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NUTRIENT MAPPING OF SOILS IN NAGARI MANDAL OF CHITTOOR DISTRICT (ANDHRA PRADESH) - A GIS APPROACH

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ABSTRACT

Geo referenced soil samples were collected from 29 villages of Nagari mandal in Chittoor district of Andhra Pradesh at ten ha grid interval following spatially balanced sampling technique. The coordinates of the sampling sites were collected by using GPS receiver. The soil samples were analyzed for various soil fertility parameters by adopting standard procedures. Analytical and statistical parameters such as range, mean, average, standard deviation and coefficient of variation were calculated. Soil fertility maps were prepared using Arc GIS 10 software. Soils were slightly to strongly alkaline in reaction with non saline in nature. Soil organic carbon per cent was medium to high. Available nitrogen was low, available phosphorus was low to high, available potassium was medium to high. By creating the fertility maps it has been concluded that these nutrients play major role in crop development.

KEYWORDS: Nutrient mapping, remote sensing, GIS, soil fertility.

The major objective of this study is to prepare detailed maps of soil fertility status of the area and to link the status of fertility with agricultural practices and the nutrient status of crops by the geo-spatial techniques. This will enable to identify the most important nutrient constraints for a sustainable production of crops. The soil properties and nutrient status have a great role in influencing yield of crop. These maps serve as a database for knowing the soil constraints and deficiency of nutrients in soils.

GIS techniques can be used to generate fertility map of a given area which helps to assess the variation of soil fertility spatially and temporally and compute complex spatial relationships between soil fertility factors. Maps were prepared for spatial variability of all soil properties through interpolation of point based measurements of soil properties, using GIS (ARC/Info) techniques. Interpolation techniques commonly used in agriculture include inverse distance weighing and kriging (Franzen and Peck, 1995 and Weisz *et al.,* 1995). The outcome of the spatial variability helps in precision agriculture which helps in application of corresponding resource application and agronomic practices with soil attributes and crop requirements. The soil information products derived through the GIS and remote sensing are of high quality in terms of both level of spatial detail and degree of attribute accuracy. Technological advancements in these fields have been a boon for soil surveys by mapping and characterizing of soils at various scales (Manchanda *et al.,* 2002).

MATERIALS AND METHODS

Nagari Mandal of Chittoor revenue division in Chittoor district of Andhra Pradesh sprawls over almost 35.45 km^2. Its geographic limits range from 13°.15' to 13º 25' North Latitude and 79° 28' to 79° 43' East Longitude and is covered by Survey of India Topographic Map Nos. D44N11. It has an average elevation of 116 meters (380 feet). The soils are mainly intra zonal soils, which are further sub classified as (i) Deep black soils, (ii) Mixed red and black soils. They are moderately productive and give good crop yields if irrigated. Temperatures vary from a minimum of 35°C and can rise up to a maximum of 45°C.

About 240 Composite surface soil samples (0-15 cm) were collected across Nagari mandal with an agricultural area of 2400 ha area with a grid size of ten ha. The GPS data at each sample location was recorded. The soil samples were air dried under shade, pounded and passed through a 2 mm sieve. The surface soil samples were

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analysed for various soil properties by adopting standard procedures.

The pH and electrical conductivity of the soil was measured in 1:2.5 soil and water extract described by Jackson (1973). Organic Carbon (OC) was determined by Walkley - Black Method. Available nitrogen was determined by alkaline permanganate method outlined by Subbaih and Asija (1956). Available phosphorus content was determined by extracting the soil with 0.5 M $NaHCO_3$ by Olsen *et al*. (1954). Available potassium in the soils was extracted by neutral normal ammonium acetate as described by Jackson (1973).

The latitude and longitudes of sample sites were recorded from study area using a hand held GPS instrument (GARMIN GPS72H). The ArcGIS 10 software was used in this study. Based on the location data obtained, prepared point feature showing the position of samples in MS excel format and linked with the spatial data by join option in Arc Map. The spatial and the non-spatial database developed are integrated for the generation of spatial distribution maps. The steps for generation of point map by using ArcGIS 10 indicated in flow diagram in Fig. 1 and the resultant map generated is presented in Fig. 2.

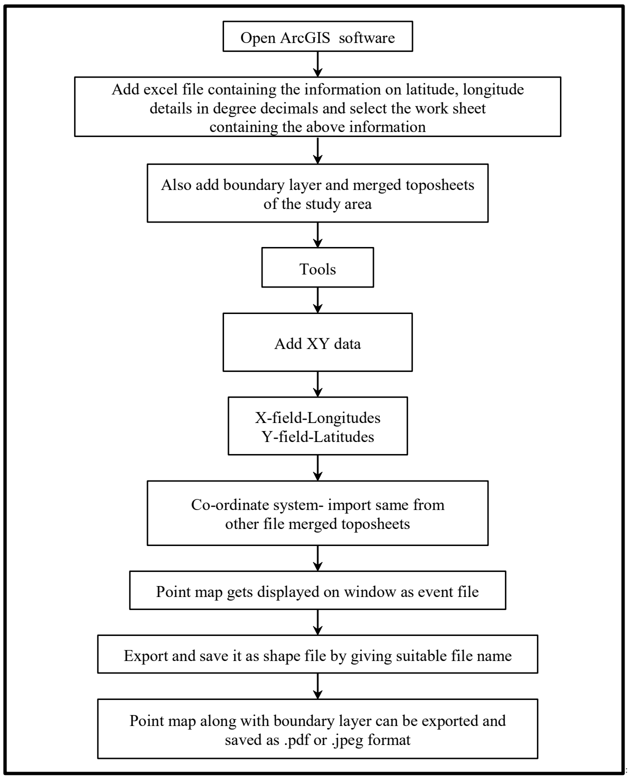

Fig. 1. Preparation of point map showing sampling sites using Arc GIS

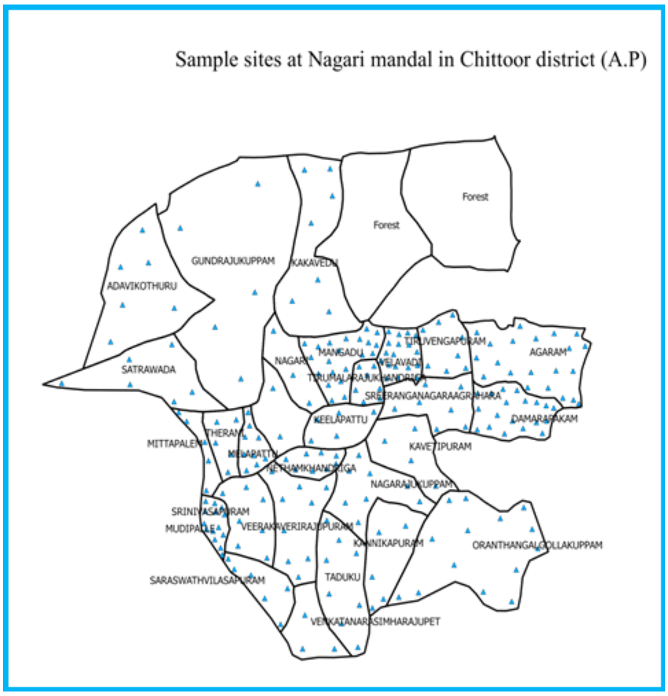

Fig. 2. Location map of soil samples collected in study area

RESULTS AND DISCUSSION

Soil reaction (pH) and Electrical conductivity

Data on soil reaction (pH) revealed that the soils under study fall under neutral to moderately alkaline range and varied from 6.42 to 8.74 with a mean value of 7.925. Majority of soils exhibited weakly alkaline to moderate alkaline reaction (7.5-8.5). The spatial distribution of pH in soils of Nagari mandal is represented by four soil reaction zones (Fig. 3). About 40.21 per cent of total area is characterized by pH range 8.0 to 8.4 (moderately alkaline) where as 16 per cent area by pH range 6.5-7.5 (Neutral), 32.08 per cent area by pH range 7.5 to 8.0, 6.20 per cent of area under the pH range of <6.5 and the zone represented by pH range of >8.4 with highly alkaline reaction is occupied by minimum area of 5.41 per cent. Neutral to moderate alkalinity may be attributed to applied fertilizer material with soil colloids, which results in retention of basic cations on the exchangeable complex of soil. (Sharma *et al*, 2008).

Electrical conductivity of the soils in study area ranged from 0.061 to 1.52 dSm^{-1} and the soils are non-saline, with a mean value of 0.408. Because of good drainage condition in almost all the villages EC is within the normal range and soils are free from problem of

Table 1. Soil characteristics of Nagari mandal

	pH	EC (dS m^{-1})	Organic carbon (%)	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
Range	6.42-8.74	0.061-1.52	0.08-2.0	44-182	2.0-133.00	65-753.00
Mean	7.92	0.41	0.75	77.00	29.00	217.00
SD	0.43	0.29	0.31	32.00	18.00	112.00
CV (%)	5.49	71.93	42.10	42.00	60.30	55.00

Table 2. Ratings for pH, EC, OC and Macro nutrients in soil

pH	**Range**
Acidic	<6.5
Neutral	6.5-7.5
Weakly alkaline	7.5-8.0
Moderately alkaline	8.0-8.4
Highly alkaline	>8.4
EC (d Sm^{-1})	
Suitable	<4.0
Not suitable	>4.0
OC (%)	
Low	< 0.50
Medium	0.5-0.75
High	> 0.75
Available nutrients (kg ha^{-1})	
Nitrogen	
Low	0 to 280
Medium	280-560
High	>560
Phosphorus (kg ha^{-1})	
Low	0-11
Medium	11-25.6
High	>25.6
Potassium (kg ha^{-1})	
Low	<120
Medium	120-280
High	>280

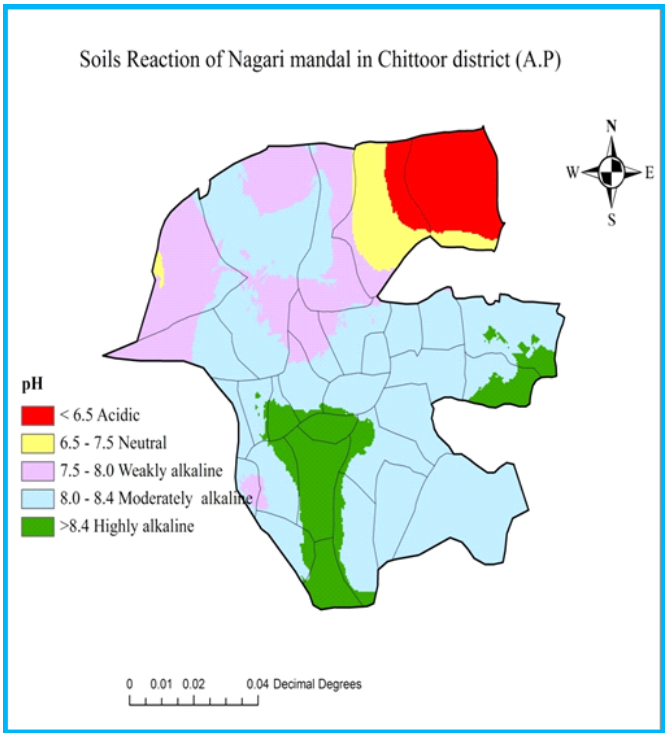

Fig. 3. Spatial distribution of pH in soils of Nagari mandal

salinity and are highly favorable to crop growth. The spatial variation in Nagari mandal pertaining to soil EC is divided into three zones (Fig. 4). Of the total mandal area major area of about 1770 ha (73.73% of total area) is having EC less than 0.5 dSm^{-1}, EC varied from 1.0 to 1.5 dSm^{-1} in minimum area of 140 ha (5.27 %) where as it was 0.5 to 1.0 dSm^{-1} in an area of 510 ha (21%). The normal EC may be ascribed to leaching of salts to lower horizons. (Sharma *et al,* 2008).

Organic Carbon

The Organic carbon content of Nagari Mandal was low to high and ranged from 0.08 to 2.0 per cent, with a mean of 0.76 per cent and standard deviation of 0.31. The spatial variation in Nagari mandal pertaining to soil Organic Carbon is resulted into three zones (Fig. 5). The Organic carbon content ranging < 0.5 per cent occupies 24.1 per cent of total area (580 ha), while 0.5 to 0.75 per ecnt occupies 28.7 per cent of area (690 ha) and the maximum area under the OC range of > 0.75 per cent covers 47.2 per cent of the area (1130 ha). As rice and sugarcane are major crops in the area, residues of these crops left in soil after harvest and their subsequent

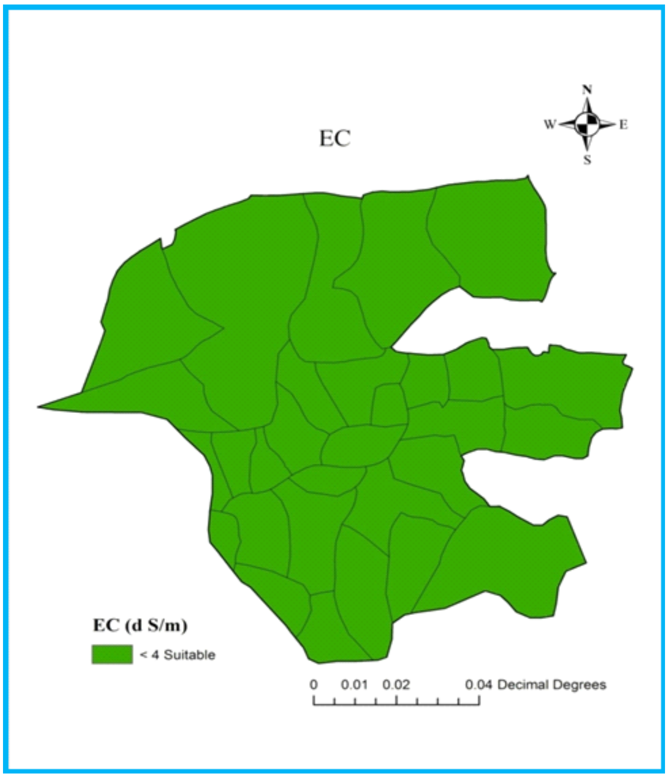

Fig. 4. Spatial distribution of EC in soils of Nagari mandal

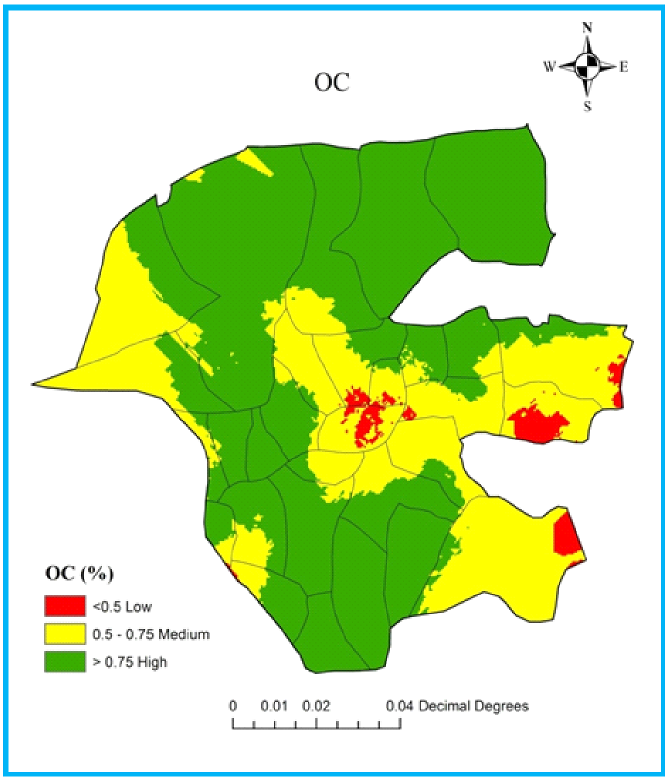

Fig. 5. Spatial distribution of organic carbon in soils of Nagari mandal

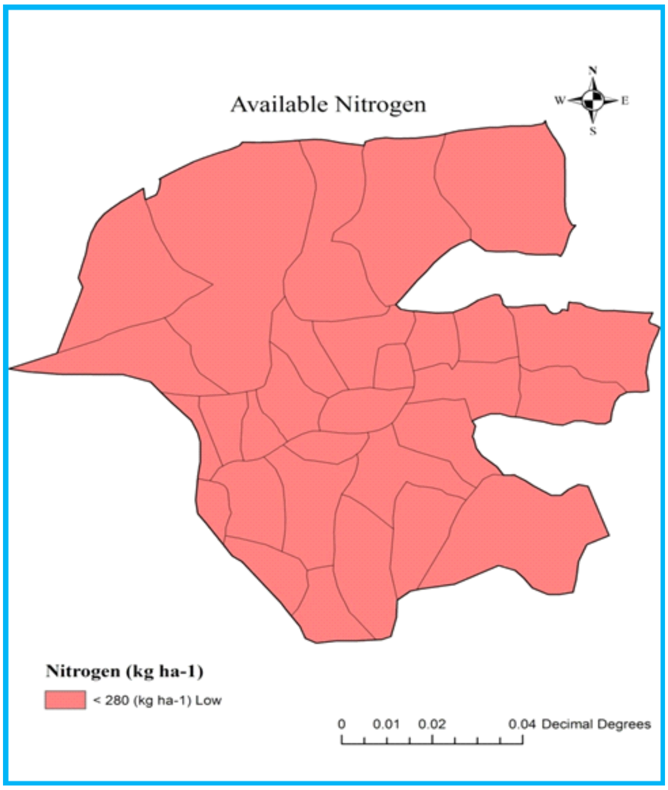

Fig. 6. Spatial distribution of available nitrogen in soils of Nagari mandal

decomposition might have resulted in increase of organic matter content in the soil over a period of time.

Available Macronutrients

The available nitrogen content in soils of Nagari fall under low range. and it varied from 44 to 182 kg ha^{-1}, with a mean value of 77 kg ha^{-1} and standard deviation of 32. Out of 29 revenue villages of Nagari mandal, the soils were low in available nitrogen within range of 280 kg ha^{-1}. The spatial variability of available Nitrogen pertaining to Nagari mandal is depicted in Fig. 6. The available nitrogen content in the area is in low range occupying 100 per cent of the study area (2400 ha). It is quite obvious that the efficiency of applied nitrogen is very low due to the fact that N is lost through various mechanisms like voltalisation (since majority of soils are alkaline), nitrification, denitrification, chemical and microbial fixation, leaching and runoff (De Datta and Buresh, 1989).

The available phosphorus status in soils of Nagari was low to high range and ranged from 2 to 133 kg ha^{-1}, with a mean value of 29 kg ha^{-1}. The spatial distribution of available phosphorus content of Nagari mandal is presented in Fig. 7 representing three fertility zones. The map shows that 44.58 per cent (1070 ha) of the mandal is characterized by medium range whereas 45 per cent (1080 ha) area by high range and 10.42 per cent (250 ha) area under low range of available phosphorus content. Adequate amount of phosphorus in majority of soils may be attributed to continuous application of phosphatic fertilizers to crops and at same time the efficiency of applied phosphorus is very low in soil. Plants take only 10-40 per cent of applied phosphorus during growing season (Aulakh and Paricha, 1999) and the rest resides in soil as less soluble product.

The available potassium content in soils of Nagari mandal ranged from 65 to 753 kg ha^{-1}, with a mean value of 217 kg ha^{-1}. Most of soils were medium to high in available potassium content. In other villages on an average the soils recorded medium to high available Potassium content. The spatial variability map of available Potassium content of Nagari mandal is shown in Fig. 8. The potassium content of high range category occupies an area of 420 ha (17.54%) of the study area while the

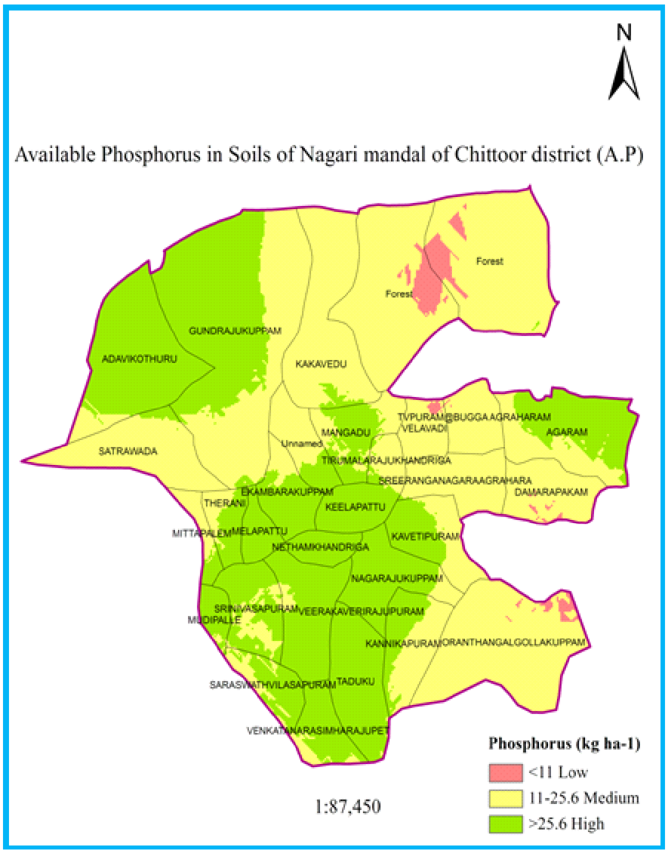

Fig. 7. Spatial distribution of available phosphorus in soils of Nagari mandal

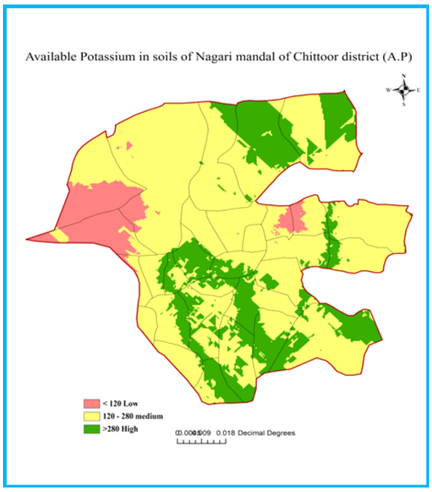

Fig. 8. Spatial distribution of available potassium in soils of Nagari mandal

medium range occupies highest area of 1660 ha (69.16%) and the remaining of 13.3 per cent (320 ha) of mandal contains soils with low potassium content. Adequate available K in these soils may be attributed to the prevalence of potassium- rich minerals like illite and feldspars.

CONCLUSION

The maps suggested variability in fertility status across the study area. In soil reaction the soil remains neutral to highly alkaline in nature and at same time electrical conductivity remains at safe level. Organic carbon status of the soils of Nagari mandal has improved because of addition of crop residues over the years as a result of intensification of agriculture. Nitrogen deficiency is majorly observed in the area due to imbalanced fertilization and loss of nitrogen through various processes. Continuous use of P fertilizer resulted in build of phosphorus in most parts of area. Most of soils were medium to high in available Potassium content. Solutions to overcome the problem is balanced fertilizer use and complementary use of organic nutrient inputs with fertilizers. These are the possible agro-techniques to sustain yield, increase fertilizer use efficiency and to restore soil fertility under intensive cropping (Dwivedi *et al.*, 2003; Timsina and Connor, 2001; Yadav *et al.*, 1998a).

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