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Fertility evaluation of salt affected soils of Dholka taluka of *Bhal* region in Gujarat

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Abstract
The present study was carried out with an objective to evaluate fertility status of surface soil from salt affected area of Dholka taluka. Soil samples were analyzed for their physical and chemical properties. It was observed that average bulk density and particle density of soil were found 1.28 and 2.44 Mg m^{-3}, respectively. The lowest soil porosity was observed in Koth village (40.13%), while, highest value (56.77%) was recorded in Arnej with an average of 47.48%. In case of maximum water holding capacity (MWHC), it found 38.98%. The soils of Javaraj, Arnej, Anandpura, Koth, Ambareli and Dholi were comes under clay textural class. Vataman and Simej soils comes under clay loam and clay textural class whereas, loam textural class was observed in case of Khatripur and Bhetawada soils. The soil pH was found moderately alkaline and soil salinity (EC) was found 1.31 dS m^{-1} (tending to become saline). The soil organic carbon (SOC) was found 0.43% (medium). In case of different major nutrients, available nitrogen, P_2O_5, K_2O and S were 185 kg ha^{-1} (low), 23.08 kg ha^{-1} (low), 246 kg ha^{-1} (medium) and 7.7 ppm (medium), respectively. The exchangeable cations (Ca^{++}, Mg^{++}, K^{+} and Na^{+}) in the entire area were 15.5, 11.9, 0.53 and 8.1 me/100 g soil, respectively. Moreover, the DTPA extractable micronutrients (Fe, Mn, Zn and Cu) were 11.1 ppm (medium), 13.2 ppm (medium), 1.19 ppm (high) and 1.69 ppm (high), respectively. Simple correlations (r) of available S with Fe and Cu, available N with available P_2O_5, OC and Cu and available P_2O_5 with OC were found significantly positive at 0.05 level. Significantly positive correlations at 0.01 level were observed in case of available N with available K_2O, available S with OC, available N with available S and available P_2O_5 with Zn.

Keywords: Available nutrients, correlation, fertility, physical and chemical properties

1. Introduction
The demand of food, fodder and fuel is increasing for growing population but agricultural land is decreasing day by day due to conversion of non- agricultural uses and increase in extent of problematic soils (salinity/alkalinity/acidity/erodibility). According to an estimate, about 7.54 million hectare (Mha) of land is covered with salt affected soils in India (Mandal *et al*., 2010) [5]. Salt affected soils are quite prevalent in Bhal region of Gujarat. Salinity in this area is due to (i) weathering of the mineral either *in situ* or elsewhere and subsequent transport and accumulations, (ii) inherent salinity, as this area remained under the sea for a long period and high saline water table has made the agricultural lands saline and (iii) lateral sea water intrusion in the lower aquifer. Presently, the crops *viz.,* cotton and sorghum are sown on upland and the low lying area are kept for growing *rabi* crops like wheat and gram on conserved moisture. This area will shortly be irrigated by Narmada canal which will bring changes in the soil and water situations. In view of the above scenario, the present study was undertaken to generate the information on the characteristics of soil with respect to constraints *viz.,* soil salinity for crop production. The study would help in planning strategies for different farming practices and irrigation management for improving the agricultural productivity and to check further degradation of the soils.

2. Materials and Methods
The Dholka taluka situated between $22^0$25'-$22^0$60' N latitude and $72^0$32' – $72^0$50' E longitude in the very popular flat area known as *Bhal* track in the middle of Gujarat state. The climate of this track can be classified as a *hot steppe* one characterized by a distinct monsoon period. The rainfall is primarily received during monsoon (400-800 mm), through a few occasional showered during May and October is not an uncommon behaviour. The average rainfall is about 600 mm. The annual mean maximum temperature is 42 ºC, and minimum temperature 10 ºC. Mean relative humidity is 35 percent. January and February are the coldest months

while May and June are the hottest months. During the summer months, hot wind with dust storms is the characteristics feature of this area. This area has *ustic* soil moisture regime.

In general, the ground water in the area is found at shallow soil depth. However, the depth varies from one place to another. Ground water in the Dholka taluka occurs under confined and unconfined aquifers. The North-East portion of the taluka is more suitable for groundwater development while waterin southern and western area is saline and unsuitable for irrigation. The aquifer above 70 meters is saline and has TDS 2500-3300 ppm. The value of transmissibility varies from 3.9 to 9.2 m day^{-1}.

Ten villages namely, Simej, Ambareli, Khatripur, Koth, Javaraj, Arnej, Bhetawada, Dholi, Anandpura and Vataman of *Bhal* region of Dholka taluka were studied for their physical and chemical properties. Soil samples were collected and analysed in the laboratory as per standard methods of Rechards (1954) [9]. Soils were classified as per USDA system. Processed soil samples were analysed for particle size distribution by using method given by Piper (1968) [8]. The organic carbon, electrical conductivity, pH, available N, P, K and S were determined as per methods described by Jackson (1973) [2]. The available micronutrients were extracted with DTPA (0.005 M DTPA + 0.01 M $CaCl_2$ + 0.1 M triethanolamine, pH 7.3) as per method described by Lindsay and Norvell (1978) [3].

3. Results and Discussion

3.1 Physical properties

The results revealed that for the entire area, the bulk density (Table 1) of soil ranged from 1.11 to 1.39 Mg m^{-3} with an average of 1.28 Mg m^{-3}. From the results, it was observed that lowest BD recorded from the Arnej (1.11 Mg m^{-3}) and highest from Javaraj (1.39 Mg m^{-3}). Similar results were also reported by Maji *et al*. (2005) [4]. They stated that the variation in bulk density of these shrink-swell soils might be attributed to the moisture content and high content of expanding type of clay minerals present. While the particle density of soil ranged from 2.25 to 2.57 Mg m^{-3} with an average of 2.44 Mg m^{-3}. In all villages particle density recorded highest as 2.57 Mg m^{-3} except Anandpura.

The lowest soil porosity was observed in Koth village and it recorded 40.13%, while, highest value (56.77%) of porosity was recorded in Arnej with an average of 47.48% (Table 1). However, major soils having almost same range of porosity. Results were in good agreement with findings of Patel (2010) [6] as they reported that the porosity ranged from 34.43 to 47.76% in the soils of different land slopes of Meghal irrigation command area in southern saurashtra of Junagadh district. In case of maximum water holding capacity (MWHC), it was ranged from 22.82 to 48.31% with an average of 38.98%. The lowest and highest values recorded from Koth and Vataman village (Table 1), respectively. Wide variation in porosity was not observed amongst the villages.The results are strongly supported by the findings of Thangasamy *et al*. (2005) [13] in soil of Chittoor district of Andhra Pradesh.

The % coarse sand, % fine sand, % silt and % clay (Table 1) contents were ranged from 1.82 to 14.25%, 7.54 to 33.56%, 21.96 to 47.50% and 21.56 to 58.20% with an average of 4.56, 18.25, 34.08 and 43.11%, respectively. Majority of soils having almost same range of % fine sand, % silt and % clay content in entire area. From an above investigation, it was found that soils of Javaraj, Arnej, Anandpura, Koth, Ambareli and Dholi comes under clay textural class. Vataman and Simej soils comes under clay loam and clay textural class whereas, loam textural class was observed in case of Khatripur and Bhetawada soils.

3.2 Chemical properties

As the soil pH was concerned, it was varied from 7.35 to 8.82 (mildly alkaline to very strongly alkaline) with an average of 7.88 *i.e.* moderately alkaline in nature (Table 2). As soils comes under 'moderately to very strongly alkaline' category might face deficiencies of several nutrients including phosphorus, iron and zinc, therefore measures should be taken to tide over such deficiencies of nutrients for possible enhancement of crop production. Thus, higher precautionary measures would be needed for soils comes under low land area *i.e.*, Simej, Koth, Javaraj, Arnej, Dholi and Vataman and soils comes under upland area *i.e.*, Ambareli, Khatripur, Bhetawada and Anandpura. The soil salinity (EC) for the entire salt affected area of Dholka taluka of *Bhal* region was varied from 0.13 to 5.80 dS m^{-1} (low to highly saline) with an average of 1.31 dS m^{-1} (tending to become saline). The lowest salinity was observed in Javaraj village while highest salinity was recorded in Koth area. *i.e.*, tending to become saline which indicated saline range as of now, and hence precautionary measures would be required to combat soil salinity hazard. The wide variation of soil EC might be due to the different concentration of basic cations. Similar results were also reported by Athokpam *et al.* (2013) [1] and Vijayakumar and Haroon (2013) [14].

The soil organic carbon (SOC) was found to be vary from 0.23 to 0.69% (low to medium) with an average of 0.43% (medium) in the surface soils of entire salt affected area of *Bhal* region (Table 2). Nearly all soil samples were either low or medium status in SOC and thus would require urgent attention for improvement of its low status through special management including incorporation of manures for sustaining soil health. These results were supported by the findings of Shinde *et al*. (2014) [10] reported that surface soils of Sarvar village in Dangs district, were low to high SOC status.

The exchangeable cations (Ca^{++}, Mg^{++}, K^{+} and Na^{+}) in the entire surface soils were ranged from 10.1 to 25.6 me/100 g soil, 5.1 to 16.9 me/100 g soil, 0.10 to 1.14 me/100 g soil and 1.9 to 19.7 me/100 g soil with an average of 15.5, 11.9, 0.53 and 8.1 me/100 g soil, respectively (Table 2). Major soils having almost same range of Ca^{++}, Mg^{++}, K^{+} and Na^{+} content. The results were supported by the finding of Soltani *et al.* (2015) [12].

3.3 Nutrient Status

3.3.1 Macronutrients

In case of different macronutrients (Table 3), available nitrogen, P_2O_5, K_2O and S were varied from 141 to 235 kg ha^{-1} (low), 3.98 to 50.41 kg ha^{-1} (low to medium), 184 to 310 kg ha^{-1} (medium to high) and 2.0 to 19.2 ppm (low to medium) with mean value of 185 kg ha^{-1} (low), 23.08 kg ha^{-1} (low), 246 kg ha^{-1} (medium) and 7.7 ppm (medium), respectively. In surface soils, availability of nitrogen is low due to low availability of organic matter which reduce the microbial activity. Availability of phosphorus reduced due to it react with basic cations in soil and form the stable form. The results clearly suggested that emphasis should be given for appropriate management of available macronutrients status of these soils particularly to overcome problems of its low availability through application of more organic manures,

biofertilizers in combination with regular and proper chemical fertilizer schedule. Results of available nitrogen, phosphorus, potassium and sulphur were supported by the findings of Shinde *et al*. (2014) [10] in surface soils of Sarvar village of Dangs district and Singh *et al*. (2014) [11] in ravenous land in Chambal region of Madhya Pradesh.

3.3.2 Micronutrients

The DTPA extractable micronutrients (Fe, Mn, Zn and Cu) were varied from 2.6 to 32.4 ppm (low to high), 2.2 to 31.9 ppm (low to high), 0.22 to 2.82 ppm (low to high) and 0.44 to 3.92 ppm (medium to high) with an average of 11.1 ppm (medium), 13.2 ppm (medium), 1.19 ppm (high) and 1.69 ppm (high), respectively (Table 3). Results were in the same line as mentioned by Patil and Mukhopadhyay (2011) [7] in soils of different areas on DTPA-extractable micronutrients.

3.4 Correlation status

Among physical and chemical parameters of surface soils from entire salt affected area of Dholka taluka, the simple correlations (r) of available S with Fe and Cu, available N with available P_2O_5, OC and Cu and available P_2O_5 with OC were found significantly positive at 0.05 level. Significantly positive correlations at 0.01 level were observed in case of available N with available K_2O, available S with OC, available N with available S and available P_2O_5 with Zn. Results were supported by the findings of Athokpam *et al*. (2013) [1].

4. Conclusions

Soils of Javaraj, Arnej, Anandpura, Koth, Ambareli and Dholi comes under clayey textural class. Vataman and Simej falls under clay loam and clay textural class, while loam textural class was observed in case of Khatripur and Bhetawada soils. Entire areas comes under moderately alkaline in pH and saline in nature. Organic carbon in the entire area comes under medium status. Available macronutrients *i.e.*, N, P_2O_5, K_2O and S comes under low, low, medium and low status, respectively. Whereas, micronutrients like Fe, Mn, Zn and Cu falls under medium, medium, high and high categories, respectively.

Table 1: Physical properties of surface soil of entire studied area

Village	BD	PD	Porosity (%)	MWHC (%)	Textural composition (%)			
	Mg m^{-3}				Coarse sand	Fine sand	Silt	Clay
Simej (CL & C)	1.21-1.31 (1.28)	2.25-2.57 (2.42)	43.3-51.0 (46.8)	32.86-40.11 (36.59)	1.82-5.15 (3.48)	28.8-33.56 (31.6)	30.6-33.9 (32.1)	29.3-35.4 (32)
Ambareli (C)	1.21-1.33 (1.27)	2.32-2.57 (2.43)	44.7-50.8 (47.5)	27.89-42.41 (36.75)	3.12-7.98 (4.59)	9.8-21.6 (14.4)	27.4-35.3 (30.8)	42.2-58.2 (49.9)
Khatripur (L)	1.21-1.31 (1.25)	2.32-2.57 (2.43)	45.9-52.5 (48.2)	38.13-45.11 (40.89)	2.16-11.23 (6.24)	20.7-32.4 (27.5)	30.6-47.5 (39.2)	22.6-31.8 (26.6)
Koth (C)	1.31-1.38 (1.36)	2.32-2.57 (2.44)	40.1-46.9 (44.2)	22.82-37.83 (31.36)	3.12-5.64 (4.37)	9.8-17.6 (12.4)	27.4-37.3 (31.8)	40.7-58.2 (51.1)
Javaraj (C)	1.22-1.39 (1.27)	2.31-2.57 (2.43)	44.5-49.6 (47.7)	34.99-42.86 (40.11)	2.88-5.64 (3.92)	9.8-19.9 (12.8)	28.9-37.9 (33.1)	44.9-58.2 (49.9)
Arnej (C)	1.11-1.19 (1.14)	2.31-2.57 (2.43)	49.9-56.8 (53.1)	34.99-42.86 (40.42)	3.12-7.98 (4.70)	9.8-18.9 (12.6)	27.4-37.3 (31.3)	42.2-58.2 (51)
Bhetawada (L)	1.32-1.37 (1.33)	2.31-2.57 (2.43)	42.3-48.8 (45)	34.99-42.86 (40.56)	2.16-9.23 (4.89)	21.3-26.1 (25.2)	43.9-46.5 (45.6)	21.6-25.5 (24.1)
Dholi (C)	1.23-1.32 (1.28)	2.32-2.57 (2.44)	43.3-50.7 (47.6)	42.66-43.86 (43.31)	3.12-14.25 (6)	7.5-17.6 (12)	21.96-35.3 (30.3)	48.4-58.2 (51.3)
Anandpura (C)	1.28-1.33 (1.30)	2.32-2.51 (2.43)	44.2-48.9 (46.4)	37.86-44.70 (42.27)	2.9-10.9 (5.4)	9.8-21.6 (16)	27.4-42.2 (34.3)	35.2-50.9 (44.2)
Vataman (CL & C)	1.25-1.28 (1.27)	2.31-2.57 (2.43)	44.5-50.7 (47.6)	41.50-48.31 (45.48)	3.12-7.98 (4.47)	9.8-18.9 (11.9)	27.4-35.3 (31)	42.2-58.2 (52.3)
Overall	1.11-1.39 (1.28)	2.25-2.57 (2.44)	40.13-56.77 (47.48)	22.82-48.31 (38.98)	1.82-14.25 (4.56)	7.54-33.56 (18.25)	21.96-47.50 (34.08)	21.56-58.20 (43.11)

*C- Clay textural class, L- Loamy, CL- Clay loam., *Values in parenthesis indicates mean value

Table 2: Chemical properties of surface soils of entire study area

Village	pH (1:2.5)	EC (dS m^{-1})	OC (%)	Exchangeable cations (me/100 g soil)			
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}
Simej	7.47-8.41 (7.83)	1.48-3.24 (2.25)	0.23-0.39 (0.33)	12.2-15.0 (13.9)	10.4-12.8 (11.4)	0.27-0.59 (0.42)	4.9-7.4 (6.0)
Ambareli	8.17-8.82 (8.33)	0.21-0.36 (0.29)	0.23-0.39 (0.33)	12.2-14.9 (13.8)	10.1-13.1 (11.5)	0.17-0.50 (0.28)	4.8-8.9 (6.0)
Khatripur	7.36-8.05 (7.65)	1.20-5.80 (3.56)	0.51-0.69 (0.61)	11.0-13.9 (12.2)	5.1-8.2 (6.7)	0.10-0.61 (0.37)	1.9-4.6 (3.0)
Koth	7.55-7.92 (7.70)	0.23-0.79 (0.38)	0.26-0.39 (0.32)	19.2-21.9 (20.8)	10.9-13.1 (12.2)	0.26-0.56 (0.37)	5.1-8.2 (6.8)
Javaraj	7.35-8.21 (7.79)	0.13-0.56 (0.32)	0.31-0.48 (0.41)	13.1-14.9 (14.1)	14.7-16.9 (15.8)	0.32-1.10 (0.56)	10.9-13.1 (12.2)
Arnej	7.87-8.24 (8.03)	0.17-0.55 (0.27)	0.33-0.48 (0.42)	13.1-16.3 (14.2)	14.7-16.8 (15.8)	0.50-0.75 (0.64)	10.4-12.3 (11.1)
Bhetawada	7.49-8.26 (7.93)	0.38-4.20 (2.24)	0.33-0.48 (0.41)	11.0-13.9 (12.4)	5.1-8.2 (6.7)	0.17-0.47 (0.32)	1.9-4.6 (3.0)
Dholi	7.61-8.25 (7.99)	0.36-0.66 (0.45)	0.48-0.61 (0.55)	17.1-21.9 (20.6)	10.9-13.1 (12.1)	0.45-0.78 (0.54)	5.1-9.4 (7.2)
Anandpura	7.50-7.88 (7.69)	0.28-1.47 (0.68)	0.48-0.61 (0.55)	10.1-14.6 (12.3)	14.7-16.9 (15.8)	0.48-0.63 (0.54)	14.9-19.7 (16.2)
Vataman	7.49-7.78 (7.66)	1.14-2.90 (1.62)	0.33-0.49 (0.43)	19.2-25.6 (21.6)	10.4-12.3 (11.1)	0.68-1.14 (0.83)	5.2-8.6 (7.1)
Overall	7.35-8.82 (7.88)	0.13-5.80 (1.31)	0.23-0.69 (0.43)	10.1-25.6 (15.5)	5.1-16.9 (11.9)	0.10-1.14 (0.53)	1.9-19.7 (8.1)

*Values in parenthesis indicates mean value

Table 3: Macro and micronutrients status of surface soils of entire study area

Village	Macronutrients (kg ha^{-1})				Micronutrients (ppm)			
	Av. N	Av. P_2O_5	Av. K_2O	S (ppm)	Fe	Mn	Zn	Cu
Simej	141-188 (174)	18.0-45.0 (35.2)	187-291 (241)	4.3-9.6 (7.3)	2.6-5.3 (4.0)	12.8-27.0 (17.9)	1.36-2.56 (1.91)	0.76-1.74 (1.35)
Ambareli	172-235 (20.6)	15.0-28.9 (21.4)	198-264 (233)	4.2-8.7 (6.2)	8.3-18.3 (13.7)	3.3-6.1 (4.1)	0.84-1.88 (1.33)	0.44-0.72 (0.52)
Khatripur	157-235 (195)	4.0-24.5 (13.9)	225-297 (263)	2.6-8.9 (5.2)	11.2-32.4 (19.0)	6.7-31.9 (20.6)	0.80-2.82 (0.80)	1.32-3.92 (2.48)
Koth	157-220 (195)	11.2-19.8 (15.9)	187-244 (219)	2.1-6.2 (3.8)	5.1-18.7 (9.3)	4.5-19.9 (12.0)	0.22-0.88 (0.56)	0.70-2.22 (1.32)
Javaraj	188-235 (206)	14.3-42.6 (32.5)	225-292 (251)	10.8-19.3 (15.0)	3.3-8.9 (6.6)	2.2-9.6 (6.5)	0.34-1.64 (0.78)	0.88-3.84 (1.71)
Arnej	141-188 (166)	10.3-22.8 (18.2)	225-289 (253)	2.4-5.5 (3.5)	6.4-8.7 (7.7)	4.5-10.5 (6.4)	0.52-0.82 (0.66)	1.00-1.52 (1.20)
Bhetawada	157-204 (182)	14.6-26.8 (19.8)	184-266 (235)	4.1-8.6 (6.1)	3.3-8.8 (5.2)	15.7-28.2 (21.4)	0.30-2.04 (0.80)	0.80-1.60 (1.15)
Dholi	157-220 (192)	14.3-25.4 (19.8)	210-284 (248)	3.5-8.8 (5.6)	8.0-10.6 (9.6)	5.0-25.3 (10.9)	0.68-1.06 (0.79)	1.2-1.7 (1.5)
Anandpura	157-188 (174)	12.3-27.8 (19.1)	245-310 (275)	4.4-9.8 (6.6)	8.2-10.6 (9.4)	8.6-15.8 (11.3)	0.26-1.54 (1.12)	1.44-1.72 (1.56)
Vataman	157-204 (179)	33.6-50.4 (41.9)	210-298 (257)	12.6-19.0 (15.7)	17.8-25.2 (20.8)	9.6-16.8 (12.6)	1.12-2.08 (1.67)	2.68-3.62 (3.03)
Overall	141-235 (185)	4.0-50.41 (23.08)	184-310 (246)	2.1-19.3 (7.7)	2.6-32.4 (11.1)	2.2-31.9 (13.2)	0.22-2.82 (1.19)	0.44-3.92 (1.69)

*Values in parenthesis indicates mean value

Table 4: Simple correlation among different parameters of surface soils

Parameters	Correlation (r)	Parameters	Correlation (r)
Available S × Fe	0.608*	Available N x Available S	0.993**
Available S × Cu	0.558*	Available P_2O_5 x Zn	0.967**
Available N x Available P_2O_5	0.933*	pH x Fe	-0.890*
Available N x OC	0.896*	pH x Zn	-0.947*
Available N x Cu	0.898*	EC x OC	-0.889*
Available P_2O_5 x OC	0.894*	EC x Fe	-0.949*
Available N x Available K_2O	0.974**	BD × Porosity	-0.725**
Available S x OC	0.967**		

** and * denote significant correlation at 0.01 level and 0.05 level, respectively

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