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Mapping of soil macro and secondary nutrients by GIS in Sakri Tehsil of Dhule district (M.S.)

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Abstract

A study was conducted to assess available macro and secondary nutrient status of soils of Sakri Tehsil of Dhule District by GIS technique. 225 soil samples (0-22.5 cm) drawn during 2014 from the 75 villages were analyzed for their fertility status and mapped by geographic information system (GIS) technique. The exact locations of soil samples were recorded with the help of GPS. The results indicated that all samples were slightly acidic to moderately alkaline in soil reaction (5.70-8.37), non-saline (0.11 -0.97dS m^{-1}), very low to high in organic carbon (2.10-9.30 g kg^{-1}) and calcium carbonates ranged from (1.25-19.5%). Regarding to macro and secondary nutrients, the available N, P and K ranged between 87.89-297.06 kg ha^{-1}, 4.57-22.96 kg ha^{-1} and 154.8-560 kg ha^{-1}, respectively, whereas, exchangeable Ca and Mg was sufficient in soils and available S is ranged between 8.13- 45.25 mg kg^{-1} which was slightly deficient to sufficient in soil. The use of GPS-GIS based technique for soil sampling is new land mark, which will enable the further researchers and University Officials to monitor the changes in soil fertility status for years to come.

Keywords: macronutrients, secondary nutrients, soil fertility maps, GPS-GIS technique

Introduction

Soil is the mother for supporting and nourishing all life on the earth termed as ‘soul of infinite life’. Its proper use generally determines the capability of life support system and socio-economic development of any nation. The tremendously growing population in the country is an acute problem that demands maximum possible output of food, fibre and fuel from each unit of cultivated land area per unit time. Soil test results of one farm need to have scope to be connected with the broader population of all farms in a given area. The ideal situation would be to sample every farm to get soil fertility status of all the farms, but we are not be able to sample each farm in the population, because it is too costly, troublesome and time consuming, especially with the multiple small farms holding in many developing countries. We thus, need to generalize results of sample farms to get information of entire area. For the periods between 1975 to 1980, soil fertility maps for nitrogen, phosphorus and potassium were prepared using soil test data generated by soil testing laboratories that functioned throughout the country. The recent technologies like Geographic Information System (GIS) and Global Positioning System (GPS) thus have much to offer for preparing soil fertility maps. Soil chemical and physical properties vary within a single field. Spatial tools like GPS and GIS for storing and analyzing spatial data can help us to make better decisions in agriculture particularly land development, environmental protection and restoration (Burrough and McDonnell, 1998) [2]. In precision agriculture, farmer’s uses GPS and GIS as yield monitors and variable rate technology to apply appropriate quantities of input in different parts of field. GPS-GIS are advanced tool for studying on site specific nutrient management which can be efficiently use for monitoring soil fertilization in Sakri Tehsil of Dhule district (M.S.) and would be useful for ensuring balanced fertilization to crops.

Materials and Methods

Study area

Sakri Tehsil is located in between 20°59’0’’ North latitude and 74°19’0” East longitude. The total geographical area of Sakri Tehsil is 2, 44,110 ha and situated 55 km away from Dhule city at the western side, Maharashtra State, coinciding with Nashik and Nandurbar District (Fig. 1).

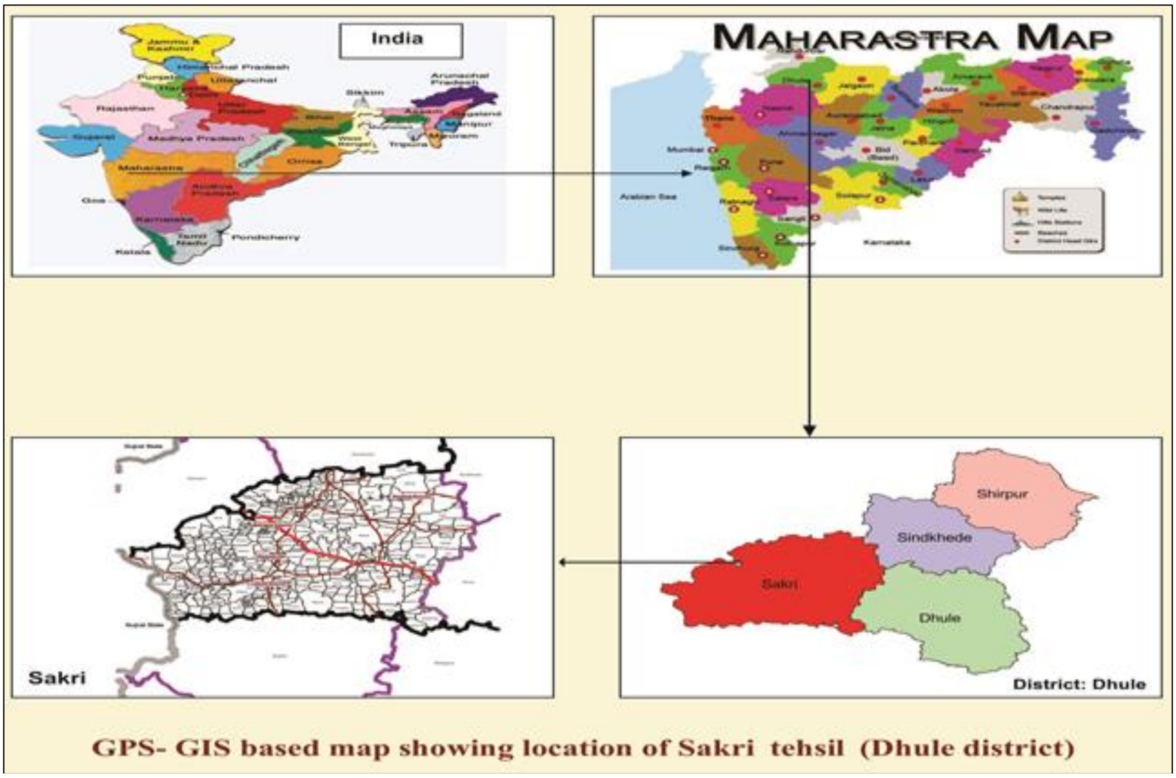


Fig 1: Location of Sakri Tehsil

Soil characteristics

Soils are resultant of the igneous rocks *viz*. basalt (Deccan trap) which is basic in nature containing mainly feldspars (plagioclase), augite and small amount of titaniferrous magnetite mineral. In the vesicular rocks cavities are filled with minerals like zeolite and quartz and the soils are black, medium black, shallow, red and calcareous types having different depth and profiles which occupies area in hectors as follows 108724 ha in black soil, 72483 ha in red soil, 28983 ha in sandy loam and 31421 ha other types.

Climate

The climate of Sakri Tehsil is warm and dry. Agro-climatically, Sakri comes under 1) Scarcity zone: Scarcity includes eastern part of Sakri having erratic rainfall 500 mm and light tone medium soils and 2) Transition II: Western part of Sakri Tehsil having 700-750 mm rainfall and light to medium soil. The annual average maximum and minimum temperature was 42 ^{0}C and 6.5 ^{0}C, respectively. The area therefore, qualified for "hyperthermic" temperature regime.

Land use and natural vegetation

The total geographic area of Sakri Tehsil is 2, 44,110 ha. Area under forest, area under cultivation, area not available for cultivation, fallow land and area not cultivated other than fallow in per cent to the total geographic area is 30.18, 45.59, 11.85, 1.78 and 10.60 per cent, respectively. The main agronomical crops are grown in kharif season viz. cotton, sorghum, bajra, maize, soybean, green gram, red gram. The crops are grown in rabi season viz. wheat, maize, gram and chilli etc. The area under kharif and rabi season are 76,547 and 24,574 ha, respectively. The main horticultural crops viz., fruits like papaya, banana, ber, custard apple, pomegranate, citrus, guava, lemon and vegetables are onion, chilli, etc. The area under fruits and vegetables is 4,150 and 3,800 ha, respectively. The natural vegetation consists of dry deciduous tree species (Eucalyptus, neem etc.). Other trees like Dhawada, Shisam, Khair, Tendu, Palas, Anjan, and Bamboo are observed in this region.

Soil sample collection and analysis

A systematic survey was carried out and a surface (0-22.5 cm depth) soil samples were collected from 225 sites of 75 villages (Fig. 2). Three soil samples of soil order shallow, medium and deep from each village were collected and the exact sample location was recorded using a GPS.

Soil samples were analyzed for chemical characteristics by following standard analytical techniques. Soil reaction was determined in 1:2.5 suspension using standard pH meter by potentiometry (Jackson, 1973) [6]. The electrical conductivity was determined by 1:2.5 suspension using EC meter by Conductometry (Jackson, 1973) [6]. Soil organic carbon was estimated using wet oxidation method (Nelson and Sommer, 1982) [9] and $CaCO_3$ is determined by Acid neutralization method by Alison and Moodie (1965) [1]. Soil available N determined by modified alkaline permanganate method (Subbiah and Asija, 1956) [16], available P by 0.5M $NaHCO_3$ method (Watanabe and Olsen, 1965) [17] and available K by flame Photometer (N*N*NH_4OAc pH (7.0) method (Jackson, 1973) [6]. Available S determined by 0.15% $CaCl_2$ extractable method described by William and Steinberg (1969) and exchangeable Ca and Mg determined by versenate titration method given by Hoffman and Shapiro (1954) [5].

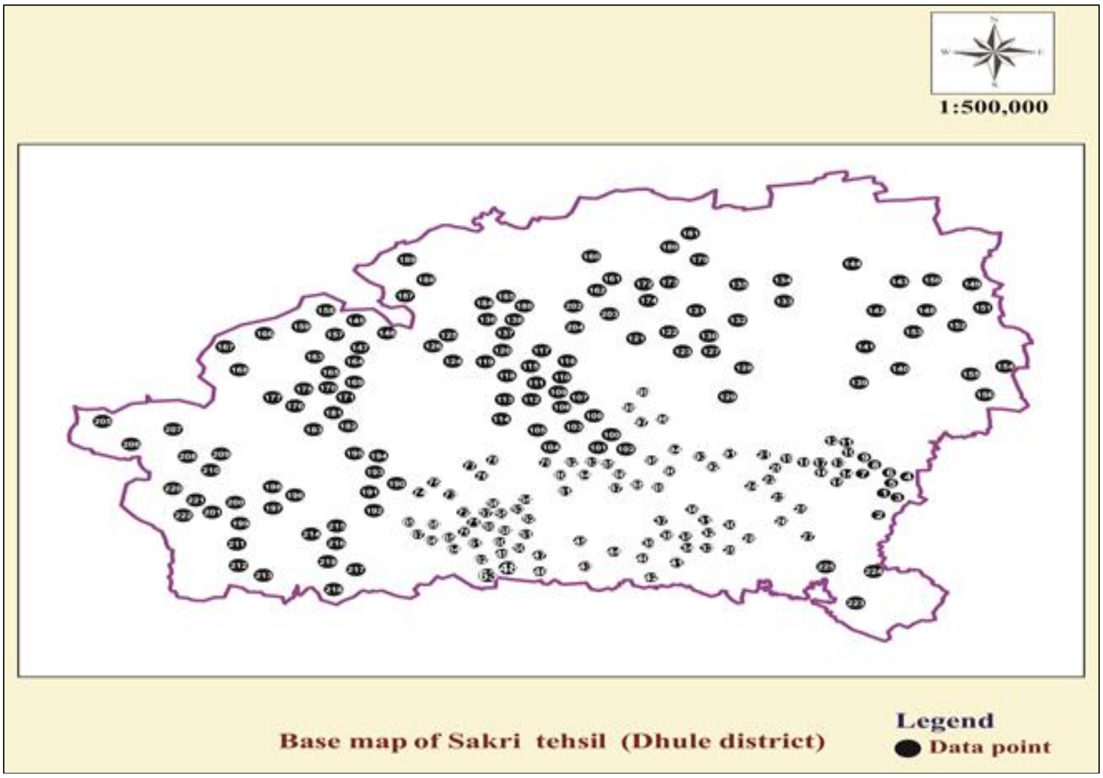


Fig 2: Base map of Sakri Tehsil

Generation of maps

The delineation of the area for different nutrient levels of soils and their extent of area were calculated and mapping was carried out by using Arc-GIS 9, version 9.3 software.

Statistical analysis

The soil chemical properties data were statistically analyzed by using standard statistical methods given by Panse and Sukhatme (1985) [10].

Results and Discussions

Soil pH, EC, organic carbon and calcium carbonate

The pH of the Sakri Tehsil ranges from 5.70 to 8.37. The mean of pH was 7.79, were slightly acidic to moderately alkaline in reaction. Similar nature of observation for soil pH were also recorded by Mahashabde and Patel (2012) [7] in soils of Shirpur Tehsil of Dhule District. The EC was ranged from 0.11 to 0.97 dSm^{-1} with mean value was 0.28 dSm^{-1}. It is observed that all 225 soils (100%) were non saline in nature. The similar results were reported by Golhar and Chaudhari (2013) [4] at Chalisgaon Tehsil of Jalgaon District, Maharashtra. The normal values of EC are recorded for upstream and topographically higher areas can be attributed to the rolling topography relatively higher gradient, seasonal irrigation and alternating cropping pattern. The organic carbon content ranged from 2.10 to 9.30 g kg^{-1} with the mean of 5.56 g kg^{-1} and calcium carbonate were ranged from 1.25 to 19.5 per cent with an average of 8.15 per cent. The soils were low to high in organic carbon and moderate to very high in calcium carbonate (Table 1 and Fig. 3). The similar nature of observations were recorded by Ghuge (2002) in Vertisols, Inceptisols and Entisols of Ujana (Ahmadpur), Marathwada region. Soils from the area are formed from basaltic and alluvium lithology under semi-arid climatic condition, characterized by low precipitation and high rate of evaporation favoring more accumulation and precipitation of $CaCO_3$.

Table 1: Soil pH, EC, Organic Carbon and $CaCO_3$ status of Sakri Tehsil

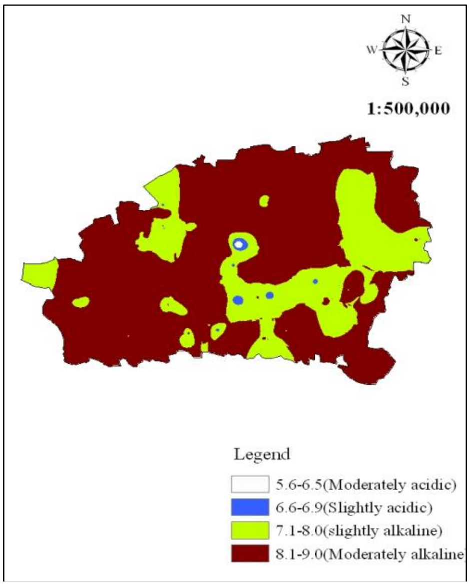
Particulars	pH	EC (dSm^{-1})	Organic Carbon (g kg^{-1})	$CaCO_3$ (%)
Mean	7.79	0.28	5.56	8.15
Range	5.70-8.37	0.11-0.97	2.10-9.30	1.25-19.5
SE±	0.03	0.01	0.09	0.19

Soil available N, P, and K

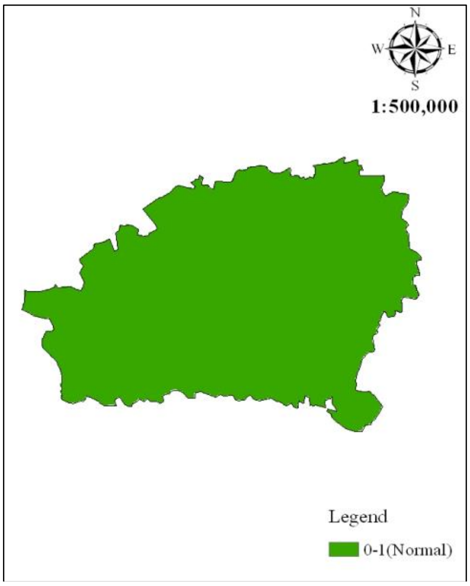
The available nitrogen values in soils varied from 87.81 to 279.06 kg ha^{-1} with an average of 174.92 kg ha^{-1}, available phosphorus in soils were ranged from 4.57 to 22.96 kg ha^{-1} with an mean value of 14.76 kg ha^{-1} and available potassium in soils was ranged from 154.8 to 560 kg ha^{-1} with an average of 346.73 kg ha^{-1}. The soils were categorized as very low to low in available nitrogen, very low to moderately high in available phosphorus and moderate to very high in available potassium (Table 2 and Fig. 3). The similar trends of results were recorded by Shinde and Phalke (2013) [15] at soil from Godavari basin of Beed, Maharashtra and Ratnakumari *et al.* (2006) [14] in soils Guntur District of Andhra Pradesh. The low available nitrogen in most of the soils might be due to the higher temperature in semiarid climate of Sakri Tehsil, which might have increased the rate of denitrification resulted in low status of available nitrogen. Low status of available P in soils of studied area might be due to alkaline soil reaction and high content of $CaCO_3$ in the soil. At the higher pH calcium can precipitate with P as Ca-phosphate and reduce phosphorus availability. At low pH, due to low CEC and low clay content reduction in P availability was observed. The available potassium content in major portion of the study area was in high category. Black soils were higher in available K status than red soils which may due to predominance of K rich micaceous and feldspars minerals in parent material.

Table 2: Soil available N, P and K status of Sakri Tehsil

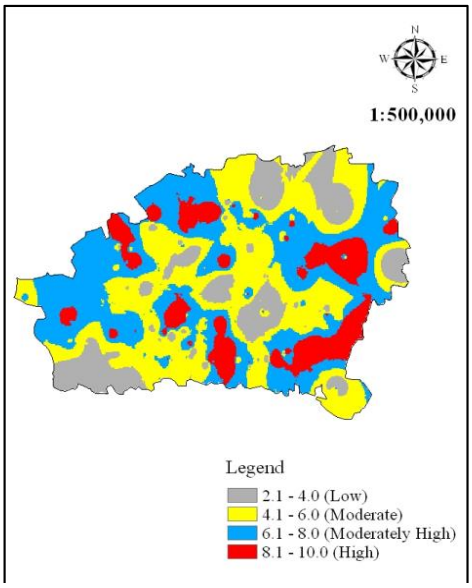
Particulars	Available Nutrients (kg ha^{-1})		
	N	P	K
Mean	174.92	14.96	346.73
Range	87.81-279.06	4.57-22.96	154.8-560
SE±	2.56	0.27	5.35



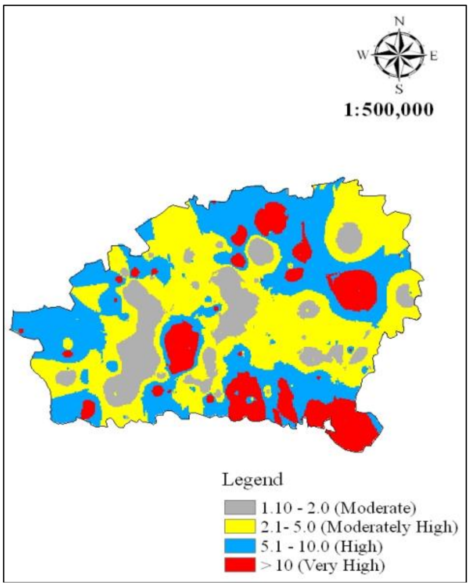
Soil pH



Soil Electrical Conductivity (dSm^{-1})



Soil Organic Carbon (g kg^{-1})



Soil Calcium Carbonate (%)

Fig 3: Soil pH, EC, organic c and calcium carbonate status of Sakri tehsil

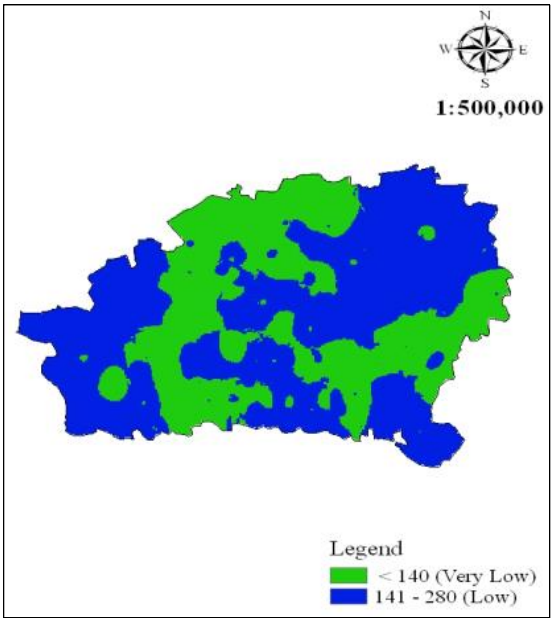
Soil exchangeable Ca^{++}, Mg^{++} and available S

The exchangeable calcium in soils ranged from 20.58 to 46.50 cmol (+) kg^{-1} with an average of 27.92 cmol (+) kg^{-1}, exchangeable magnesium in soils were ranged from 10.73 to 36.07 cmol (+) kg^{-1} with an average of 16.86 cmol (+) kg^{-1} and available sulphur in soils ranged from 8.13 to 45.25 mg kg^{-1} with an average of 23.93 mg kg^{-1} (Table 3 and Fig. 4). The soils of Sakri Tehsil were sufficient in exchangeable calcium and magnesium. However, out of all soil samples, 93.33 per cent soils were sufficient and 6.67 per cent were deficient in available sulphur. The similar results were observed by Prasad *et al*. (2006) [12] in swell-shrink orange cropped soils of Nagpur District, Nayak *et al.* (2006) [8] in swell and shrink soils of Vertisol order in Vidarbha and Patel *et al.* (2014) [11] at different villages of Kutch District of Gujrat. The higher amount of exchangeable Ca content found in soils under study may be due to high clay content and calcareous nature. The sufficiency of exchangeable Ca and Mg is due to no leaching of bases and moderate to high organic carbon values. At high pH and calcareousness, sulphur availability is greater in the soil and at low OC available sulphur content is low. Similar observations were reported by Pulakeshi *et al*. (2012) [13].

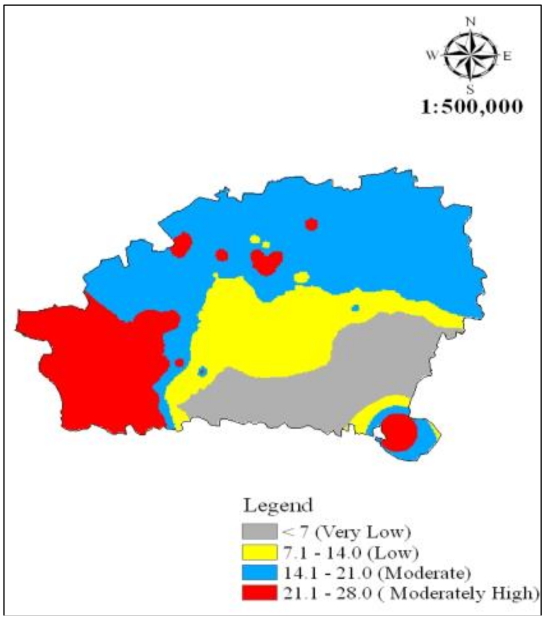
Table 3: Exchangeable Ca^{++} and Mg^{++} and available S status of soils of Sakri Tehsil

Particular	Exchangeable Ca^{++} (cmol (+) kg^{-1})	Exchangeable Mg^{++} (cmol (+) kg^{-1})	Available S (mg kg^{-1})
Mean	27.92	16.86	23.93
Range	20.58-46.50	10.73-36.07	8.13-45.25
Critical limit	20	10	10
Deficient	0 (0.00)	0 (0.00)	15 (6.67)
Sufficient	225 (100)	225 (100)	215 (93.33)
SE±	0.31	0.30	0.64

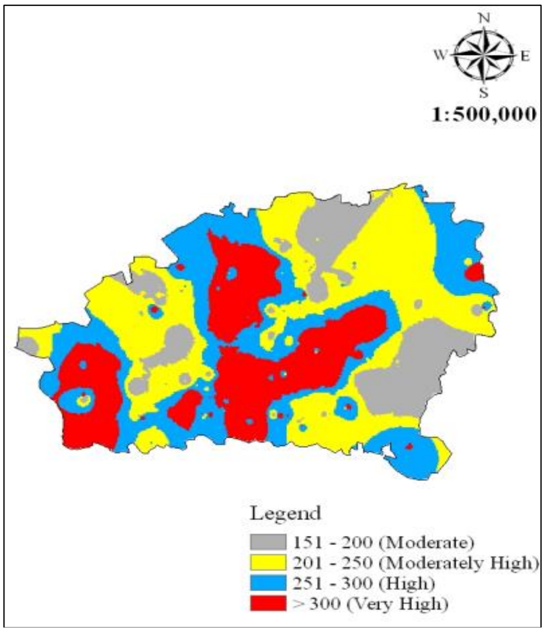
Note: Total number of soil samples analysized-225, figures in parenthesis expressing per cent value.



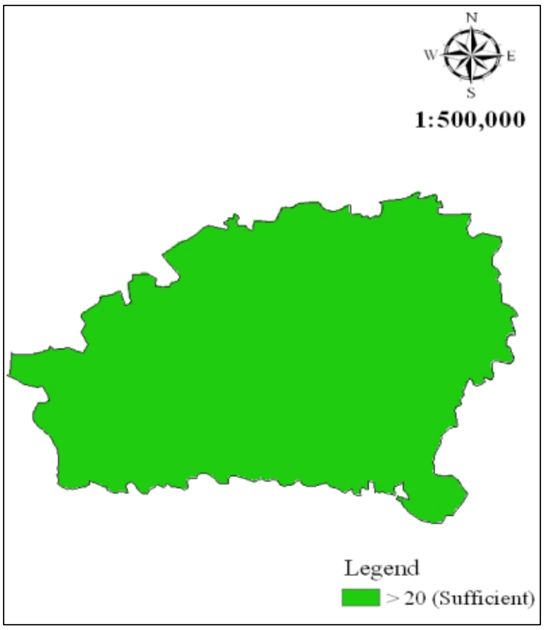
Soil available Nitrogen (kg ha^{-1})



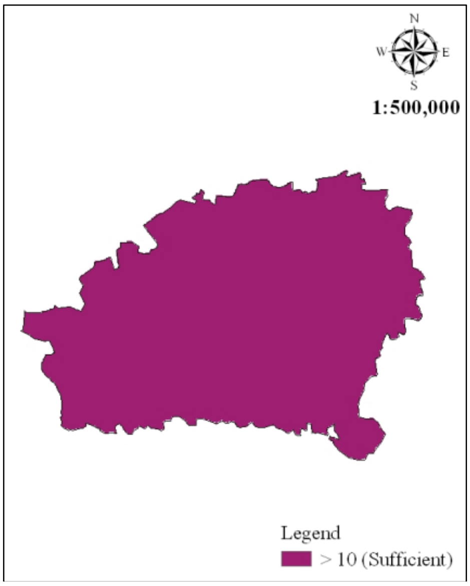
Soil available Phosphorus (kg ha^{-1})

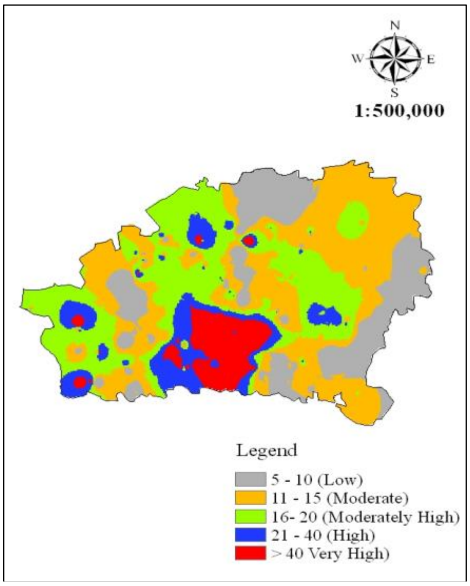


Soil available Potassium (kg ha^{-1})



Soil Exchangeable Ca^{++} (cmole kg^{-1})





Soil Exchangeable Mg^{++} (cmole kg^{-1}) **Soil available Sulphur (mg kg^{-1})**

Fig 4: Soil macro and secondary nutrient status of Sakri tehsil

From the study, it can be concluded that, soils of Sakri Tehsil area slightly acidic to moderately alkaline in soil reaction, non- saline in nature, low to high in organic carbon and moderate to very high in calcium carbonate. The soils were categorized as very low to low in available nitrogen, very low to moderately high in available phosphorus, moderate to very high in available potassium, sufficient in exchangeable calcium and magnesium and slightly deficient to sufficient in available S. Thus, the chemical property like pH, EC, organic carbon and $CaCO_3$ alone or in combination controls the availability of nutrients in the soil. Therefore, these factors could be manipulated in order to combat any present or future deficiencies of macro and secondary nutrients in these soils.

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