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Level of significance of various chemical properties of soils in Sakri Tehsil of Dhule District (M.S.)

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Abstract
The available forms of nutrients governs the fertility of soil and controls the productivity of crops but this is influenced by pH, EC, organic carbon and $CaCO_3$ status of soil. A study was conducted to assess available nutrient status and their relationship with chemical properties of soils of Sakri Tehsil of Dhule District by GIS technique and results showed that, the positive significant correlation of soil pH with available P and significant negative correlation with available micronutrients i.e. F, Zn, Cu and B was observed. EC was negatively and significantly correlated with available Mn. Organic carbon was non-significantly and negatively correlated with available P, K, S, Fe, Zn, Cu, Mo and exchangeable Mg while, non-significantly and positively correlated with available N, S, Mn, B and exchangeable Ca. Calcium carbonate shows non-significantly negative correlation with available P, S, Fe, Mn and exchangeable Ca and Mg.

Keywords: Geographic information system, Global positioning system, Soil fertility status, correlation coefficient.

Introduction
Soil fertility is one of the important factors controlling yields 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. 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 farm holding in many developing countries. According to the Vishwanath (1938) the incidence of micronutrient deficiencies in various crops of the Khandesh region has increased markedly in recent years and opinioned that it might be due to continuous and intensive multiple cropping and use of high yielding cultivars which may have higher micronutrient demand, enhanced production of crops on marginal soils that contain low levels of essential nutrients, increased use of high analysis fertilizers with low amount of micronutrient contamination, decreased use of organic manures *viz*; animal manures, composts and crop residues, use of soils that are inherently low in micronutrient reserves and involvement of natural and anthropogenic factors that limit adequate plant nutrient availability and create element imbalances.

The recent technologies like 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 Global Positioning System (GPS) and Geographic Information System (GIS) for storing and analyzing spatial data can help us to make better decisions in agriculture particularly land development, environmental protection and restoration. 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.. Farmers can use GPS to locate the nutrient deficiencies and can manage the accurate distribution of fertilizer chemicals. GPS can provide suitable location on the earth with a unique address (its precise location). A GIS is basically a descriptive database of the earth or a specific part of the earth. 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.

Material 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. Sakri Tehsil is situated at the western side of Dhule city, about 55 km away from Dhule city coinciding with Nashik and Nandurbar District. (fig 1).

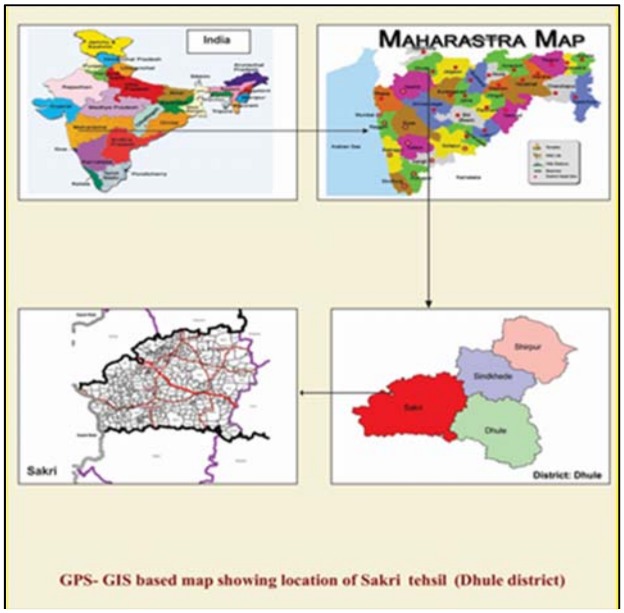

Fig 1: Location of Sakri Tehsil

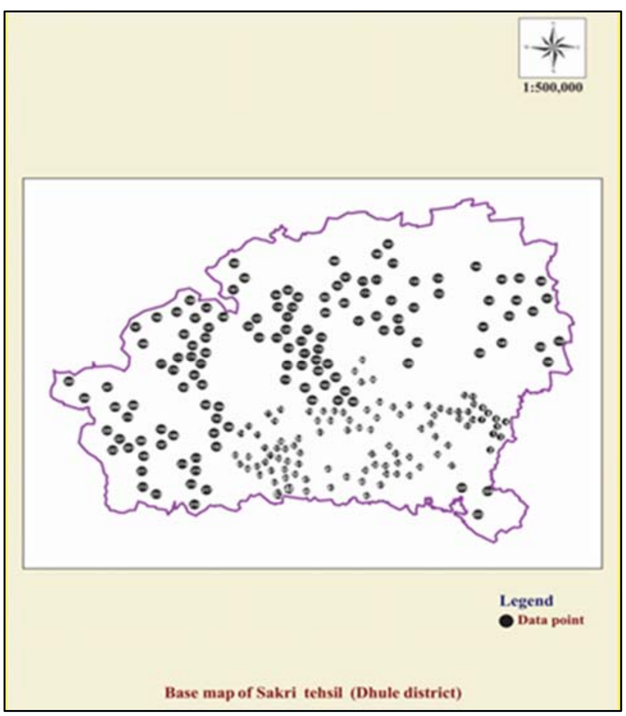

Fig 2: Base map of Sakri Tehsil

Geology

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.

Hydrology

The well and Dam are the main sources of irrigation in Sakri Tehsil. Jamkhedi, Burai and Akkalpada dams are present in the tehsil. Total area under irrigation is 22,374 ha. Total rainfed area is 95426 ha. Area under well irrigation is 78.48 per cent and area under surface irrigation is 21.56 per cent

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.
2. Transition II: Western part of Sakri Tehsil having 700-750 mm rainfall and light to medium soil.

The average annual rainfall is 576 mm out of which 75 per cent rainfall is received in monsoon period, 17 per cent is received in post monsoon period and 8 per cent is received in pre monsoon period. About 65 per cent of the annual rainfall is received in July and August. In the remaining period there is practically a dry spell with abundant sunshine and clear sky. Very scanty but occasional rains are during summer season and hence, assured irrigation facilities are needed for growing summer crops. 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.

Physiography

Study region represents varied topographical features and landscape. Most part of the Sakri Tehsil is occupied by Dhanora and Galana hills. Kondaibari and Lalingbari are major ghats in the study region

Methodology

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. Three soil samples of soil order shallow, medium and deep (Entisols, Inceptisols and Vertisols) from each village following the standard procedures of soil sample collection. The exact sample location was recorded using a GPS. (fig 2).

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) [17]. The electrical conductivity was determined by 1:2.5 suspension using EC meter by Conductometry (Jackson, 1973) [17]. Soil organic carbon was estimated using the wet oxidation method (Nelson and Sommer, 1982) and $CaCO_3$ is determined by Acid neutralization metod by Alison and Moodie (1965) [3].

Soil available N determined by Modified alkaline permanganate Subbiah and Asija (1956) [36], available P by 0.5M $NaHCO_3$ (Watanabe and Olsen, 1965) [38] and available K by Flame Photometer (N*N*NH_4OAc pH (7.0), (Jackson, 1973) [17]. Available S determined by 0.15% $CaCl_2$ extractable method by William and Steinberg (1969) and exchangeable Ca and Mg determined by Versenate titration method given by Hoffman and Shapiro (1954) [14].

DTPA-extractable micronutrients Fe, Mn, Zn and Cu were extracted from the soil samples by 0.005M DTPA at pH 7.3 according to Lindsay and Norvell (1978) [19] and the concentration of the micronutrients was estimated by atomic absorption spectrophotometer (AAS). While, B determined by Azomethine-H method (Bingham, 1973) [6] Mo estimated by AB-DTPA method given by (Soltanpour and Schwab, 1977) [34].

Statistical analysis

The soil chemical properties data were statistically analyzed by using standard statistical methods given by Panse and Sukhatme (1985) [27].

Result and Discussion

Physico-chemical properties

The pH ranges from 5.70 to 8.37. The mean of pH was 7.79, were slightly acidic to moderately alkaline in reaction. The data indicate that soils were slightly to moderately alkaline and slightly acidic in respect of soil reaction which appeared to be influence of parent material, rainfall and topography. Similar nature of observation for soil pH were also recorded by Mahashabde and Patel (2012) [20] 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 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. (Deshmukh, 2012) [10]. 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. The very low OC content of these soils may be attributed to the poor vegetation and high rate of organic matter decomposition under hyper-thermic temperature regime which leads to extremely high oxidizing conditions and the calcareousness of soils are common feature in soils of arid and semiarid climate particularly in Vertisols (black soils) due to precipitation of carbonates and bicarbonates under water stress. The results confirm the findings for organic carbon by Ghuge (2002) [13] in Vertisols, Inceptisols and Entisols of Ujana (Ahmadpur), Chaudhari and Kadu (2007) [8] in soils of Dhule Tehsil of Dhule District The similar nature of observation for $CaCO_3$ in soils of Shevgaon Tehsil of Ahmednagar District were reported by Dhage *et al*. (2000) [11].

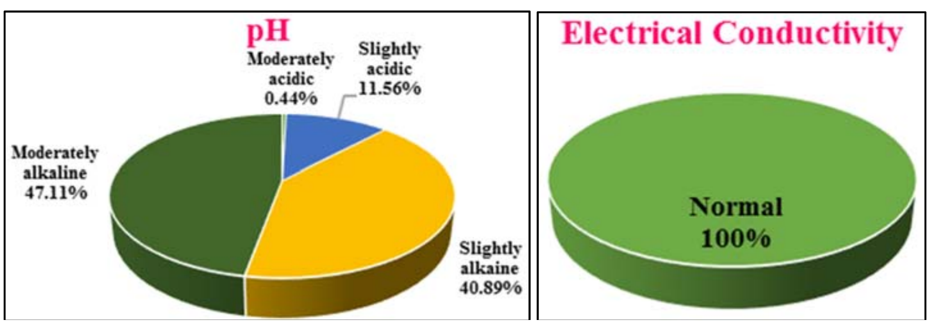

Fig 3: pH and Electrical Conductivity (dSm^{-1}) status of Sakri Tehsil

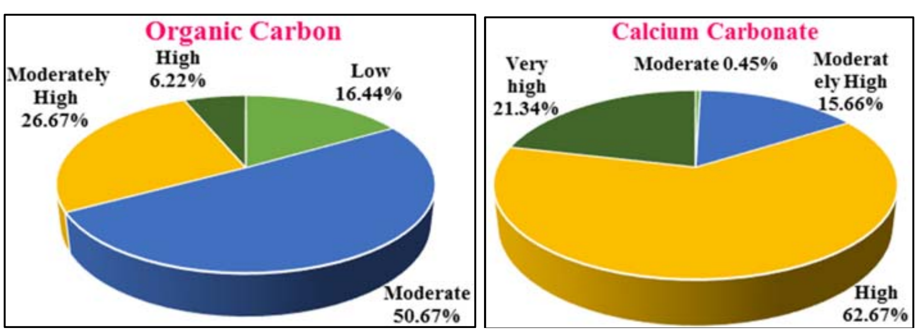

Fig 4: Organic Carbon (g kg^{-1}) and $CaCO_3$ (%) status of Sakri Tehsil

Primary nutrients

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 to low in available nitrogen, very low to moderately high in available phosphorus and moderate to very high in available potassium, The similar results were recorded by Singh and Rathore (2013) [33] in soils of Aravalli mountain ranges and Malwa plateau of Pratapgarh, Rajasthan, Chase and Singh (2014) [7] at Khonoma, Nagaland and Shinde and Phalke (2013) [31] at soil from Godavari basin of Beed, Maharashtra.

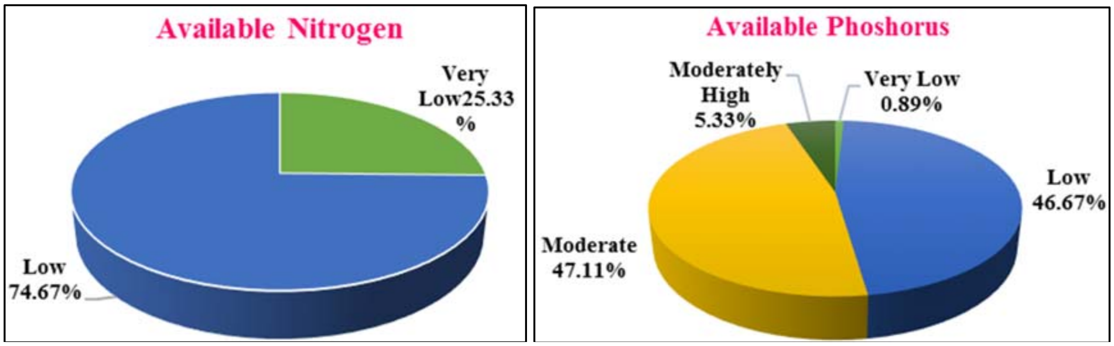

Fig 5: Available Nitrogen and Phosphorus (kg ha^{-1}) status of Sakri Tehsil

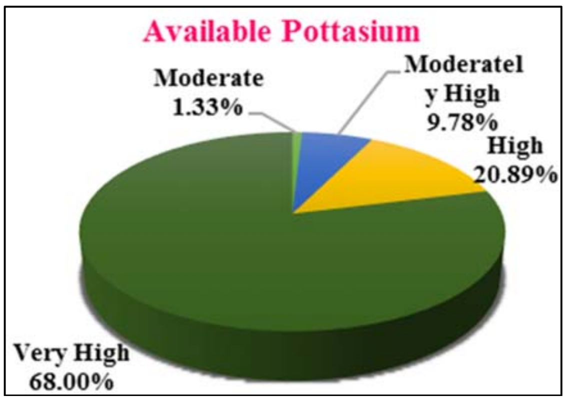

Fig 6: Available Potassium (kg ha^{-1}) status of Sakri Tehsil

Secondary nutrients

The exchangeable calcium in soils ranged from 20.58 to 46.50 cmol (p+) kg^{-1} with an average of 27.92 cmol (p+) kg^{-1}, exchangeable magnesium in soils were ranged from 10.73 to 36.07 cmol (p+) kg^{-1} with an average of 16.86 cmol (p+) 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}. 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) in swell-shrink orange cropped soils of Nagpur District, Nayak *et al.* (2006) [24] in swell and shrink soils of Vertisol order in Vidarbha and Patel *et al.* (2014) [28] at different villages of Kutch District of Gujrat.

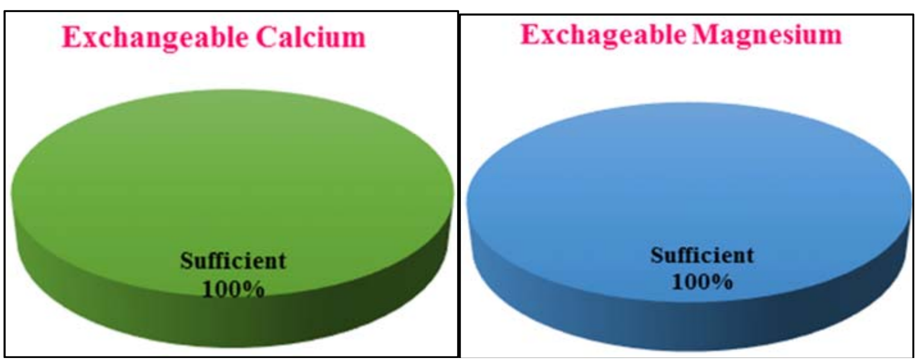

Fig 7: Exchangeable Ca and Mg [cmole(p^+)kg^{-1}] status of Sakri Tehsil

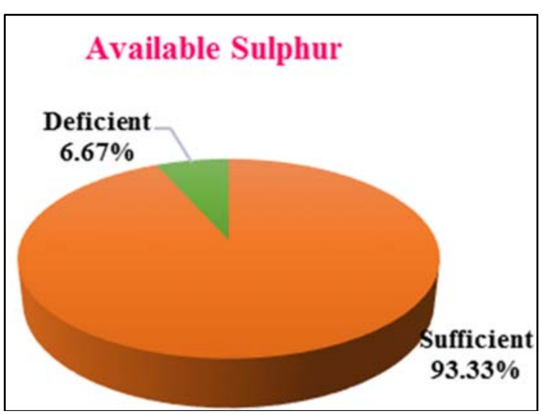

Fig 8: Available Sulphur (mg kg^{-1}) status of Sakri Tehsil

Micro nutrients

The available Fe in soils was rambled from 1.20 to 17.97 mg kg^{-1} with an average of 8.47 mg kg^{-1}. Out of the total soil samples, 40.89 per cent were deficient and 59.11 per cent sufficient in available Fe. The majority of soils of this region were sufficient in Fe, this might be due to availability of Fe under slightly acidic condition. The availability of Fe is due to organic matter content and in some content due to lack of moisture. The deficiency in some area might be due to excess of pH in soil. The similar trend of Fe was reported by Dhage *et al.* (2000) [11] in soils of Shevgaon Tehsil of Ahmednagar, Balpande *et al*. (2007) [5] in grape growing soils of Nashik District, Maharashtra.

The available manganese in soils was rambled from 2.04 to 6.60 mg kg^{-1} with an average of 3.15 mg kg^{-1} while, Sakri

Tehsil are sufficient in manganese content. The sufficiency of available Mn might be due to high organic matter content under optimum soil reaction. The similar observations were also reported by Ram (1999) [30] in soils of Bundelkhand (U.P), Dwivedi *et al* (2005) [12] in soils of cold arid region of Ladakh.

The available zinc in soils was rambled from 0.10 to 1.51 mg kg^{-1} with an average of 0.64 mg kg^{-1}. Whereas 36.11 per cent soils were sufficient and 36.89 per cent soils were deficient in Zn. The deficiency of available zinc might be due to low organic matter content in soil. Minakshi *et al*. (2005) [22] recorded the similar trends of DTPA Zn status in soils of Patiala District, Nagendran and Angayarkanni (2010) [23] in soils of Cumbum valley (Tamilnadu).

The available copper in soils was varied from 0.29 to 3.93 mg kg^{-1} with average value of 2.52 mg kg^{-1}. Data indicated that 100 per cent soils of Sakri Tehsil were sufficient in Cu content. The data indicate the sufficiency of Cu soils might be due to interactive effect of soil properties like pH, EC and OC which have managing role in the availability of Cu. Similar results were observed by Venkatesh *et al.* (2003) [37] in soils of various land use system of Meghalaya and Patil and Mukhopadhyay (2010) [29] in soils of West Bengal.

The available boron in soils rambled from 0.05 to 0.84 mg kg^{-1} with an average of 0.56 mg kg^{-1} whereas, 64 samples (28.44 %) were found deficient and 161 samples (71.56 %) sufficient in available B. The deficiency of boron in soils might be due to higher content of $CaCO_3$ and alkaline pH of soil. Similar results were also reported by Anderson (2007) at Nepal.

The available molybdenum in soils was varied from to 0.053 to 0.372 mg kg^{-1} with an average of 0.110 mg kg^{-1}. It also indicated that the soils of Sakri Tehsil are sufficient in Mo. The sufficient of molybdenum might be due to higher amount of bases like Ca and Mg and high pH at observing sites. The similar result was reported by Hundal *et al.* (2006) [15] at Punjab.

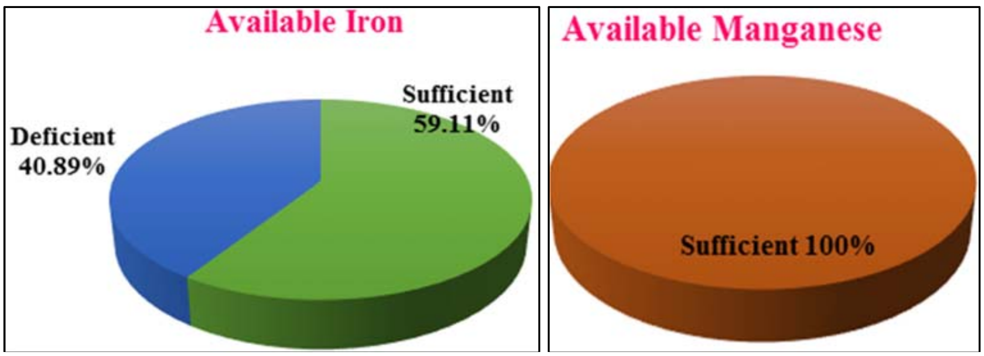

Fig 9: Available Iron and manganese (mg kg^{-1}) status of Sakri Tehsil

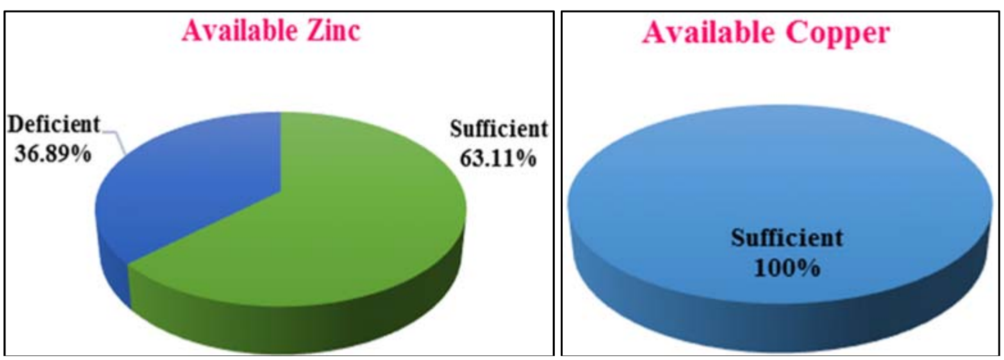

Fig 10: Available Zinc and Copper (mg kg^{-1}) status of Sakri Tehsil

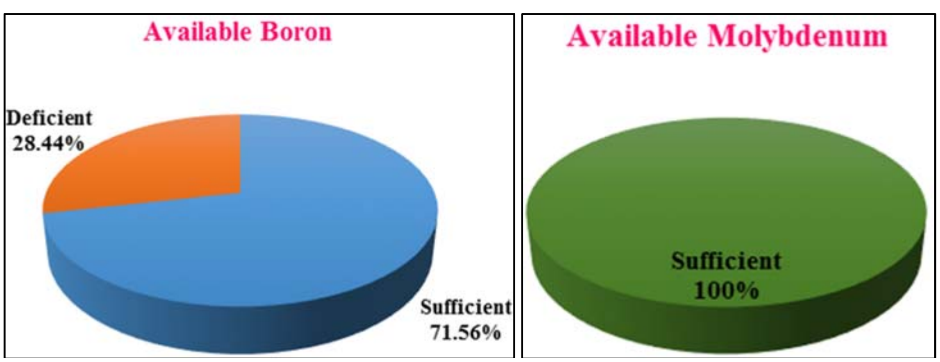

Fig 11: Available Boron and Molybdenum (mg kg^{-1}) status of Sakri Tehsil

Relationship of Soil Characteristics and nutrient status

Table 1: Correlation of soil properties with available nutrients

Chemical properties Available nutrients	pH	EC	OC	$CaCO_3$
N	-0.042	0.093	0.049	0.105
P	0.141*	0.006	-0.056	-0.023
K	0.106	0.021	-0.012	0.089
Ca	0.112	-0.002	0.079	-0.045
Mg	-0.062	-0.043	-0.036	-0.111
S	0.008	-0.046	0.018	-0.026
Fe	-0.484**	-0.033	-0.011	-0.024
Mn	0.046	-0.150*	0.010	-0.019
Zn	-0.355**	0.016	-0.011	0.058
Cu	-0.184**	0.001	-0.105	0.014
B	-0.349**	-0.011	0.046	0.035
Mo	0.029	-0.039	-0.021	0.062

(* Significant at 5% level, ****** Significant at 1% level)

Correlation of soil pH with available nutrients

The pH of the soils revealed Significant and non- significant correlation with available macro and micro nutrients. pH of the soil was significantly and positively correlated with available P (r=0.141*). It shows that P is directly proportional to the pH, similar result found to Shinde *et al.* (2014) [32] at Udgir tehsil of Latur district. pH is highly significant and negative correlation with Fe (r=-0.484**) followed by Zn (r=-0.355**), B (r=-0.349**) and Cu (r=-0.184**). It can be observed that Iron and micronutrients are decrease with the increase in pH of the soil. pH also non-significantly negative correlated with Mg (-0.062) and available N and non-significantly positive correlated with K (0.106), Ca (0.112), S (0.008), Mn (0.046) and Mo (0.029). pH is negatively significantly correlated with Zn. The same was also found by Katkar *et al*. (2013) [18] at Wardha, Maharashtra and Ali and Lakhan (2013) [2] in soils of Aligarh District of Uttar Pradesh. The positive relation between pH and Mo was found by Adhikari and Patel (2013) [1] in selected Benchmark soils of India.

Correlation of Electrical conductivity with available nutrients

Soil EC was negatively and significantly correlated with available Mn (r=-150*). The EC Also was non-significantly correlated with all macro and micro nutrients. Non-significant positive correlation of EC was observed with available N (0.093), P (0.006) K (0.021), Zn (0.016) and Cu (0.001.) The correlation between EC with each of exchangeable Ca (-0.002) and Mg (-0.043), available S (-0.046), Fe (-0.033), B (-0.011) and Mo (-0.039) were negative and non-significant. The similar results were recorded by Chaudhari *et al.* (2012) and reported that available N has shown positive significant correlation with electrical conductivity and there was positive but not-significant correlation with available K and exchangeable Mg in sandy loam soils of Haridwar. Mali *et al.* (2002) [21] studied the negative correlation of available Fe and Mn with EC of soil paste extract but it was not statistically significant, available Zn and Cu were not shown any significant correlation with EC of soil.

Correlation of organic carbon with available nutrients

Organic carbon was non-significantly correlated with macro and micro nutrients. Organic carbon showed positive non-significant correlation with available N (0.049), exchangeable Ca (0.079), S (0.018) Mn (0.010), and B (0.046). Organic carbon has shown non-significantly negative correlation with available P (-0.056), K (-0.012), exchangeable Mg (-0.036), Fe (-0.011), Zn (-0.011), Cu (-0.105) and Mo (-0.021). The relationship between organic carbon and available phosphorus might be due to the presence of more than 50% of P in organic forms and after decomposition of organic matter as humus is formed which forms complex with Al and Fe and that is protective cover for P fixation with Al and Fe thus reduce Phosphate fixation. The similar results were found by Singh and Rathore (2013) [33], they reported the positively non-significant correlation of available P, K, Zn and Cu with organic carbon whereas, available Fe and Mn were negatively non-significant correlated with organic carbon in Aravalli mountain ranges and Malwa Plateau of Pratapgarh, Rajasthan, India.

Correlation of $CaCO_3$ with available nutrients

All available nutrients were non-significantly correlated with $CaCO_3$. The value of $CaCO_3$ shown positively non-significant correlation with available N (0.105), K (0.089), Zn (0.058), Cu (0.014), B (0.035) and Mo (0.062) while negative non-significant correlation with available P (-0.012), exchangeable Ca (-0.045) and Mg (-0.111), available S (-0.026), Fe (-0.024) and Mn (-0.019). Similar result was found by Indulkar *et al*. (2007) [16], they stated that the available P shown negative significant correlation with $CaCO_3$. Chaudhari *et al*. (2012) observed that available N did not show any significant correlation with $CaCO_3$ content of soil in sandy loam soils of Haridwar. Mali *et al.* (2002) [21] recorded that there was no any significant correlation between available Cu and $CaCO_3$ in salt affected soils. Minakshi *et al*. (2005) [22] studied the spatial distribution of micronutrients in soils of Patiala District, and reported that $CaCO_3$ had shown positive correlation with Mn, Cu while, negatively with Fe, Zn. The negatively significant relation of $CaCO_3$ and available sulphur found by Pandey *et al.* (2013) [26] at Dewas District of Madhya Pradesh. The $CaCO_3$ is Positive correlated with Cu observed by Sood *et al*. (2009) [35] at Punjab.

Conclusion

From the study, it can be concluded that, soils of Sakri Tehsil are have wide variation in chemical nature and nutrient status, it is because of rainfall variation, temperature, natural vegetation, parent material and agricultural management practices of soil.

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