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Mapping of soil macro and secondary nutrients by GIS in Shirol Tehsil of Kolhapur District. (M.S.)

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Abstract
A study was conducted to assess available macro and secondary nutrient status of soils of Shirol Tehsil of Kolhapur District by GIS technique. 200 soil samples (0-22.5 cm) drawn during 2013 from 39 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 pH of soils of Shirol Tehsil varied from 7.0 to 9.0, most of the soils found to be moderately alkaline (77.5%) while EC varied from 0.06 to 6.30 dS m^{-1}, the soils found to be normal (91.5%). The calcium carbonate content varied from 1.1 to 15.1 per cent, the area was moderately calcareous (56%) to calcareous (27.5%). Organic carbon content varied from 0.30 to 1.29 per cent. The available nitrogen, phosphorus and potassium ranged from 185 to 580, 14.1 to 49.6 and 89.6 to 980.0 Kg ha^{-1}, respectively. The exchangeable calcium and magnesium ranged from 0.8 to 48.0 and 0.2 to 39.0 cmol (p^{+}) Kg^{-1}, respectively. The soils were 66% and 33.5% sufficient and 34% and 66.5% deficient in exchangeable calcium and magnesium respectively. The available sulphur varied from 7.60 to 49.69 mg Kg^{-1}. The soils were 99% sufficient and 1% deficient in available sulphur content.

Keywords: Geographic information system, global positioning system, nutrient mapping, soil fertility status

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 farm 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 (N), Phosphorus (P) and Potassium (K) were prepared using soil test data generated by soil testing laboratories that functioned throughout the country (Ghosh and Hasan, 1979) [5].

Soil fertility plays a key role in increasing crop production in the soil. It comprises not only in supply of nutrients but also their efficient management. The fertility status of soil indicates their nutrient supplying capability. Soils of Maharashtra state are categorized as poor in fertility and they vary widely in genetic, morphological, physical, chemical and biological characteristics. The soil fertility undergoes changes due to intensive cropping, manuring and fertilizer applications.

The recent technologies like GPS and GIS thus have much to offer for preparing soil fertility maps. Global positioning system (GPS) is a space based navigation and positioning system administered by U.S military, which helps to determine the exact position of an object on the earth surface in terms of geographical co-ordinates (French, 1996) [4]. Geographic information system (GIS) is a computer system for capturing, storing, querying and displaying geographical data (Chang, 2002) [1]. Once the soil fertility maps are created, it is possible to transform the information about the fertility status of the area.

Such maps provide site-specific recommendation, validation for soil fertility over the following years.

GPS-GIS are advanced tool for studying on site specific nutrient management which can be efficiently use for monitoring soil fertility status in Shirol tehsil of Kolhapur district (M.S), and it is useful for ensuring balanced fertilization to crops. Systematic study of nutrients including assessment of major and secondary status of soil with delineation of areas of nutrient deficiency or sufficiency. The information of soil fertility status of Shirol tehsil based on GPS-GIS studies is very limited. Therefore, the present investigation was planned.

Material and Methods

Study Area

Shirol is one of the tehsil of Kolhapur district of Maharashtra state, India. The geographical area of tehsil is 50300 ha. It belongs to Desh or Paschim Maharashtra region and located between 16^0 44' 0'' North latitude and 74^0 36' 0'' East longitude and elevation 550 m from mean sea level.

Soil Characteristics

The soils of the district are developed over soft weathered and hard ruptured basalt and occur on nearly levelled to very gentle sloping upper and lower pediments. The soils which occur mostly on upper pediment, lack of horizonation except a plough layer are classified as order Entisol, whereas the soils which occur as lower pediment, nearly levelled to very gentle sloping and having one or two diagnostic horizon e.g. cambic subsurface diagnostic horizon are classified as order Inceptisol. The very deep soil occurring on the levelled lower pediment and developed over soft weathered basalt very dark greyish brown clayey, strong coarse angular blocky peds with shiny pressure faces and well developed intersecting slickenside are classified under order Vertisol.

Climate

The climate of Shirol tehsil is very hot in summer. During summer highest day temperature is in between 33 ^{0}c to 41 ^{0}c. Average temperature is in between 25 ^{0}c to 29 ^{0}c. Annual average Rainfall is 750 mm.

Land use and natural vegetation

The major crops cultivated are sugarcane, banana, mango, sorghum and soybean, groundnut, chickpea and other vegetable crops. The forest trees like teakwood, neem and bamboo are also planted on bunds and uncropped land. Similarly, a few grasses of ecological importance such as *Heteropogon contrortus, Cynodon doctylon, Celosia argentea, Mimosa pudica* etc. are observed including Kardai.

Soil sample collection and analysis

A systematic survey was carried out and a surface (0-22.5 cm depth) soil samples were collected from 200 sites of 39 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.

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 the wet oxidation method (Nelson and Sommer, 1982) [9] and $CaCO_3$ is determined by rapid titration method by (Piper, 1966) [14].

Soil available N determined by modified alkaline permanganate (Subbiah and Asija, 1956) [17], available P by 0.5M $NaHCO_3$ (Watanabe and Olsen, 1965) [18] and available K by flame photometer N*N*NH_4OAc pH (7.0), (Jackson, 1973) [6]. Exchangeable Ca and Mg determined by versenate titration method given by (Page, 1982) [10] and available S determined by 0.15% $CaCl_2$ extractable method by (William and Steinberg, 1969).

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) [11].

Result and Discussion

Chemical characteristics of soil

The soils of Shirol tehsil were found slightly alkaline (22%) to moderately alkaline (77.5%) in reaction with pH ranging from 7.0-9.0. The soils were categorized as normal for emergence of seed except some pockets of village Shirol, Dharangutti, Majarewadi, Bastawad. EC of the soil ranged from 0.06-6.30. The organic carbon content of soils were categorized as moderate (13.5%) to very high (39.5%) which ranged from 0.30-1.29 per cent. The calcium carbonate content was categorized as slightly calcareous (10%), moderately calcareous (56%), calcareous (27.5%) and highly calcareous (6.5%) which ranged from 1.1-15.1 per cent. (Table 1 and Fig.1, 2, 3 and 4).

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

Particulars	pH	EC (dSm^{-1})	Organic Carbon (gm kg^{-1})	$CaCO_3$ (%)
Mean	8.2	0.48	0.89	4.82
Range	7.0-9.0	0.06-6.3	0.30-1.29	1.1-15.1
SE ±	0.02	0.04	0.01	0.20

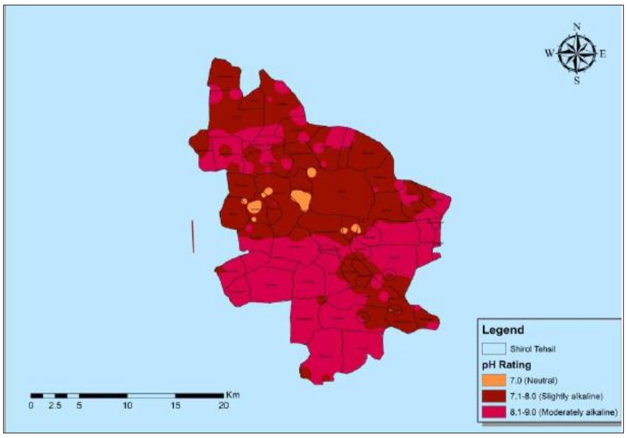

Fig 1: pH of Shirol Tehsil

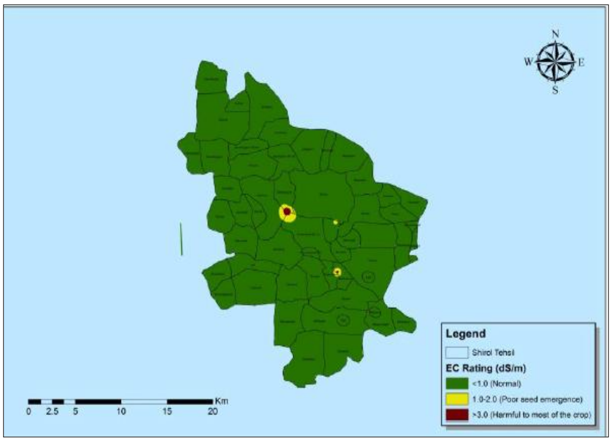

Fig 2: EC of Shirol Tehsil

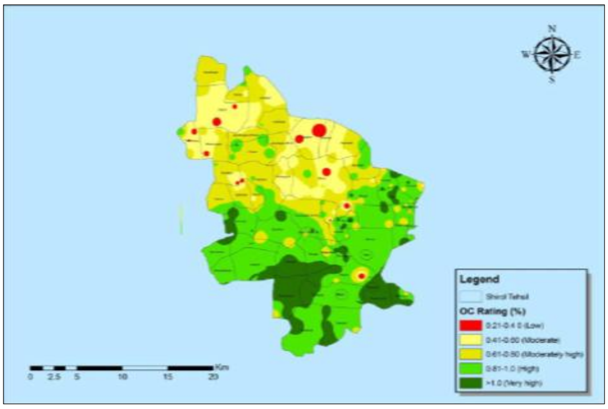

Fig 3: OC content of Shirol Tehsil (%)

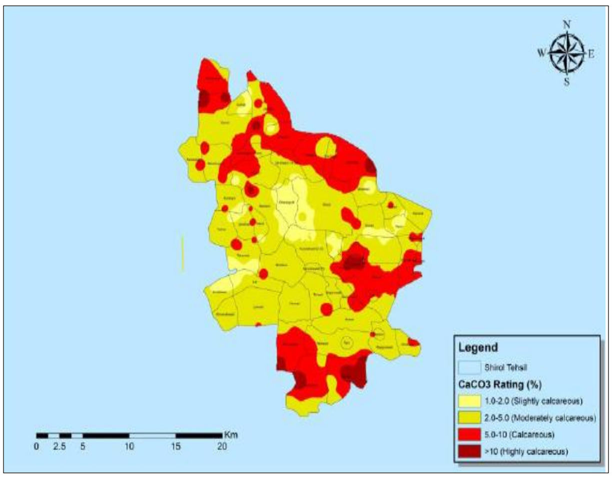

Fig 4: Calcium Carbonate content of Shirol Tehsil (%)

Primary nutrients

The available nitrogen was low (89%) followed by moderate (9.5%), moderately high (1%) and high (0.5%) which ranged from 185-580 Kg ha^{-1}. The available phosphorus was very high (35.5%) followed by high (27%), moderately high (26.5%) and moderate (11%) which ranged from 14.10-49.60 Kg ha-1. The available potassium was categorized as low (0.5%) to very high (68%) which ranged from 89.6-980.0 Kg ha^{-1}. (Table 2 and Fig. 5, 6 and 7). The similar results were recorded by Patil and Sonar (1994) [12] in swell-shrink soils of Maharashtra and Patil (2011) [13] in different soil series of Kolhapur district.

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

Particulars	Available Nutrients (kg ha^{-1})		
	N	P	K
Mean	250.8	31.78	442.0
Range	185.0-580.0	14.10-49.60	89.6-980.0
SE±	2.98	0.64	19.96

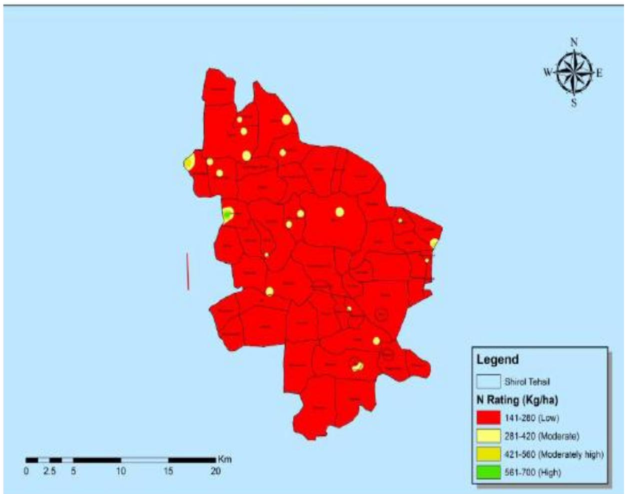

Fig 5: Available Nitrogen of Shirol Tehsil (kg ha^{-1})

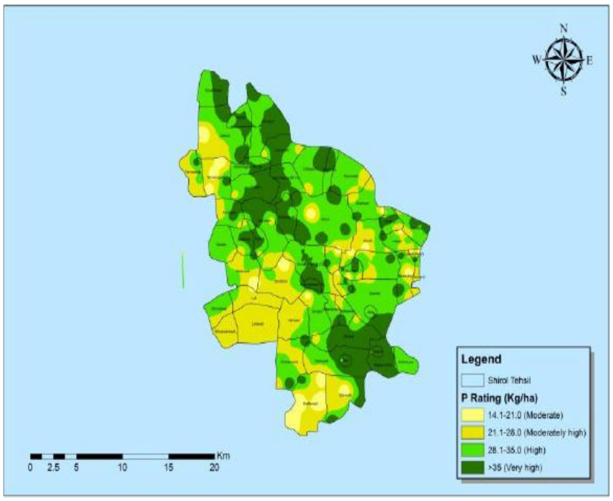

Fig 6: Available Phosphorus of Shirol Tehsil (kg ha^{-1})

Secondary Nutrients

The exchangeable calcium and magnesium were found to vary from 0.8-48.0 cmol (p^{+}) Kg^{-1} and 0.2-39 cmol(p^{+}) Kg^{-1} respectively. Out of the samples 66 and 33.5 per cent soils were sufficient in exchangeable calcium and magnesium respectively. However, 34 and 66.5 per cent soils were deficient in exchangeable calcium and magnesium respectively. The available Sulphur varied from 7.6-49.6 mg

Kg^{-1}, which is categorized as low (1%), moderate (7%), moderately high (15%), high (59%) and very high (18%). (Table 3. Fig. 8, 9 and 10). The similar results were observed by Chinchmalatpure *et al.* (1998) [2] in soils of north western part of Nagpur district, Mandal and Sharma (2005) [7] in soils of Nagpur district, Rajput and Polara (2012) [15] in coastal Bhavnagar district of Saurashtra region of Gujrat, Mandal and Sharma (2012) [8] in salt affected areas in Rajasthan, Durgude (1999) [3] and Ravte (2008) [16] in soils of Ausa and Nilanga tehsil of Lathur district.

Table 3: Exchangeable Ca and Mg and available S status of soils of Shirol Tehsil

Particular	Exchangeable Ca [cmol (p+)kg^{-1}]	Exchangeable Mg [cmol(p+)kg^{-1}]	Available S (mg kg^{-1})
Mean	23.9	6.6	30.20
Range	0.8-48.0	0.2-39.0	7.60-49.69
Critical limit	20	10	10
Deficient	68 (34%)	133 (66.5%)	2 (1%)
Sufficient	132 (66%)	67 (33.5%)	198 (99%)
SE±	0.91	0.43	0.77

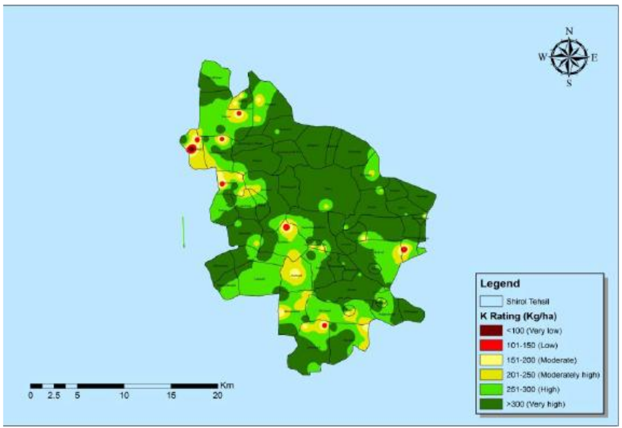

Fig 7: Available Potassium of Shirol Tehsil (kg ha^{-1})

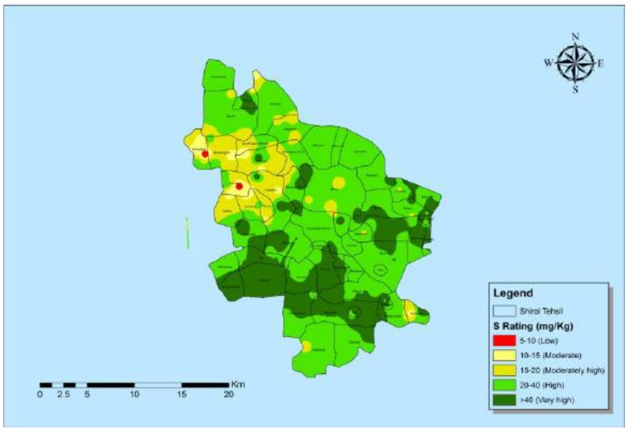

Fig 10: Available Sulphur of Shirol Tehsil (mg kg^{-1})

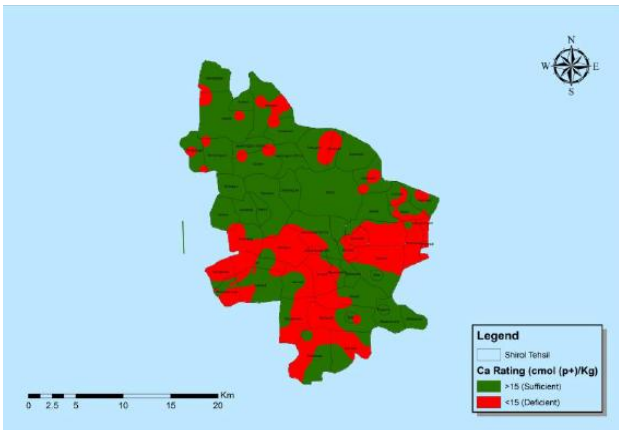

Fig 8: Exch. Ca of Shirol Tehsil [cmole(p$^+$)kg^{-1}]

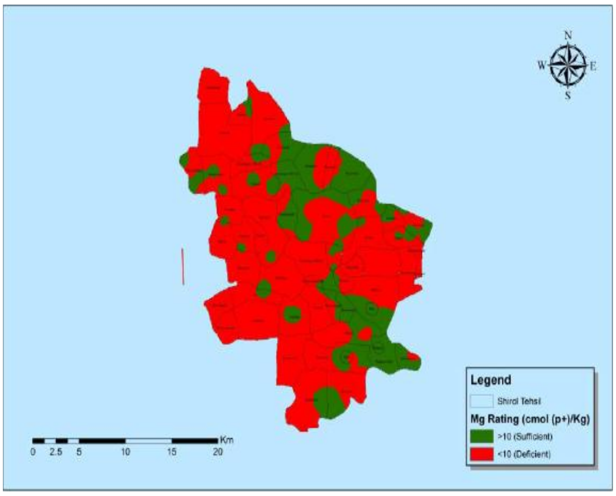

Fig 9: Soil Exch. Mg of Shirol Tehsil [cmole(p$^+$)kg^{-1}]

Conclusion

The soils of Shirol tehsil were slightly alkaline to moderately alkaline in reaction, normal in salt content, moderately high to very high in organic carbon and moderately calcareous to calcareous in nature. Available nitrogen was low, moderate to very high in available phosphorus and moderate to very high in available potassium content. Exchangeable calcium (66.0%) and magnesium (33.5%) were in sufficient range. 99% of the soils were sufficient in available sulphur.

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