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Status of available major nutrients in soils of Gandhi nagar district of Gujarat

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Abstract
A study was undertaken to outline the status of obtainable major nutrients and chemical properties of soils of Gandhinagar district of Gujarat. Total 160 representative surface soil samples (forty soil samples from each taluka) were collected from farmers' fields during April, 2016 using multistage stratified random sampling. The collected soil samples were analyzed for available major (N, P, K and S) and chemical properties *viz.*, electrical conductivity (EC), soil reaction (pH) and organic carbon. Soils of Gandhinagar district are mildly to moderately alkaline in reaction (pH 7.94) with low soluble salt content (EC 0.52 dS/m). The organic carbon status of soils of Gandhinagar district was low (0.38 %). The available nitrogen, phosphorus, potassium and sulphur content in these soils ranged from 78.6 to 376.3, 18.61 to 69.57, 114.24 to 645.33 kg/ha and 6.74 to 36.06 mg kg^{-1} with a mean value of 231.8, 41.06, 306 kg/ha and 18.97 mg kg^{-1}, respectively. Out of 160 soil samples, 79.38 per cent were found to be low in available nitrogen status, 71.88 per cent were found to be medium in available phosphorus status, 50 per cent were found to be high in available potassium status and 48.75per cent were found to be high in available sulphur status.

Keywords: Major nutrients, Gandhinagar, nutrient index, Gujarat

Introduction
The concept of soil quality has evolved since the last decade of the 20th century to answer the growing concern about sustainable soil management. Over exploitation and mismanagement of soil resources in quest for immediate gains without any regards to long term sustainability of its health have led to adverse alteration in soil properties, environment quality, agricultural productivity and sustainability. Soil fertility has a direct relation with the crop yields, provided other factors are in optimum level. Soil fertility must be periodically estimated as there is continues removal of macro and micro nutrients by the crop intensively grown in every crop season. In order to achieve higher productivity and profitability, every farmer should realize that fertility levels must be measured as these measurements can then be used to manage soil fertility. It is determined by the sufficiency or deficiency of nutrients i.e. macro and micronutrients. Balanced nutrient use ensures high production level and helps to maintain the soil health. Fertilizing soils to bring all the deficient elements at high levels as to provide sufficient ionic activity in soil solution for crop uptake is one of the most important considerations for maximization of the crop yield.
Macronutrients (N, P, K and S) are important soil elements that control its fertility. Soil fertility is one of the important factors controlling yields of the crops. Soil characterization in relation to evaluation of fertility status of soils of an area is an important aspect in context to sustainable agriculture production. Soil testing is the key to fertility management while reclamation and rehabilitation of degraded lands is strategic to maintain over all soil health. The major nutrients (N, P, K and S) play important role in maintain soil fertility. Nitrogen is one of the most important major nutrient as well as expensive input in agricultural production, which is closely associated with growth and development of plants. It is found in amino acid, proteins, nucleic acids and chlorophyll. Phosphorus is essential constituents of nucleic acids, ADP and ATP. It also regulates root flower growth, cell division and formation of protein. Potassium is important because of its role in regulating stomatal opening and closing. As the opening for gas exchange, stomata help to maintain a healthy water balance. Sulphur is essential for protein structure and the vitamins thiamine and biotin. It is a coenzyme of vitamin A, which is important for respiration and fatty acid metabolism.

Materials and Methods
In order to delineate the available major nutrients (N, P, K and S) status and chemical properties (EC, pH and OC) of soils of Gandhinagar district of Gujarat,

the studies were carried out. The general information viz., location, climate, land use pattern, soil, natural vegetation and cropping pattern of the district in general as well as experimental details are described as under. Geographically, Gandhinagar district is an administrative division of Gujarat, which is the state capital, organized in 1964. It is located at $23^0.01'$ to $23^0.56'$N (Latitude) and $72^0.33'$ and $73^0.73'$E (Longitude). It has an average elevation of 81 meters (265 feet), it is situated on the banks of the Sabarmati River and located in north-central Gujarat. The geology of the region is mainly composed of sandy loam soil. The total geographical area of the district is 2163.48 km^2. The district has been divided into 4 Talukas and 298 *Gram panchayat* spread in 303 villages. Gandhinagar district is surrounded by the districts of Sabarkantha and Aravalli to the North, Kheda to the south-east, Ahmedabad to south-east, and Mehsana to the north-east.

According to climate, topography, soil characteristics and cropping pattern, Gandhinagar districts falls under North-Gujarat Agro-climatic zone-IV. The climate of the region is sub-tropical monsoon type and falls under semi-arid region. The annual rainfall in the district is received through the south-west monsoon which normally starts from middle of June, July and August are the major month of monsoon. The average annual rainfall of the district is 665 mm, however scanty and uneven rainfall pattern is common. The temperature varies from 7 ^{0}C to 45 ^{0}C. The soil is low in nitrogen, medium in phosphorus and high in potash content. However, in some areas the deficiency of phosphorus and potash is also noticed. The soils of Gandhinagar district is also deficient in sulphur, zinc and iron because the soils are course textured coupled with intensive farming, little use of farmyard manure and absence of legume crops in a cropping system.

To delineate the available major nutrients (N, P, K and S) status and chemical properties (EC, pH and OC) of soils of Gandhinagar district, total 160 representative surface soil samples were collected from farmer's fields. Forty soil samples were collected from each 4 talukas of Gandhinagar district during April-2016 using multistage stratified random sampling method. Representative surface soil samples were collected from different fields' up to a depth of 0 to 15 cm by zigzag method. The standard analytical methods followed for estimating EC, pH, organic carbon and available major nutrients in soil are given in table 1.

Table 1: The standard analytical methods followed for estimating EC, pH, organic carbon and available major nutrients in soil

Parameter	Method	Reference
pH (1: 2.5)	Potentiometric method	Jackson (1973)
EC (1: 2.5)	Conductometric method	Jackson (1973)
Organic carbon	Walkley and Black's titration method	Jackson (1973)
Available N	Alkaline potash permanganate method	Subbiah and Asija (1956)
Available P_2O_5	Extraction: 0.5 M $NaHCO_3$ (pH 8.5) Colorimetric method	Olsen *et al.*(1954)
Available K_2O	Extraction: 1 N NH_4OAc (pH 7.0)Flame photometric method	Jackson (1973)
Available Sulphur	Extraction: 0.15% $CaCl_2$,Turbidity Method	Williams and Steinbergs (1959)

Result and Discussion

Chemical properties of soils of Gandhinagar district

Soil samples were analyzed for different chemical properties viz., $EC_{2.5}$, $pH_{2.5}$ and organic carbon by using standard methods. The range and mean values of EC, pH and organic carbon of soil in different talukas of Gandhinagar district are presented in Table 2.

Table 2: Talukawise range and mean values of EC, pH and OC in soils of Gandhinagar district

Name of Taluka	$EC_{1:2.5}$ (dS/m)	$pH_{1:2.5}$	OC (%)
Mansa	0.11-1.13 (0.44)	7.24-8.98 (8.04)	0.27-0.55 (0.40)
Kalol	0.28-1.90 (0.73)	7.11-9.00 (8.05)	0.19-0.57 (0.41)
Gandhinagar	0.29-1.36 (0.56)	7.09-9.10 (7.86)	0.12-0.62 (0.28)
Dehgam	0.09-1.64 (0.36)	7.06-8.82 (7.81)	0.14-0.77 (0.42)
District	0.09-1.90 (0.52)	7.06-9.10 (7.94)	0.12-0.77 (0.38)

Note: Value in parenthesis indicates mean value

Electrical conductivity ($EC_{1:2.5}$)

Electrical conductivity of soils is a measure of the total concentration of soluble salts. The $EC_{2.5}$ of soil samples were determined by making use of 1:2.5 soil water ratios. Overall, it was varied from 0.09 to 1.90 with a mean value of 0.52 dS/m (Table 2). The lowest (0.09 dS/m) EC value was recorded in the soil sample collected from Dehgam taluka, whereas the highest value of (1.90 dS/m) was recorded in Kalol taluka. The data further revealed that the lowest mean value of 0.36 dS/m was observed in soils of Dehgam taluka and the highest mean value of 0.73 dS/m was registered in soils of Kalol taluka. The low EC of soil might be due to high leaching of soluble salts takes place from surface to sub-subsurface afforded by their light texture as well as high permeability. Similar findings were reported by Anon., 2008 in the soils of oilseed farm of Junagadh district, Shirgire (2012) [12] in Jamnagar district of Gujarat and Mokala soil series of Rajasthan. Similar results were also obtained for soils of Indo Gangetic alluvial plain in Amritsar district of Punjab (Sharma *et al.*, 2008) [23] and for soils of Mandvi talukas of Kutch district of Gujarat (Patel *et al.*, 2012c) [17].

Soil reaction ($pH_{1:2.5}$)

Soil reaction is one of the most important properties of soil because it controls the availability of nutrients, microbial activities and physical conditions of soils up to a great extent. Soil reaction indicates the activities of H^+ and OH^- ions in soil solution. In general, soils of this district are mildly alkaline and moderately alkaline in reaction. The pH values of soils for the entire district were ranging from 7.06 to 9.10 with a mean value of 7.94 (Table 2). The lowest mean pH value of 7.06 was recorded in a soil samples collected from Dehgam taluka and the highest mean value of 9.10 was recorded in the samples collected from Gandhinagar taluka. The relative high

pH in these soils might be due to the presence of high degree of base saturation and medium to high degree of sodium saturation which on hydrolysis gives OH^- ions and high component of carbonate and bicarbonate. Similar results were also obtained for soils of Girnartoposequence of South Saurashtra region (Gandhi, 2013) [8], for oilseed farm of Junagadh district (Anon., 2008) and for Tonk district of Rajasthan (Meena *et al.*, 2006) [12]. Similar results were obtained for soils of northern transition zone of Haveri, Gadag and Dharwad district of Karnataka (Nagaral *et al.*, 2016) [13].

Organic carbon (%)

In general, soils of Gandhinagar district are low in organic carbon status. Overall organic carbon content in soils ranged from 0.12 to 0.77 per cent with a mean value of 0.38 per cent (Table 2). The lowest mean OC status (0.28 per cent) was recorded in a soil samples collected from Gandhinagar taluka and the highest mean value of 0.42 per cent was recorded in samples collected from Dehgam taluka. The low organic carbon content of these soils may be attributed to occasional addition of organic materials, lack of natural vegetation, poor decomposition due to low rainfall, oxidation due to high summer temperature and wind erosion. Similar results were obtained by Meena *et al.* (2006) [12] in Rajasthan, Patel *et al.* (2012a) [15] in Gujarat and Kumar and Babel (2011) in Rajasthan. The results are strongly supported by the findings of Singh and Mishra *et al.*, (2012) [26] in soils of Chiraigaon block of Varanasi (U.P.).

Available major nutrients content in soils of Gandhinagar district

Soil samples were analyzed for available major nutrients viz., N, P_2O_5, K_2O and S by using standard methods. The taluka wise number of soil samples and per cent distribution of soil samples falling in low, medium and high fertility classes for available major nutrients are presented in Table 3 and Table 4, respectively.

Available nitrogen content

Overall, available nitrogen status for the Gandhinagar district was low and it ranged from 78.40 to 376.30 kg/ha with a mean value of 231.77 kg/ha. The highest mean value of available N was found in Dehgam (253.23 kg/ha) taluka followed by Kalol (242.65 kg/ha) and Gandhinagar (216.39 kg/ha) taluka. The lowest mean value of available nitrogen was found in Mansa (214.81 kg/ha) taluka. The lower values for available nitrogen might be due to lower content of organic carbon and little addition of organic matter as well as less use of organic manures in the arid tract. The data presented in table 3 indicated that organic carbon has positive correlation (0.096) with nitrogen. Out of 160 soil samples, 127 samples (79.38 per cent) were found to be low in available nitrogen, whereas 33 samples (20.62 per cent) were medium in available nitrogen content (Table 3). Similar results were reported for soils of Saurashtra region by Anon., (2004) [4], Polara and Chauhan (2015) [20], in Gir Somnath district, Savalia, (2005) and Singh and Rathore, (2013) [28] in Pratapgarh district of Rajasthan.

Table 3: Talukawise range and mean values for available N, P_2O_5, K_2O and S in soils of Gandhinagar district Available phosphorus status

Name of Taluka	Available N(kg/ha)	AvailableP_2O_5(kg/ha)	AvailableK_2O(kg/ha)	Available S(mg/kg)
Mansa	109.80-329.30(214.81)	22.97-67.64(40.46)	114.24-618.24(316.68)	7.88-32.95(18.74)
Kalol	125.40-345.00(242.65)	23.40-57.31(39.38)	194.88-645.33(365.33)	6.74-36.06(20.88)
Gandhinagar	78.60-360.60(216.39)	18.61-58.58(39.34)	134.40-443.52(284.93)	8.10-26.85(17.01)
Dehgam	94.10-376.30(253.23)	19.42-69.57(46.48)	121.96-630.34(255.33)	7.08-33.33(19.25)
District	78.60-376.30 (231.77)	18.61-69.57 (41.06)	114.24-645.33(306.00)	6.74-36.06 (18.97)

Note: Value in parenthesis indicates mean value

Table 4: Per cent distribution of soil samples according to low, medium and high categories for available major nutrients in different talukas of Gandhinagar district

Name of Taluka	Available N			Available P_2O_5			Available K_2O			Available S		
	L	M	H	L	M	H	L	M	H	L	M	H
Mansa	92.5	7.5	0.0	20.0	72.5	7.5	2.5	37.5	60.0	20.0	35.0	45.0
Kalol	82.5	17.5	0.0	10.0	82.5	7.5	0.0	32.5	67.5	10.0	37.5	52.5
Gandhinagar	82.5	17.5	0.0	20.0	70.0	10.0	5.0	52.5	42.5	27.5	25.0	47.5
Dehgam	60.0	40.0	0.0	12.5	62.5	25.0	10.0	60.0	30.0	20.0	30.0	50.0
District	79.38	20.62	0.0	15.62	71.88	12.50	4.37	45.63	50.0	19.38	31.87	48.75

Where, L=Low, M=Medium, H=High fertility class

The available P_2O_5content was medium in most of talukas. The available P_2O_5 content of soils varied from 18.61 to 69.57 kg/ha with a mean value of 41.06 kg/ha, which was in medium categories. The highest mean value of available P_2O_5 was found in Dehgam (46.48 kg/ha) taluka and it was followed by Mansa (40.46 kg/ha) and Kalol (39.38 kg/ha) taluka. The lowest mean value of available P_2O_5 was found in Gandhinagar (39.34 kg/ha) taluka (Table 3). The medium content of available phosphorus in these soils might be due to regular application of phosphatic fertilizers to realize higher yields of oil seeds, which are the principal crops of the area. The data presented in Table 6 indicated that the available P_2O_5 gave significant negative correlation with pH (-0.369**) and significantly positive correlation with organic carbon (0.473**). Thus, the availability of phosphorus reduced with increase in salinity and alkalinity hazards of soils on account of the accumulation of soluble salts and exchangeable sodium. Furthermore, the availability of phosphorus increases with increase in organic carbon due to the formation of phosphorus humic complexes which are easily assimilated by plants, anions replacement of phosphate by humation and the coating of sesquioxide by particles of humus to form a protective cover and thus reduce the phosphate fixing capacity of the soils. Out of 160 soil samples, 25 samples (15.62 per cent) were found to be low, 115 samples (71.88 per cent) were medium and remaining 20 samples (12.50 per cent) were high in available phosphorus content (Table 4). Similar results were also obtained by Hadiyal *et al.*, (2016) and Patel *et al.*, (2017) [12].

Available potash content

Overall, available K_2O status for the Gandhinagar district was

high and varied from 114.24 to 645.33 K_2O kg/ha with an average of 306 kg/ha. The highest mean value for available K_2O was found in Kalol (365.33 kg/ha) and it followed by Mansa (316.68 kg/ha) and Gandhinagar (284.93 kg/ha) talukas. The lowest mean value of available K_2O was found in Dehgam (255.33 kg/ha) taluka (Table 3). The high available potash content in these soils might be attributed to the prevalence of potassium rich minerals like illite, feldspar, muscovite and high potassic fertilizers use. Out of 160 soil samples, 7 samples (4.37 per cent) were found to be low, 73 samples (45.63 per cent) were medium and remaining 80 samples (50 per cent) were high in available K_2O content (Table 4). Similar results were also obtained for the soils of Patan district of Gujarat (Annual Report, 2013) [1, 2], in Gir Somnath district by Polara and Chauhan, (2015) [20], for Bhavnagar district (Rajput and Polara, 2012) and for Gandhinagar district of Gujarat (Patel *et al.*, 2017) [12].

Available sulphur status

Overall, available sulphur status for the Gandhinagar district was medium and varied from 6.74 to 36.06 mg/kg with a mean value of 18.97 mg/kg. On the basis of mean values, soils of Kalol taluka have the highest amount of available sulphur (20.88 mg/kg) and it was followed by Dehgam (19.25 mg/kg) and Mansa (18.74 mg/kg) talukas. While, soils of Gandhinagar taluka have the lowest mean value (17.01 mg/kg) of available sulphur. The medium status of sulphur in soils of Gandhinagar district might be due to use of S-bearing fertilizers such as ammonium sulphate and magnesium sulphate by the cultivators and cultivation of Sulphur loving oil seed crops**.** The data presented in table 6 indicated that available sulphur has significantly positive correlation (0.416**) with organic carbon. Out of 160 soil samples, 31 samples (19.38 per cent) were found to be low, 51 samples (31.88 per cent) were medium and remaining 78 samples (48.75 per cent) were high in available sulphur content (Table 4). Such medium status of available sulphur in soils of Banaskantha district was also recorded by Patel *et al.* (2012) [16], at fruit research station of Mangrol by Anon., (2008) [4]. Shirgire (2012) [12] observed similar results for soils of Jamnagar district of Gujarat. Singh *et al.* (2009) [27] reported similar results for the soils of Udham Singh Nagar district of Uttarakhand.

Nutrient index of available major nutrients

The nutrient indexes for available major nutrients are presented in Table 5. The fertility maps of available major nutrients in soils of Gandhinagar district (based on nutrient index) are presented in Table 5. Overall, soils of Gandhinagar district had nutrient indexes of 1.21, 1.97, 2.46 and 2.31 for available N, P_2O_5, K_2O and S, respectively. The highest nutrient index (1.43) for available N was reported in soils of Dehgam and it followed by Gandhinagar talukas (1.40). The highest nutrient indexes for available P_2O_5 were (2.12) in Dehgam taluka, K_2O and S were 2.70 and 2.43 in the soils of Kalol taluka, respectively. The lowest nutrient index of available N (1.07) and P_2O_5 (1.88) were found in Mansa taluka. The lowest nutrient index of available K_2O (2.25) and S (2.20) were found in soils of Dehgam and Gandhinagar talukas, respectively, Based on overall nutrient index of soils of Gandhinagar district and the criteria suggested by Stalin *et al.* (2010) the soils of Gandhinagar district have very low available N, marginal available P_2O_5, high in available K_2O and adequate in available S status. Similar results were reported for available nitrogen in soils of Amreli district of Gujarat (Polara and Babaria, 2006), for available phosphorus in soils of Patan district of Gujarat (Annual report, 2013) [1, 2], for available potassium in soils of Bhavnagar district of Gujarat (Rajput and Polara, 2012) and for available sulphur in soils of Gandhinagar district of Gujarat (Patel *et al.*, 2017) [12].

Table 5: Talukawise nutrient index and fertility status of available major nutrients in soils of Gandhinagar district

Name of Taluka	Nutrient index				Fertility status			
	N	P_2O_5	K_2O	S	N	P_2O_5	K_2O	S
Mansa	1.07	1.88	2.58	2.25	Very low	Marginal	Very high	Adequate
Kalol	1.17	1.97	2.70	2.43	Very low	Marginal	Very high	High
Gandhinagar	1.40	1.90	2.32	2.20	Very low	Marginal	High	Adequate
Dehgam	1.43	2.12	2.25	2.30	Low	Adequate	Adequate	Adequate
District	1.21	1.97	2.46	2.31	Very low	Marginal	High	Adequate

Correlation coefficient (r) among different properties of soils of Gandhinagar district

The correlation among different properties of soils (EC, pH, OC, available N, P_2O_5, K_2O, S, Fe, Mn, Zn and Cu) were worked out and their values are presented in Table 6. The data of correlation values indicates that positive correlations between organic carbon with available nitrogen (r = 0.096), Availability of nitrogen increases with organic carbon content in soil because it is a source of nitrogen. Similar results were also obtained for the soils of Tonk district of Rajasthan (Meena *et al.*, 2006) [12]. Negative correlation between EC and available nitrogen (r = -0.048) were observed. Available P_2O_5 (r = -0.109) showed negative correlation with soil pH which indicates that available P_2O_5 content in soil decreases with rise in pH. Similar results were also obtained for soils of Tonk district of Rajasthan (Meena *et al.*, 2006) [12]. Available S showed highly significant and positive correlation with OC (r = 0.416**) which indicated that available S increases with increasing organic carbon in soil. Singh *et al.* (2009) [27] reported similar results for Udham Singh Nagar district of Uttarakhand. Similar results were recorded for soils of De was district of Madhya Pradesh (Chouhan *et al.*, 2012) [7] and for Nagpur district of Maharashtra (Wagh *et al.*, 2016) [30].

Table 6: Correlation coefficient (r) among different properties of soils of Gandhinagar district

Soil properties	EC	pH	OC	Avail. N	Avail.P_2O_5	Avail. K_2O	Avail. S
pH	0.019						
OC	0.085	-0.610**					
Avail. N	-0.048	-0.021	0.096				
Avail. P_2O_5	-0.109	-0.369**	0.473**	0.052			
Avail. K_2O	0.144	0.039	0.021	-.054	0.023		
Avail. S	0.107	-0.283**	0.416**	0.111	0.322**	0.089	

*Significant at 5 per cent level** Significant at 1 per cent level

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