"
14	283	20° 42' 79 "	73° 35'89"	14	236	20° 41' 30.2 "	73° 35' 30.5"	14	324	20° 38'45.9 "	73° 35'95.2"
15	286	20° 42' 72.6 "	73° 35'82.8"	15	248	20° 41' 23.3 "	73° 35' 33.5"	15	327	20° 38'40.1"	73° 36'29.0"
16	279	20° 42' 65.5 "	73° 35'87.9"	16	248	20° 41' 30.2 "	73° 35' 30.5"	16	332	20° 38'36.1 "	73° 36'65.0"
17	283	20° 42' 64.8 "	73° 35'92.5"	17	250	20° 41' 21.9 "	73° 35' 32.5"	17	338	20° 38'34.8 "	73° 36'12.7"
18	292	20° 42' 64.8 "	73° 35'98.8"	18	253	20° 41' 19.9 "	73° 35'33.5"	18	339	20° 38'32.6 "	73° 36'14.9"
19	298	20° 42' 65.1 "	73° 36'5.8"	19	255	20° 41' 18.1 "	73° 35' 32.5"	19	342	20° 38'38.2 "	73° 36'15.8"
20	294	20° 42' 64.5 "	73° 35'11.5"	20	257	20° 41' 16.1 "	73° 35' 32.9"	20	356	20° 38'40 "	73° 36'19.2"
21	301	20° 42' 65 "	73° 36'18.2"					21	378	20° 38'40.5 "	73° 36'32.9"
22	306	20° 42' 61.9 "	73° 36'24.8"					22	380	20° 38'59.7 "	73° 36'28.8"
23	309	20° 42' 63.6 "	73° 36'29.2"					23	376	20° 38'59.7 "	73° 36'24.5"
24	305	20° 42' 68.1 "	73° 36'32.9"								
25	300	20° 42' 70.5 "	73° 36'30.1"								
26	301	20° 42' 75.1 "	73° 36'30.2"								
27	302	20° 42' 79.7 "	73° 36'30.5"								
28	297	20° 47' 79.2"	73° 36'22.5"								
29	300	20° 42' 85.3 "	73° 36'18"								
30	293	20° 42' 84.3 "	73° 36'9.8"								

Simple correlations among different parameters of surface soils of Daguniya village

Simple correlations among different parameters (pH, EC, O.C, available P_2O_5 , available K_2O and micro nutrients) of surface soils of Daguniya village were worked out and are presented below in [Table-6]. As far as available major nutrients are concerned, the results revealed [Table-6] that available P_2O_5 was positively and significantly correlated with only pH and available K_2O was positively and significantly correlated with elevation of soil sample.

So far as available (DTPA-extractable) micronutrients are concerned, the results revealed [Table-6] that DTPA-Fe was positively and significantly correlated with EC, DTPA-Mn and Zn, while the DTPA-Mn was positively and significantly correlated with pH and DTPA-Fe. DTPA-Zn was positively and significantly correlated with O.C. and DTPA-Fe and Cu. DTPA-Cu was positively and significantly correlated with available K_2O and DTPA-Zn. So far as other parameters are concerned, O.C. was negatively and significantly correlated with pH. Co- relations of similar kind were also observed by [12, 7].

Conclusion

From the overall results it can be concluded that surface soils depicting around 26, 33 and 26 % soils with low to medium status in SOC; 73, 70 and 65.0 per cent soils with low status in available P_2O_5 ; 10, 10 and 17 per cent soils with low status of available K_2O and 53, 30 and 30 per cent soils with low status in DTPA-Zn respectively in Motidabdar, Chikhaldia and Daguniya village in chronological order, call for improvement of these parameters through proper management- practices for fulfillment of crop demand and there by possible increase in crop yield and sustaining soil health.

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Author Contributions

1st author contributed in carrying out research activities, while 2nd author contributed in framing up the research problem, assessment and interpretation of data and also assisting in writing the manuscript.

Abbreviations

MSL: Mean sea level

Conflict of Interest: None declared

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