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GPS-GIS based soil fertility maps of Chandgad tehsil of Kolhapur district (M.S.)

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Abstract
The study was carried out to know the fertility status of soils of Chandgad tehsil, of Kolhapur district by using GPS-GIS technology and to correlate soil properties with the available nutrient status and also to evaluate the fertility index of Chandgad tehsil during the year 2015-2016.

The pH of soils of Chandgad tehsil varied from 5.01to 7.21, most of the soils were found to be moderately acidic (57.15%) while EC varied from 0.04 to 0.70 dS m^{-1}, the soilswere found to be normal (100 %) in salinity. The Calcium Carbonate content of soils of Chandgad tehsil varied from 0.51 to 3.07 per cent, the area was barely calcareous (33.77%), slightly calcareous (50%) and moderately calcareous (16.23%). Organic Carbon content varied from 0.31 to 1.12 per cent and categorized as low (24.02%), moderate (24.03%), moderately high (21.42%), high (19.50%) and very high (11.03%).

The soil available Nitrogen, Phosphorus and Potassium in Chandgad tehsil ranged from 143.21 to 420.26, 1.03 to 20.6 and 102.8 to 293.6 Kg ha^{-1}, respectively. The soils were low (35.71%) and moderate (64.29%) in available Nitrogen. In respect of available Phosphorus very low (40.26%) low (46.75%) and moderate (12.99%). In case of available Potassium low (24.68%), moderate (9.74%), moderately high (36.36%) and high (29.22%). The exchangeable Calcium and Magnesium ranged from 10.00 to 25.00 and 2.25 to 12.50 cmol (p^+) Kg^{-1}, respectively. The soils were sufficient (25.32%), deficient (74.68%) and sufficient (13.63%), deficient (86.37%) in exchangeable Calcium and Magnesium, respectively. The exchangeable sodium ranged from 0.13 to 0.97 cmol (p^+) Kg^{-1}.

The available sulphur varied from 5.12 to 35.93 mg Kg^{-1}. The soils were low (26.62%), moderate (22.73%), moderately high (23.38%) and high (27.27%) in available Sulphur content.

The pH was significantly and positively correlated with exchangeable Calcium and Magnesium. EC was non-significant and positively correlated with Nitrogen, Phosphorus, Calcium, Magnesium, Sodium and Manganese. The organic carbon was significantly and positively correlated with Nitrogen, Phosphorus, Potassium and Sulphur. Calcium carbonate was significantly correlated with calcium, magnesium and Sulphur.

The fertility index of Chandgad tehsil for Organic Carbon, available Nitrogen, Phosphorus and Potassium was medium (2.02), low (1.32), low (0.86) and medium (1.85), respectively.

Keywords: Chandgad tehsil, GPS-GIS technology, soil fertility maps

Introduction
The advanced technologies like GIS and global Positioning System (GPS) thus have much more importance for preparing soil fertility maps. Soil physical and chemical properties vary within a single field. Spatial tools like Global Positioning System (GPS) and Geographic Information System (GIS) for analyzing and storing spatial data can help us to make better decisions in particular land development for agriculture environmental protection and restoration. In precision agriculture, farmer's use GPS and GIS as yield monitors and variable technology to apply appropriate quantities of input in different parts of field. Land use planners and developers use GPS and GIS to assess soil protection of ground and surface water and wetlands.

GPS is a based system location on consultation with about 24 satellites orbiting the earth at every 12 hours. The distance of an orbiting satellite is approximately 11,000 miles from the earth's surface. GPS was developed by the United States, Departments of Defense (DOD) for its tremendous application as a military for locating object.

Materials and Methods

Chandgad tehsil of Kolhapur district was selected to assess the soil macro and micro nutrient status and delineate the fertility map, 77 villages were selected randomly in such a way that itCovers the whole area of the tehsil. One hundred and fifty four representative soil samples were collected from sixty six villages of Chandgad tehsil along with GPS reading.

Collection and processing of soil samples

Seventy seven villages from Chandgad tehsil were selected for sampling keeping in mind to avoid overcrowding of sampling site on GPS based soil fertility map. Geo-referenced surface (0-22.5) cm soil samples from each selected villages representing different soils were collected. The latitude and longitude of sampling sites were recorded with the help of differential Global Positioning system with detailed observation on cropping pattern and fertilizer use. The soil samples were collected with the help of wooden peg. The samples were air dried and ground using wooden mortar and pestle and passed through 2.0 and 0.5 mm sieves. The sieved soil samples were stored in cloth bags with proper labeling for subsequent analysis. The soils were analyzed for different parameters.

The pHwas measured by in 1:2.5 soil water suspension using glass electrode pH meter and EC ($dS^{-1}m$) was measured in the supernatant solution of 1:2.5 soil water suspension using conductivity meter (Jackson, 1973) [3]. Organic carbon by wet oxidation method (Nelson and Sommers1982) [9]. Available Nitrogen was estimated by alkaline permanganate method of Subbiah and Asija (1956) [16] available phosphorus was extracted with 0.5 *M* $NaHCO_3$ solution buffered at pH-8.5 Watanabe and Olsen (1965) [18] and Bray I 0.03 *N* ammonium fluoride at pH-3.5 (Bray and Kurtz, 1945)[2]. Available Potassium was estimated by shaking the requisite amount of soil sample with 1*N* neutral ammonium Acetate solution at pH-7.0 (1:5 soil water ratio), (Knudsen and Peterson, 1982) [6] available and Sulphur was estimated by turbidimetry with calcium chloride extractable (Williams and Steinbergs, 1959) [19]. The $CaCO_3$ % by Rapid titration method (Piper, 1966) [12] and Exchangeable CA& Mg by Versenate titration method (Page *et al.* 1982) [6].

Results and Discussion

The result of the investigation carried out during the year 2015-2016 with the view to study the GPS-GIS based fertility status of soils in Chandgad tehsil are presented below-

Nutrient status of soils of chandgad tehsil

The soil samples collected from Chandgad tehsil were analyzed by adopting standard procedure and the data pertaining to different parameters was categorized as per the six tier rating. The data pertaining to pH, Electrical conductivity, Calcium carbonate, and Organic carbon, available N, P and K are presented in Table 1 and 2.

Soil reaction (pH)

The pH of the soils in Chandgad tehsil of Kolhapur district ranged from 5.01 to 7, among the soil samples tested, 24.02 per cent soils were strongly acidic followed by moderately acidic 57.15 per cent, 14.93 per cent soils were slightly acidic and 3.90 per cent soils were slightly alkaline in nature with the mean value 6.02. The lowest soil pH was 5.01 and highest soil pH was 7.21. The soils were strongly acidic to slightly alkaline in reaction, the acidic reaction of maximum soils of the tehsil might be due to sloppy land and undulating topography, high rainfall leading to leaching losses of bases from the surface soils and accumulation of iron oxides. The decomposition of organic residues and application of nitrogenous fertilizers hasten the soil acidity.Similar nature of observation for soil pH was also recorded by Kurlapur *et al.* (2014) [7] in the soils of Mangroves from western coast of Maharashtra.

Electrical conductivity (EC)

The EC ranged from 0.04 to 0.70 Ds m^{-1} with an average mean value were 0.14 Ds m^{-1}. These observations indicate that, all the 100 per cent soils were normal, non-saline in nature and suitable for healthy plant growth. Singh *et al.* (2009) [15]. Reported the similar results in Hoshangabad district of Madhya Pradesh.

The low EC was may be due to low temperature, porous structure of soil, heavy rainfall, erosion, leaching down soluble salts

Per cent Calcium Carbonate equivalent content

The per cent calcium carbonate equivalent content in soils of Chandgad Tehsil of Kolhapur district ranged from 0.51 to 3.07 per cent eqv. Categorized as barely calcareous to moderately calcareous with the mean value 1.38 per cent. Out of all the soil samples collected, 33.77 per cent soils were barely calcareous, 50 per cent soil samples were slightly calcareous followed by 16.23 per cent soil samples were moderately calcareous. The low calcium carbonate content was may be due to low temperature, porous nature of soil, heavy rainfall, erosion, rapid leaching down of soluble salts and soils basic cations. The similar results were reported by Nirwar *et al.* (2009) [10] in the soils of ahmedpur tehsil of latur district.

Table 1: pH, EC and $CaCO_3$ content in soils of Chandgad tehsil

Particular	pH(1:2.5)	EC($dS\ m^{-1}$)(1:2.5)	Per cent$CaCO_3$eq.
Mean	6.02	0.14	1.38
Range	5.01 – 7.21	0.04-0.70	0.51 -3.07
Category	Strongly acidic37 (24.02%)	Normal154 (100%)	Non-calcareous-
	Moderately acidic88 (57.15%)		Barely calcareous 52 (33.77%)
	Slightly acidic23 (14.93%)		Slightly calcareous 77(50%)
	Slightly alkaline6 (3.90%)		Moderately Calcareous 25(16.23%)

Total no. of soil samples-154, figures in parenthesis indicates percentage.

Organic carbon

The organic carbon content of soil ranged from 0.31 to 1.12 per cent, categorized as low to very high with the mean value 0.64per cent (moderately high). Out of all the soil samples collected from Chandgad tehsil, 24.02% soil samples found low in organic carbon content, where as 24.03% soils samples moderate, 21.42% moderately high, 19.50% high and 11.03% soil samples were very high in organic carbon content. This might be due to addition of FYM, low temperature, high rainfall, accumulation and decomposition of leaves, organic residues and litters. The low organic carbon content in the soils may be attributed to poor management practices such as lack of addition of crop residues and organic manures. The greater organic carbon content in surface soils which was attributed due to the addition of organic manures and plant residues to surface soils that resulted in higher organic carbon content. The similar results were recorded by Jagtap *et al.* (2007) [4]. In the soils of chakur and shirur-anantpal tehsil of later district.

AvailableN

The available nitrogen ranged from 143.21 to 420.26 kg ha-1, categorized as low to moderate with the mean value 302.44 kg ha-1 (moderate). Medium status of available nitrogen might be due to liberal crop residue addition to soil. Low nitrogen status in the soils could be due to low amount of organic carbon in soils and high rainfall and undulating topography leads to loss of nitrates by leaching. The similar results were recorded by Bidari*et al*. (2008) [8].In soil profiles of Dharwad, Karnataka.

Available phosphorus

The available phosphorus were ranged from 1.03 to 20.6 kg ha^{-1}, categorized as very low to moderate with the mean value 8.93 kg ha^{-1}. Low status of available phosphorus in soil might be due to acidic nature of soil reaction and fixation of phosphorus in acidic soils with aluminium, iron etc. The similar results were recorded by Ratnakumari *et al*. (2006) [13].

Available K

The available potassium in soils of Chandgad tehsil were ranged from 102.8 to 293.6 kg ha^{-1}. Majority of the soils were moderately high and high in available potassium. Adequate available potassium in the soils may be attributed to the prevalence of potassium rich minerals like illite and feldspar (Sharma *et al.*2008) [14]. The similar results were recorded by Sudharani *et al.* (2013) [17].

Available sulphur

The available sulphur in the soils ranged from 5.12 to 35.93 mg kg^{-1} (low to high) with the mean value 16.14 mg kg^{-1}. The total sulphur in soil was present in organic combination; therefore soils which are rich in organic matter will have high level of sulphurand also coarse texture soils havelow amount of sulphur than fine textured soils due to leaching losses and adsorption of sulphates on organic matter leads to unavailable to plants (Kanwar, 1976) [5]. The results indicated that sufficiency of available sulphur was directly proportional to organic sulphur content of soil. The similar results were recorded by Jat and Yadav (2006) in the soils of jaipur district of Rajasthan.

Table2: Organic carbon and available nitrogen, phosphorus, potassium and sulphur content in soils of Chandgad tehsil

Particular	Organic carbon (%)	Available nutrients (kg ha^{-1})			
		N	P	K	S(mg kg^{-1})
Mean	0.64	302.44	8.93	208.01	16.14
Range	0.31-1.12	143.21 – 420.26	1.03 - 20.6	102.8 - 293.6	5.12– 35.93
Very low	-	-	62(40.26%)	-	
Low	37 (24.02%)	55 (35.71%)	72 (46.75%)	38 (24.68%)	41(26.62%)
Moderate	37 (24.03%)	99 (64.29%)	20 (12.99%)	15 (9.74%)	35(22.72%)
Moderately high	33 (21.42%)	_	_	56(36.36%)	36(23.38%)
High	30 (19.50%)	_	_	45 (29.22%)	42(27.28%)
Very high	17 (11.03%)	_	_	-	_

Total No. of soil samples-154, figures in parenthesis indicates percentage.

Exchangeable calcium

The exchangeable calcium in the soils of Chandgad tehsil ranged from 10 to 25 [cmol (p^+) Kg^{-1}], with the mean value 14.25 [cmol(p^+)Kg^1]. The deficiency may be due to porous structure of soil, heavy rainfall, erosion and leaching losses of basic cations. Mandal *et al*. (2005) [8] reported similar results as regards the exchangeable calcium content in soils of Nagpur district (Maharashtra).

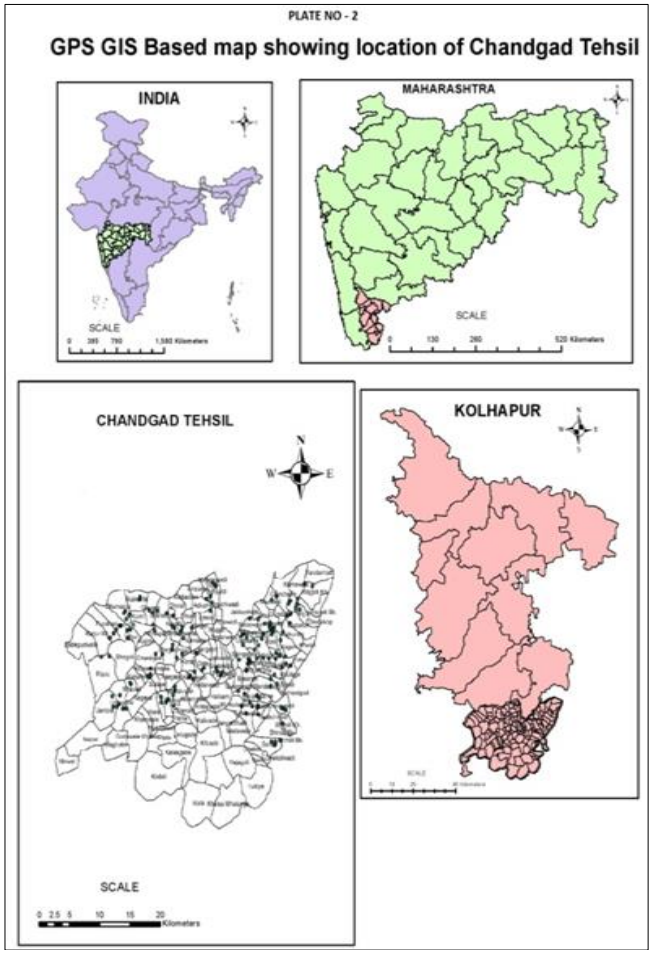

Fig 1: Location map of study area

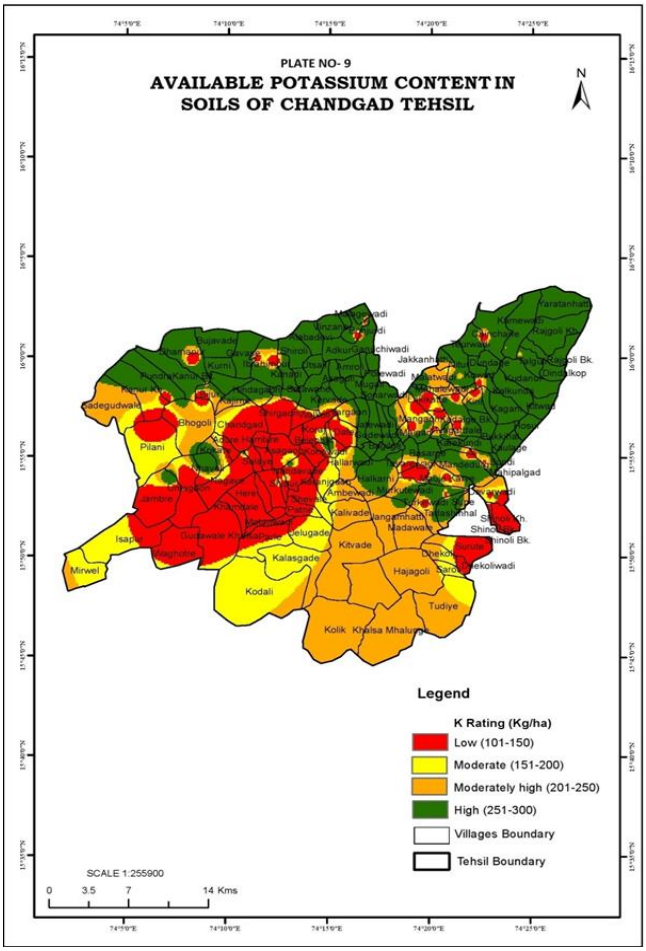

Fig 3: Avail. K of Chandgad tehsil

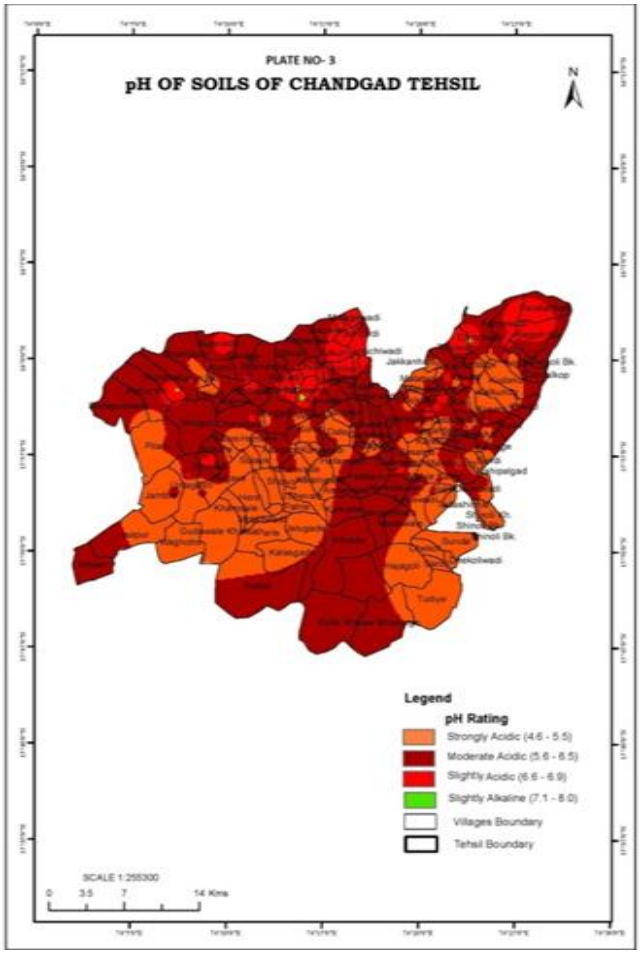

Fig 2: pH of Chandgad tehsil

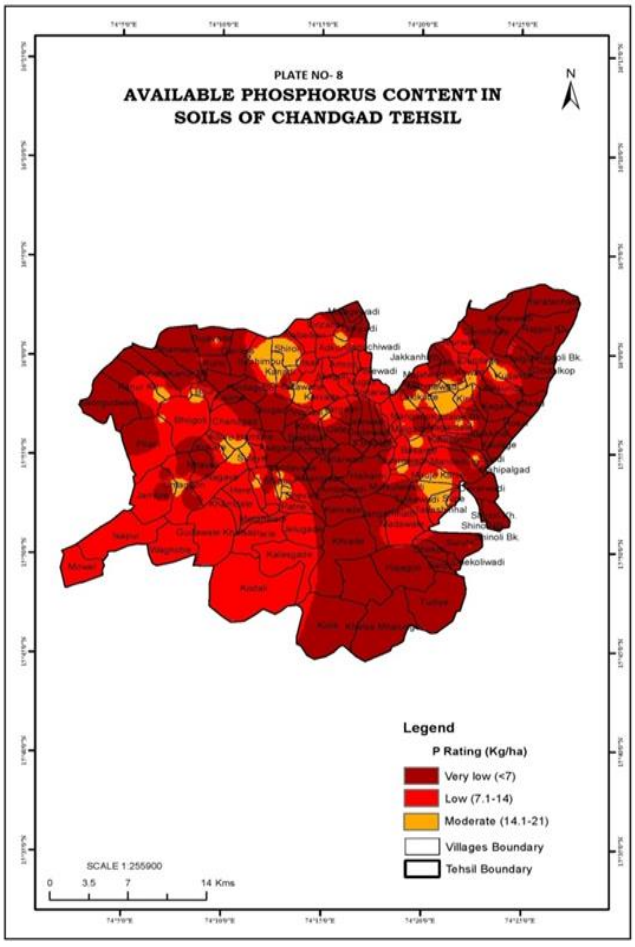

Fig 4: Avail. P of Chandgad tehsil

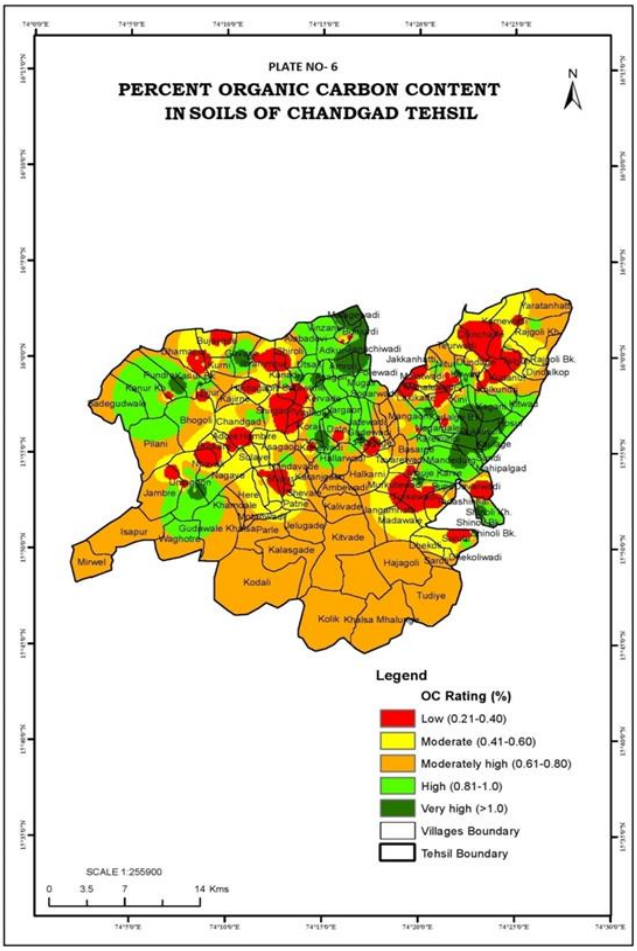

Fig 5: OC of Chandgad tehsil

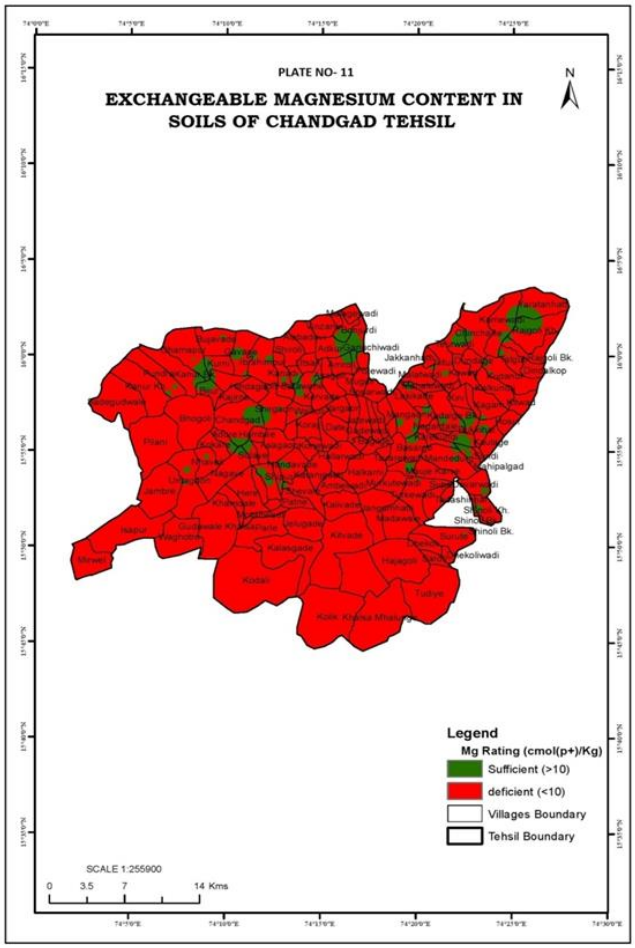

Fig 7: Mg content in Chandgad tehsil

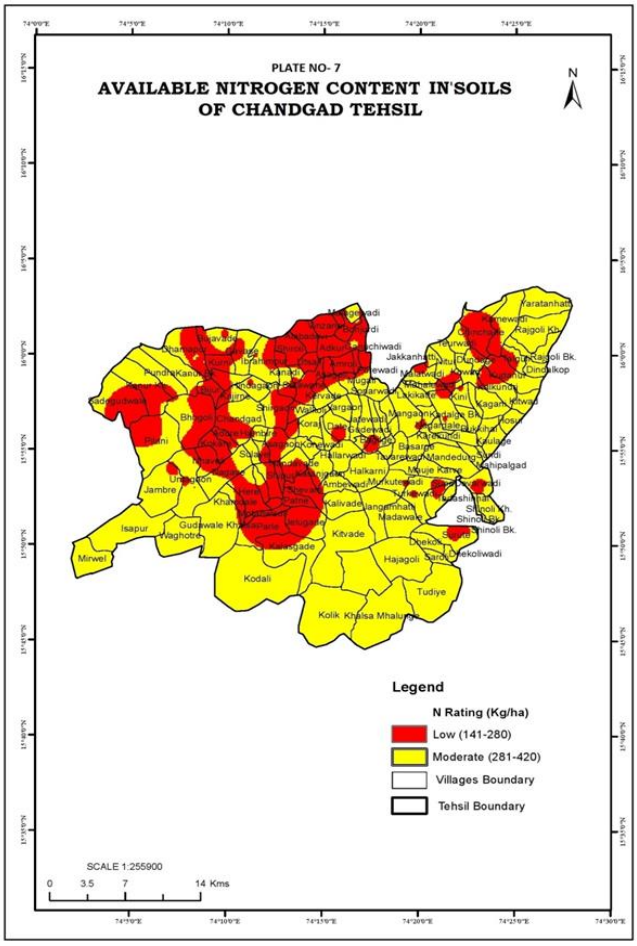

Fig 6: Avail. N of Chandgad tehsil

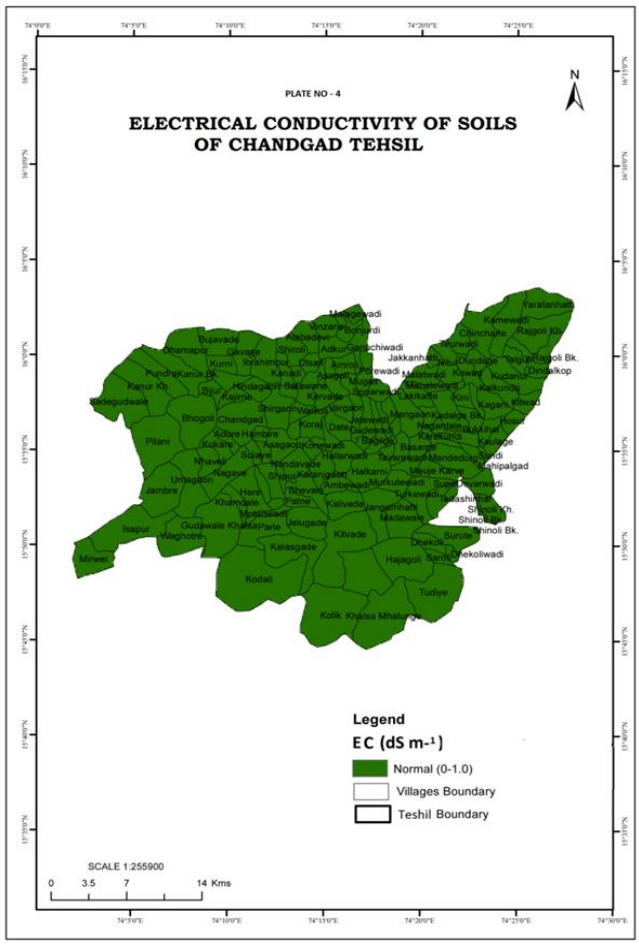

Fig 8: EC of Chandgad tehsil

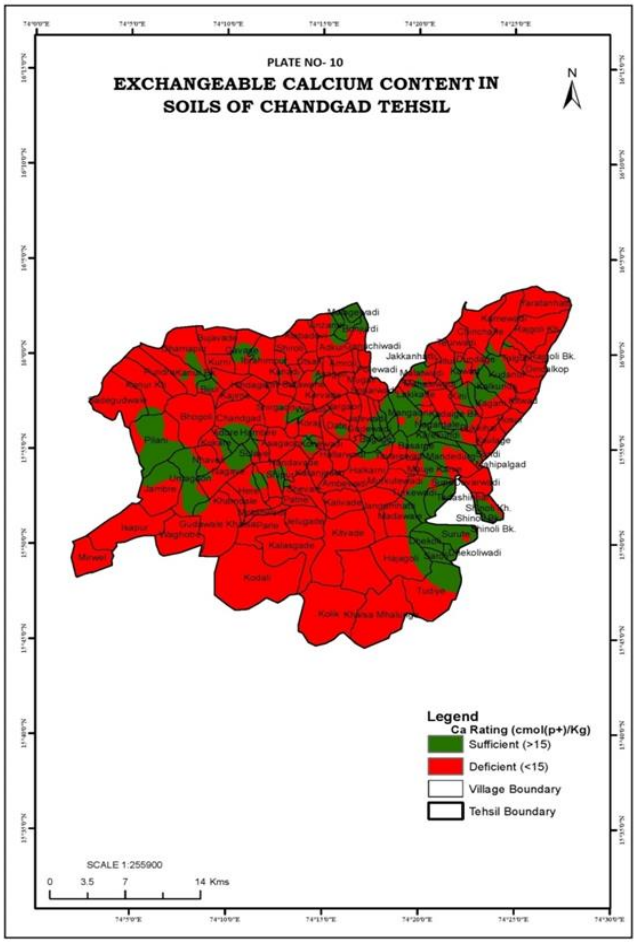

Fig 9: Ca content of Chandgad tehsil

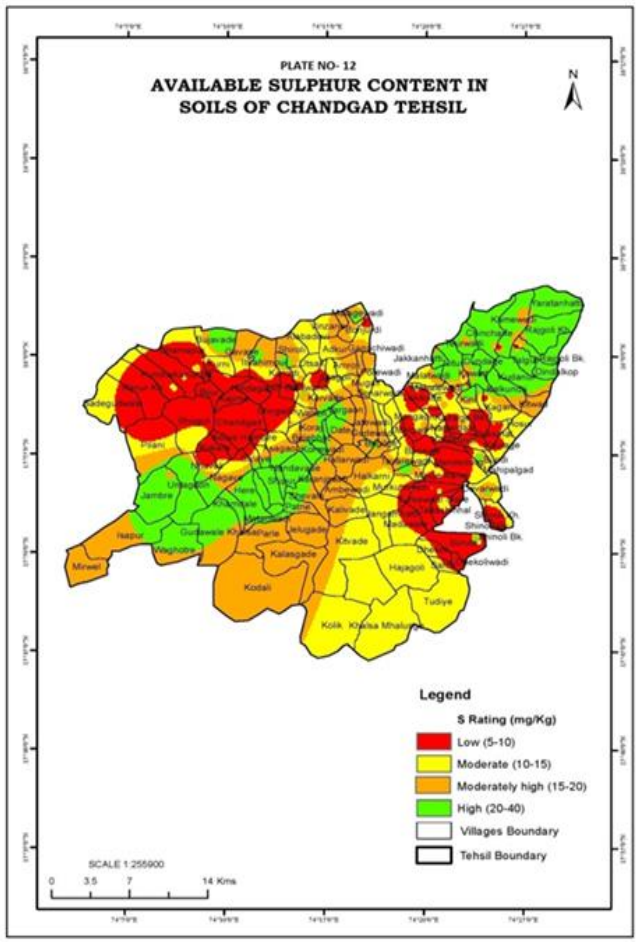

Fig 11: Avail. S of Chandgad tehsil

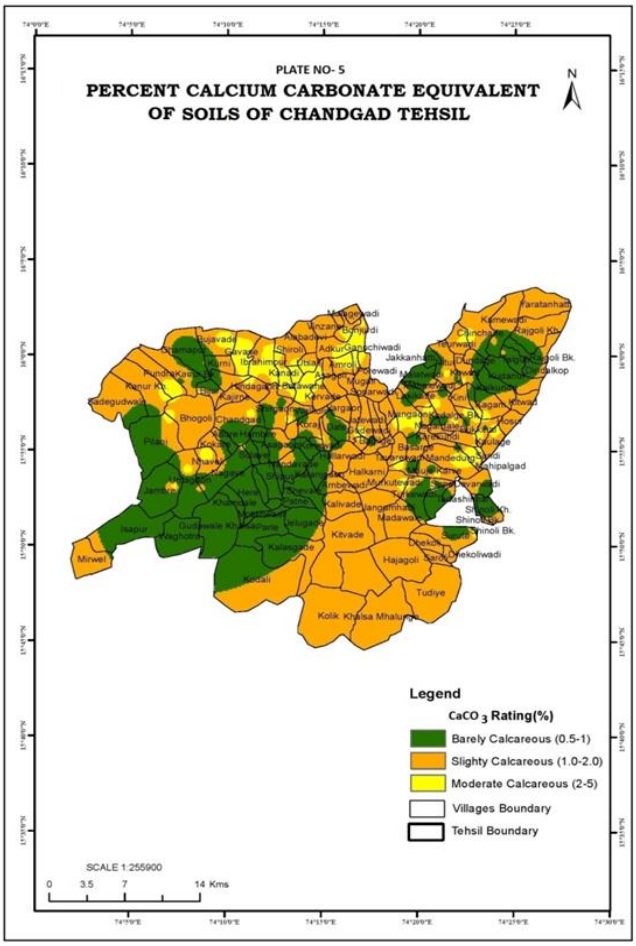

Fig 10: $CaCO_3$ content of Chandgad tehsil

The exchangeable magnesium in the soils of tehsil ranged from 2.25 to 12.5 [cmol (p^+) kg^{-1}]. The deficiency may be due to porous structure of soil, heavy rainfall, erosion, leaching losses of basic cations and low temperature condition Mandal *et al*. (2005) [8] reported similar results as regards exchangeable magnesium content in soils of Nagpur district (Maharastra).

From the study, it can be concluded that, the soils of the Chandgad tehsil were found to be strongly acidic to slightly alkaline in reaction, normal in salt content indicating that the soils are free from salinity, low to very high in organic carbon content and barely calcareous to moderately calcareous in per cent calcium carbonate equivalent content. Soils of tehsil were low to moderatein available nitrogen and that indicates nitrogen is the major limiting nutrient in the soils and also foundmajority samples were low (46.75%) in available phosphorus whereaslow (24.68%) to high (29.22%) in available potassium content. The soils were low (26.62%) to high (27.28%) in available sulphur and 74.68 and 86.37 per cent soil samples found deficient in exchangeable calcium and in exchangeable magnesium content respectively. The maps generated under the study will be useful for generating homogenous units and guiding the farmers to decide the amount and kind of macronutrients to be applied for optimizing economic returns. The geo-referenced sampling sites can be revisited with the help of GPS, which helps in monitoring the changes in the status of nutrients over a period of time, which otherwise is not possible by traditional methods of sampling.

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