Biological Forum – An International Journal **(SI-AAEBSSD-2021) 13(3b): 255-259(2021)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Assessment of Soil Fertility through Geospatial Techniques in Kurnool Division of Andhra Pradesh

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(Received 01 July 2021, Accepted 25 September, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Soil analysis of the study area (Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals) of Kurnool Agricultural Revenue Division, Kurnool Dt of AP state during 2016-17 revealed nature of soils as neutral to strongly alkaline in reaction with low electrical conductivity. Soil OC and available N were low to medium, with respective to available phosphorus the values ranged from low to high and the available potassium from medium to high. The available Ca, Mg, S and Mn were sufficient whereas Zn, Fe and Cu are deficient to sufficient in range. Spatial variability of soil properties were premeditated and the generation of maps was done making use of geo-statistics. Spacial variability was observed in all the nutrients except calcium, magnesium and manganese. The spatial variability was high with phosphorus followed by sulphur, zinc, iron, nitrogen, potassium and copper.

Keywords: Soil Fertility Mapping, Geospatial Techniques, Spatial Variability.

INTRODUCTION

Soil categorization with mention to fertility grade of a region is key characteristic for targeting sustainable agricultural production in the backdrop of usage of unnecessary and inadequate fertilizer coupled with other inputs lower efficiency. Tremendous decline in production efficiency was observed with use of chemical fertilizers in past few days (Yadav and Meena, 2009). With the intervention of Green revolution in India farmers were forced to go for usage of elevated dose of NPK without micronutrient component thus resulting in deficiency of micro nutrients in crops and becoming a major challenge in achieving the productivity potential, sustainability and stability of soils.

In the modern era of agriculture, for sustainable crop production the technologies *viz.,* Global Positioning System (GPS) and Geographic Information System (GIS) have been adopted for effective management of land and other resources (Palaniswami *et al.,* 2011). The modern day space age technology can be utilized for fast propagation of the results of research on optimum nutrient doses for maximization of farm profitability (Singh *et al.,* 2005) to farmers, scientists, extension workers and industry personnel. Use of soil fertility maps to recommend fertilizer doses based on soil test values is one of the technology being used. Macro and micronutrients availability status in soils helps in demarcating the areas where, application of particular nutrient is needed for profitable crop yields (Sood *et al.,* 2009).

Awareness on spatial variability in maintaining fertility of soils is necessary for precise nutrient management. In this study area, spatial variable properties that controls soil fertility such as soil Organic Carbon, available Nitrogen, available phosphorus, available potassium, secondary and micro nutrients in surface soils of 383 farmer's field representing five mandals were tested and the respective thematic maps were drawn on the basis of ratings of nutrients.

MATERIALS AND METHOD

Study Area

The study area, comprises of five mandals (Kurnool, Gudur, Kallur, C. Belagal and Kodumur) of Kurnool Agricultural Revenue Division, Kurnool District, Andhra Pradesh is located on NH 44. Its geographic limits fall between 15°54′18″ to 15°33′15″ N latitudes and 77°36′18″ to 78°12′21″ E longitudes located in Scarce Rainfall Zone of Andhra Pradesh.

Ground truth data collection. Preliminary investigation of the study area was conducted and representative areas of soils were arrived by discussing with the farmers of each village. GPS data was recorded for every sampling location. Soil sampling intensity was increased from Revenue Division to village level to ensure accurate and field wise fertilizer recommendations. Apart from these the information regarding crops, cropping pattern followed and production practices in the study region were collected from farmers.

Collection and analysis of soil samples. Under Consideration of uniformity in soil sample distribution of study area, 383 surface soil samples (0-15 cm depth) were collected from five mandals in a methodical pattern from diverse locations during *rabi*, 2016-17 seasons using GPS. The collected soil samples were shade dried and further analysis was carried out.

Soil samples analyis was done for availability of nutrients by following the standard analytical procedures. The pH and EC of soil samples were estimated in 1:2.5, soil: water suspension (Jackson 1973). Finely grounded soil sample was passed through 0.2 mm sieve and organic carbon was estimated by Walkely and Black (1934) wet oxidation method as described by Jackson (1973) and expressed in percentage (%). Available N was analyzed by potassium permanganate method of Subbaiah and Asija (1956). The extraction of Available P_2O_5 was done using 0.5*M* $NaHCO_3$ solution buffered at pH 8.5 (Olsen *et al.,* 1954). Phosphorus in the extract was estimated by developing blue colour using ascorbic acid method (Watanabe and Olsen, 1965). Available K was extracted by shaking the requisite amount of soil sample with 1*N* NH4OAc (pH 7.0) solution (1:5 soil solution ratio) (Pratt, 1982). Lindsay and Norvell (1978) was used for the determination of micronutrients (Mn, Cu, Fe and Zn) in AAS by using DTPA extract.

Soil fertility maps - preparation and fertilizer recommendation. The fertility maps presenting status of nutrients were generated by means of critical data of individual nutrient. Spot data collected by using GPS was then altered into polygon data by adopting geostatistical tool of IDW (Inverse Distance Weighted) in *ArcGIS* 10.3 environment. Fertilizer Recommendation was given based on the soil test outcome in the study area.

RESULTS AND DISCUSSION

Soil reaction (pH): The pH of study area of surface soils are moderately acidic to strongly alkaline. The pH of soils in Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals varied from 6.51 to 9.12, 6.28 to 8.78, 7.12 to 8.91, 6.69 to 8.99 and 6.48 to 9.06, respectively. Soil maps are generated for soil reaction using Inverse Distance Weighting (IDW) method at 1:50000 scale. The spatial disparity of pH in Kurnool division is grouped into four classes (Fig. 1). Major segment of the area studied (74.75 %) is moderately alkaline and rest of the area is faintly alkaline (13.02 %) to strongly alkaline (10.96 %). The higher pH of soils could be accredited to lower intensity of leaching and buildup of bases as confirmed with the findings of Patil *et al.* (2016) and Prabhavati *et al.* (2015). The lower pH values observed in surface soils of study area might be due to continuous removal of basic cations by plants or movement of basic cations to deeper layers of soil. This might be due to the release of organic acids during decomposition of organic matter as envisaged by Arunkumar *et al.* (2002) and Thangasamy *et al.* (2005).

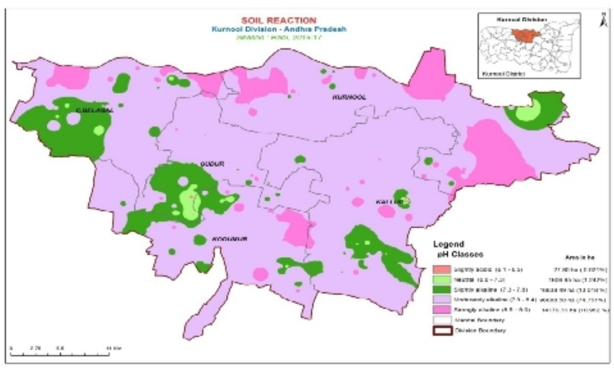

Fig. 1. Spatial distribution of soil pH in study area, 2016-17.

Table 1: Soil Physico–chemical and available macro nutrient properties in the study area.

Location		pH	EC (dS m^{-1})	OC (%)	N	P_2O_5	K_2O
					(kg ha^{-1})		
Kurnool	Range	6.51-9.12	0.11-4.01	0.09-0.62	88-289	14.2-89.4	211-815
	Mean	-	0.27	0.34	180	47.1	501
Kallur	Range	7.12-8.91	0.06-0.79	0.09-0.66	88-289	18.6-88.2	210-809
	Mean	-	0.27	0.33	179	50.4	468
C. Belgal	Range	6.69-8.99	0.10-2.21	0.17-0.62	100-289	20.6-96.2	236-804
	Mean	-	0.42	0.34	198	48.7	484
Gudur	Range	6.28-8.78	0.09-0.57	0.15-0.58	100-263	17.6-95.2	197-885
	Mean	-	0.25	0.32	186	52.0	487
Kodumur	Range	6.48-9.06	0.07-0.71	0.12-0.56	100-289	20.6-96.4	236-836
	Mean	-	0.24	0.34	178	50.9	491

Electrical conductivity (EC): EC of the soils ranged from 0.11 to 4.01, 0.09 to 0.57, 0.06 to 0.79, 0.10 to 2.21 and 0.07 to 0.71 dS m^{-1} with average value of 0.27, 0.25, 0.27, 0.42 and 0.24 dSm^{-1} in Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals, respectively. Nearly in all the mandals of study area, EC was in the regular range and soils be non saline in nature. Major portion of investigated area (99.23%) was non saline and rest of the area was very slightly saline (0.63 %) and slightly saline (0.13 %).

Organic Carbon (OC): The organic carbon (OC) content in surface soils of study area varied from 0.09 to 0.62, 0.15 to 0.58, 0.09 to 0.66, 0.17 to 0.62 and 0.12 to 0.56 per cent with mean of 0.34, 0.32, 0.33, 0.34 and 0.34 per cent in five mandals of Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals, respectively. Spatial variability map of organic carbon generated by GIS revealed that 97.08 % of the study vicinity was lower in organic carbon (< 0.5 %), only 2.3 per cent was medium (0.5 to 0.75 %) in soil organic carbon (Fig. 2). The disparity in the organic carbon content in study area soils could be due to discrepancy in appliance of organic manures like farm yard manure or crop residues by the farmers. The low organic carbon (OC) in top soils is due to low input of farm yard manure (FYM) and crop reminants (crop residues) coupled with rapid rate of decay under high temperature was reported by Vijayakumar *et al.* (2011).

Table 2: Soil available secondary and micro nutrient status in the study area.

Location		Ca	Mg	S	Zn	Cu	Fe	Mn
		(c mol (p^+) kg^{-1})		(mg kg^{-1})				
Kurnool	Range	10.47-34.50	3.20-22.40	3.75-22.14	0.16 - 1.43	0.16-2.60	2.41-17.62	1.09-13.68
	Mean	22.5	9.4	11.41	0.60	0.78	6.07	5.91
Kallur	Range	14.4-37.2	5.0-14.6	3.58-22.47	0.13-1.48	0.12-2.58	1.02-14.58	1.08-15.48
	Mean	24.3	9.7	10.92	0.57	0.69	4.78	5.79
C. Belgal	Range	14.4-38.8	4.2-15.7	3.74-22.45	0.26-1.30	0.26-1.85	1.54-12.58	1.38-14.22
	Mean	26.0	10.5	12.52	0.61	0.76	5.38	6.17
Gudur	Range	16.0-35.7	4.2-16.4	2.50-20.45	0.17-1.33	0.18-2.03	1.08-11.91	1.02-16.48
	Mean	25.1	10.1	9.65	0.64	0.90	4.39	6.28
Kodumur	Range	12.4-35.6	4.0-14.8	3.26-24.53	0.16-1.25	0.03-1.89	1.15-9.52	1.03-12.75
	Mean	24.8	9.1	11.36	0.53	0.77	4.78	6.04

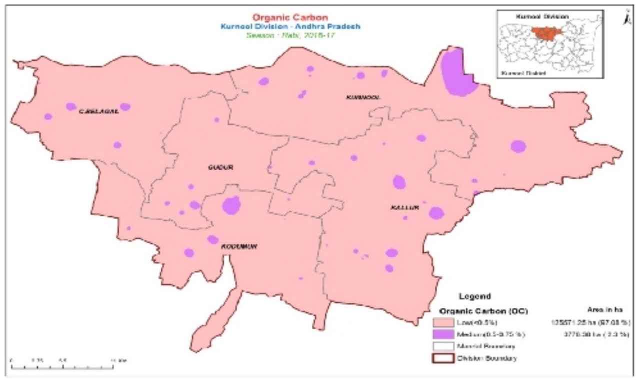

Fig. 2. Spatial distribution of soil OC in study area, 2016-17.

Available nitrogen. Availability of nitrogen in soils of Kurnool division ranged from low to medium. The available N content of the soils in different mandals Kurnool, Gudur, Kallur, C. Belagal and Kodumur varied from 88 to 289, 100 to 263, 88 to 289, 100 to 289 and 100 to 289 kg/ha with a mean of 180, 186, 179, 198 and 178 kg/ha, respectively. The nitrogen content was lower in 99.91 % of study area and only 0.09 % of part was medium in available nitrogen. It is quite evident that the efficiency of applied nitrogen is very low as nitrogen is lost through various mechanisms like nitrification, succeeding denitrification, chemical and microbial fixation, NH_3 volatilization, runoff and leaching which resulted in lower amount of soil available nitrogen in soil (Datta and Buresh, 1989).

Available Phosphorus (P_2O_5): The available phosphorus (P_2O_5) in Kurnool division soils ranged from 14.2 to 89.4, 17.6 to 95.2, 18.6 to 88.2, 20.6 to 96.2 and 20.6 to 96.4 kg/ha with mean value of 47.1, 52.0, 50.4, 48.7 and 50.9 kg ha^{-1} in Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals, respectively. Mapping of available P_2O_5 by using GIS method confirmed that, it was low in 0.08 %, medium in 74.84 % and higher in 25.08 % in study area (Fig. 3). Phosphorus build up in the study area that attributed to high available phosphorus status is due to its Semi-arid environment with low rainfall and continuous usage of high analysis fertilizers especially DAP.

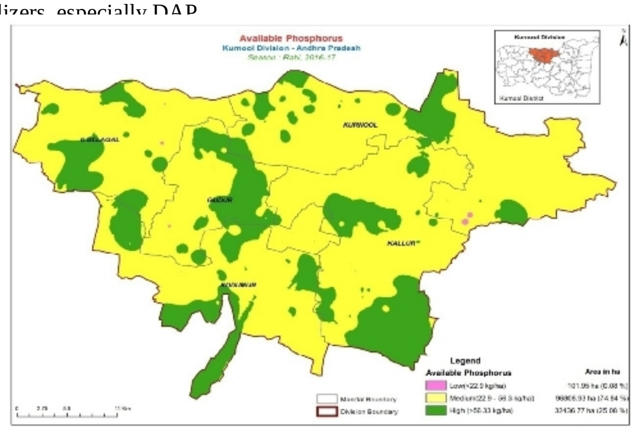

Fig. 3. Spatial distribution of soil Phosphorus in study area, 2016-17.

Available Potassium (K_2O): The available potassium in surface soil of Kurnool division during 2016-17 ranged from 211 to 815, 197 to 885, 210 to 809, 236 to 804 and 236 to 836 kg $ha^{-1}$with mean of 501, 487, 468, 484 and 491 kg ha^{-1}in Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals, respectively. Mapping of available potassium by using GIS method revealed that largest area of 99.35 % was high in available potassium content. Potassium content is medium in the remaining area (0.65%).

Available Calcium (Ca^{+2}) and Magnesium (Mg): The available calcium varied from 10.4 to 34.5, 16.0 to 35.7, 14.4 to 37.2, 14.4 to 38.8 and 12.4 to 35.6 (c mol (p^+) kg^{-1}) with mean of 22.5, 25.1, 24.3, 26.0 and 24.8 (c mol (p^+) kg^{-1}) and the available magnesium varied from 3.2 to 22.4, 4.2 to 16.4, 5.0 to 14.6, 4.2 to 15.7 and 4.0 to 14.8 (c mol (p^+) kg^{-1}) with mean value of 9.4, 10.1, 9.7, 10.5 and 9.1 (c mol (p^+) kg^{-1}) in five mandals of Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals, respectively. The results revealed that the entire study area of Kurnool division are sufficient with respective to available calcium and magnesium. The higher amount of exchangeable Ca and Mg content found in soils may be owing to high clay content and shale parent material.

Available Sulphur (S): The available sulphur in soil samples of Kurnool division during 2016-17 ranged from 3.75 to 22.14, 2.50 to 20.45, 3.58 to 22.47, 3.74 to 22.45 and 3.26 to 24.53 mg $kg^{-1}$with mean of 11.41, 9.65, 10.92, 12.52 and 11.36 mg kg^{-1} in Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals, respectively. Available sulphur revealed that 68.74 per cent in the reading locality was adequate and 31.26 % was deficient (Fig. 4). The low available S was partly due to gypsiferous nature of sulphur which is non-available in black soils. Low and medium level of available S was due to lack of sulphur addition and continuous removal by crops (Venkatesh and Satynarayana, 1999).

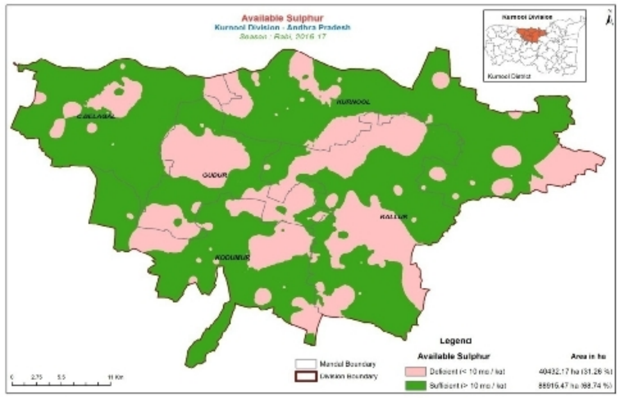

Fig. 4. Spatial distribution of soil Sulphur in study area, 2016-17.

Available Zinc (Zn): The available zinc content of soils of Kurnool division varied from 0.16 to 1.43, 0.17 to 1.33, 0.13 to 1.48, 0.26 to 1.30 and 0.16 to 1.25 mg kg^{-1} with mean of 0.60, 0.64, 0.57, 0.61 and 0.53 mg kg^{-1} in Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals, respectively. The spatial distribution map of available zinc revealed that only 24.0 per cent in the study area was sufficient and rest of the area was deficient in available zinc (Fig. 5). Prasad *et al.*, 2009 attributed the low available zinc is due to high soil pH values and inturn formation of insoluble compounds of zinc or insoluble calcium zincate.

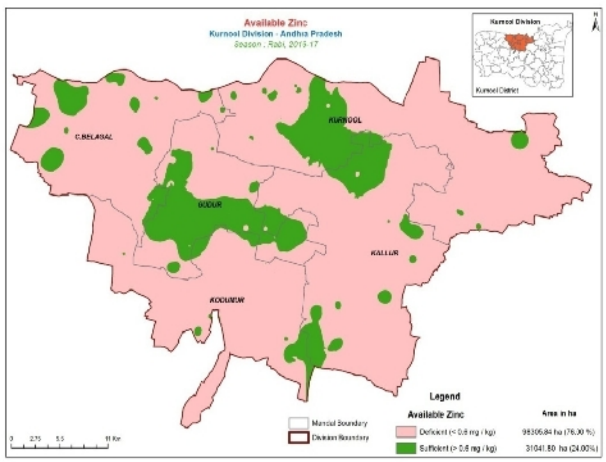

Fig. 5. Spatial distribution of soil Zinc in study area, 2016-17.

Available Copper (Cu) and Manganese (Mn): The available copper content of soils of Kurnool division varied from 0.16 to 2.60, 0.18 to 2.03, 0.12 to 2.58, 0.26 to 1.85 and 0.03 to 1.89 mg kg^{-1} with mean of 0.78, 0.90, 0.69, 0.76 and 0.77 mg kg^{-1} and the available manganese varied from 1.09 to 13.68, 1.02 to 16.48, 1.08 to 15.48, 1.38 to 14.22 and 1.03 to 12.75 mg $kg^{-1}$with mean of 5.91, 6.28, 5.79, 6.17 and 6.04 mg kg^{-1} in Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals, respectively. The spatial distribution map of available copper and manganese revealed the whole study area was satisfactory in available copper and manganese. The higher concentration of copper and manganese in the top horizon might be suitable to higher biological activity and chelating of organic compounds released during the decomposition of organic matter left after harvesting of the crop. This results are in conformity with the findings of Reddy and Naidu (2016).

Available Iron (Fe): The available iron content of soils of Kurnool division varied from 2.41 to 17.62, 1.08 to 11.91, 1.02 to 14.58, 1.54 to 12.58 and 1.15 to 9.52 mg kg^{-1} with mean value of 6.07, 4.39, 4.78, 5.38 and 4.78 mg kg^{-1} in Kurnool, Gudur, Kallur, C. Belagal and Kodumur mandals, respectively, it was sufficient in 61.49 % of the study area and deficient in 38.51 % of the study area (Fig. 6). The low iron content in some parts of study area can be attributed to precipitation of iron by $CaCO_3$, which decreased its availability. This is in similarity with the results of Ravikumar *et al.* (2007).

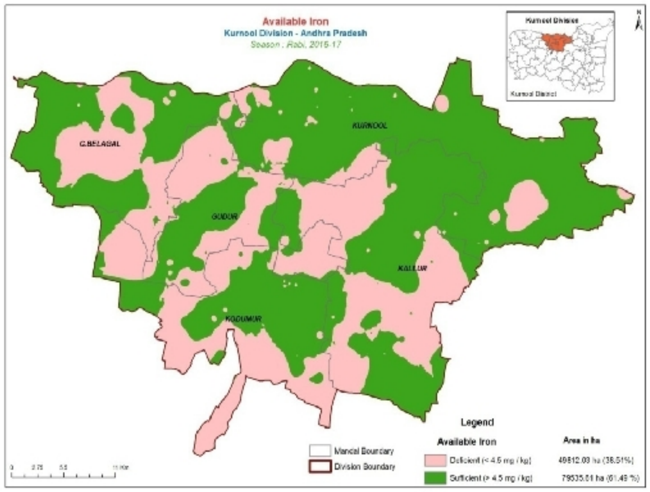

Fig. 6. Spatial distribution of soil Iron in study area, 2016-17.

CONCLUSION

Investigation on spatial variability of soil nutrients for different locations and thematic maps of soil fertility using geospatial techniques would help in rationalization of fertilizer use and efficient nutrient management that leads to sustainability in agricultural production.

FUTURE SCOPE

Future studies need the incorporation of long term, multifactor experimental design for other soil variables like salinity index, micronutrients to validate the robustness of the estimation of variables using remote sensing. This might prove useful and beneficial to test the relationship between spectral indices and soil nutrient status.

Acknowledgement: The authors are thankful to the anonymous reviewers for their constructive comment and suggestions to improve the manuscript. Authors are thankful to APSAC, Vijayawada for providing satellite and ancillary data support. The authors are thankful to the ANGRA University for providing necessary facilities for the investigations.
Conflicts of Interest. The authors declare no conflict of interest.

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