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Mapping of Nutrient Status of Rice Soils in Guntur District (Andhra Pradesh) Using GIS Techniques

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Spatial distribution of nitrogen (N), phosphorus (P), potassium (K) and organic carbon (OC) was studied by collecting geo-referenced surface (1-15 cm) and sub surface (15-30 cm) samples from 96 sites representing intensively rice growing soils using global positioning system (GPS) and mapped in GIS environment. These samples were analyzed for physical, physico-chemical and chemical properties of the soils. The content of available nitrogen varied from 120 to 450 kg ha^{-1}, available P from 13.8 to 62.6 kg ha^{-1}, available K from 100 to 583 kg ha^{-1} and organic carbon varied from low to medium. The maps of various nutrient elements clearly indicated the specific locations, where deficiency of nutrients constrained crop production.

Key words : GPS and GIS, Mapping.

Rice crop requires application of heavy doses of nutrients, particularly nitrogen (N), to achieve full yield potential. Application of fertilizers by the farmers in the fields without prior knowledge of soil fertility status might result in adverse effects on soils as well as crops both in terms of nutrient deficiency and toxicity either by the adequate or over use of fertilizers (Sharma, 2004). A scant attention was paid to collect the geo-referenced samples and whole district was taken as a single mapping unit. With the invent of modern technologies of remote sensing, GIS and GPS, it is now possible to monitor the changes in fertility status of the study area for site-specific nutrient requirement of the crop. Keeping this in view, present study was taken up in Guntur district of Andhra Pradesh to study the spatial distribution of soil nutrients.

MATERIAL AND METHODS

Guntur district occupies an area of 276 thousand ha of rice with a production of 850 thousand tonnes and productivity of 3136 kg ha^{-1}. Surface soil samples from 0-15 cm and sub surface soil samples from 15-30 cm depth were drawn from the ground truth sites from intensively rice grown areas. Ninety six geo-referenced soil samples were collected and location of soil sampling sites of the district were worked out with the help of global positioning system (GPS) used during collection of soil samples. The soil samples were ground and passed through a 2 mm sieve. Soil pH was measured in 1:2.5 soil water suspension using glass electrode pH meter. Particle size analysis by Bouyoucos hydrometer method, cation exchange capacity (CEC) was determined by using neutral sodium acetate and organic carbon by rapid titration method (Walkley and Black, 1934). The available nitrogen was estimated by alkaline permanganate method of Subbiah and Asija (1956). Available phosphorus was extracted with 0.5*M* $NaHCO_3$ solution buffered at pH 8.5 (Olsen *et al.,* 1954). Phosphorus in the extract was determined by developing blue colour using ascorbic acid method (Watanabe and Olsen, 1965). Available potassium (K) was extracted by shaking the requisite amount of soil sample with 1*N* NH_4OAc (pH 7.0) solution (1:5 soil solution ratio) (Pratt, 1982).

The soils samples were taken using GPS to mark the location of samples. These point locations are fed into categories based on criteria given in Table1. The points having same category were grouped into class as a polygon and the maps for individual nutrients were generated in Arc GIS.Though map showing the entire district, the area was calculated only for rice growing areas by using rice mask of the district.

RESULTS AND DISCUSSION

Soil reaction:

The results of soil reaction revealed that the surface soils under study fall under slightly acidic to alkaline range (Table 2). The pH of soils under the study varied from 6.0 to 8.3 with a mean value of 7.7 and standard deviation of 0.46. The soil reaction of subsurface soils ranged from 6.0 to 8.7 with a mean value of 8.0 and standard deviation of 0.4. Majority of the soils had slightly acidic to alkaline pH with an average pH of 7.7 which is ideally suited for cultivation of wide range of crops with no limitation. The slightly acidic to alkaline pH may be attributed to the reaction of applied fertilizer material with soil colloids, which resulted in the retention of basic cations on the exchangeable complex of the soil. Sharma *et al.* (2008) and Madhuvani *et al.* (2000) also reported the similar results. The alkaline pH values in subsurface soils might be due to efficient recycling of basic cations and also due to presence of sodium as dominant cation on exchangeable complex (Prasad *et al.,* 1998).

Electrical conductivity:

The electrical conductivity of the soil samples increased with depth. The slight increase in EC values in subsurface soils, might be due to translocation of soluble salts from surface horizons to deeper layers. All soil samples were in the normal EC range and the study area was free from salinity problem. Similar results were reported by Sharma *et al.* (2008) and Sahu *et al.* (1990).

Organic carbon:

The results of the organic carbon revealed that the soils under study fall under low to medium in range. The organic carbon content of the surface soils varied from 0.2 to 0.7 per cent with a mean value of 0.47 per cent (Table 2). The organic carbon content of subsurface soils was low and varied from 0.12 to 0.53 per cent with a mean value of 0.31 and standard deviation of 0.1. The variations in organic carbon content was mapped under GIS environment (Fig 1). It is observed that 118553 ha (48.4 per cent) of the soils were in low category and 126276 ha (51.6per cent) of the soils were medium in category (Table 3).The organic carbon content of surface soil was greater than sub surface soils. This was attributed to the addition of organic manures and plant residues to surface soils which resulted in higher organic carbon content in surface horizons than subsurface soils. These observations are in accordance with results of Basavaraju *et al.* (2005).

Texture:

The texture of the surface soils varied from sandy loams to clay. More than 60 per cent of the soils were clayey in nature and 23 per cent of the soils were sandy clay loams. The clay content varied from 12.0 to 68.0 per cent with a mean value of 43.2 per cent, while the sand fraction varied from 7.0 to 81.0 per cent with a mean value of 37.1 per cent. The silt content of these soils varied from 6.0 to 32.0 per cent with a mean value of 19.7 per cent. The texture of the subsurface soils varied from sandy clay loam to clay in nature. As the depth of the soil increases, the percent of clay increased, the sand content decreased and silt content did not follow any trend with depth. The clay content of subsurface soils varied from 23 to 73 per cent with a mean value of 48 and standard deviation of 12.9. The sand fraction varied from 6.0 to 62.0 per cent with a mean value of 30 with a standard deviation of 14.3. The silt content of these soils varied from 6.0 to 34 per cent with a mean value of 22 and a standard deviation of 6.2. Increase in clay content with depth might be due to more intensive weathering at deeper layer and impoverishment of finer particles from surface horizon leaving behind coarse sand particles in surface layers. The variation in texture was mainly because of deposition of finer fraction. Similarly, the illuviation process also affected the vertical distribution of silt and sand content. Similar observations were also made by Sharma *et al.* (2004).

Available nitrogen:

The results of the available nitrogen revealed that the surface soils under study fall under low to medium range. The available nitrogen in the soils varied from 120 to 450 kg ha^{-1}, with a mean value of 286 kg ha^{-1} (Table 2). Forty two per cent of soils were low in available nitrogen, while 58 per cent of soils were medium in available nitrogen. The variations in nitrogen was mapped under GIS environment (Fig 2). It is observed that 106361 ha (43.4per cent) of the soils were in the low category and 138471 ha (56.6per cent) of the area was in

Table 1. Criteria for assessment of organic carbon and macronutrients in soils. (Tandon, 1993).

Parameter	Low	Medium	High
Organic carbon (per cent)	<0.5	0.5-0.75	>0.75
Available nitrogen (kg ha^{-1})	<280	280-560	>560
Available phosphorus (kg ha^{-1})	<22.5	22.5-56	>56.0
Available potassium (kg ha^{-1})	<135	135-335	>335

Table 2. Physico-chemical and chemical characteristics soils of Guntur district.

Soil property	Surface soil				Sub surface soil			
	Min	Max	Mean	SD	Min	Max	Mean	SD
pH (1:2.5)	6.0	8.3	7.7	0.46	6.0	8.7	8.0	0.4
EC(dS m^{-1})	0.03	0.77	0.28	0.46	0.12	0.53	0.36	0.2
Organic carbon (per cent)	0.2	0.70	0.47	0.14	0.12	0.53	0.31	0.1
Sand (per cent)	7.0	81.0	37.1	18.0	6.0	62.0	30.0	14.3
Silt (per cent)	6.0	32.0	19.7	6.6	6.0	34.0	22.0	6.2
Clay (per cent)	12.0	68.0	43.2	13.8	23.0	73.0	48.0	12.9
Available nitrogen (kg ha^{-1})	121	450	286	66.5	97	378	217	67.7
Available phosphorus (kg P_2O_5 ha^{-1})	10.2	62.6	31.2	66.9	8.6	35.4	21.6	7.2
Available potassium (kg ha^{-1})	100	583	276	11.0	73	324	174	66.6
CEC (c mol (p+) kg^{-1})	10.0	55.8	35.8	100	17.4	57.3	39.1	10.7

the medium category (Table 3). The available nitrogen in the soils decreased with increase in depth. The available nitrogen in the subsurface soils varied from 97 to 378 kg ha^{-1} with a mean value of 217 and standard deviation of 67.7. Most of the subsurface soils fall under low in available nitrogen. Low organic matter content in this area facilitates faster degradation and removal of organic matter leading to nitrogen deficiency. The medium nitrogen status noticed in some area may be due to application of nitrogen fertilizers.

Available phosphorus (P_2O_5):

Results revealed that the phosphorus status of surface soils under study was low to high and the values ranged from 10.2 to 62.6 kg ha^{-1}, with a mean value of 31.2 kg ha^{-1} and a standard deviation of 66.9 (Table 2). Most of the soils fall under medium status in available phosphorus. The variations in phosphorus status were mapped under GIS environment. For presentation purpose, medium level was further categorized into 2 levels for map presentation (Fig 3). The available phosphorus in the soils decreased with increase in depth. The available phosphorus in subsurface soils was low to medium in range. The available phosphorus status in sub surface soils ranged from 8.6 to 35.4 kg ha^{-1}, with a mean value of 21.6 kg ha^{-1}. It is observed that 7110 ha of the area (2.9 per cent) were in the low category and 237721 ha of the area (97.1per cent) were in the medium category (Table 3). Adequate amount of P in majority of soils may be attributed to continuous application of phosphatic fertilizers to crops which resulted in buildup of phosphorus as efficiency of applied P is very low and it comes in available form very slowly (Sharma *et al.,* 2008).

Available potassium (K_2O):

The available potassium in surface soils varied from 100 to 583 kg ha^{-1}, with a mean value of 276 kg ha^{-1} (Table 2). Majority of soils were

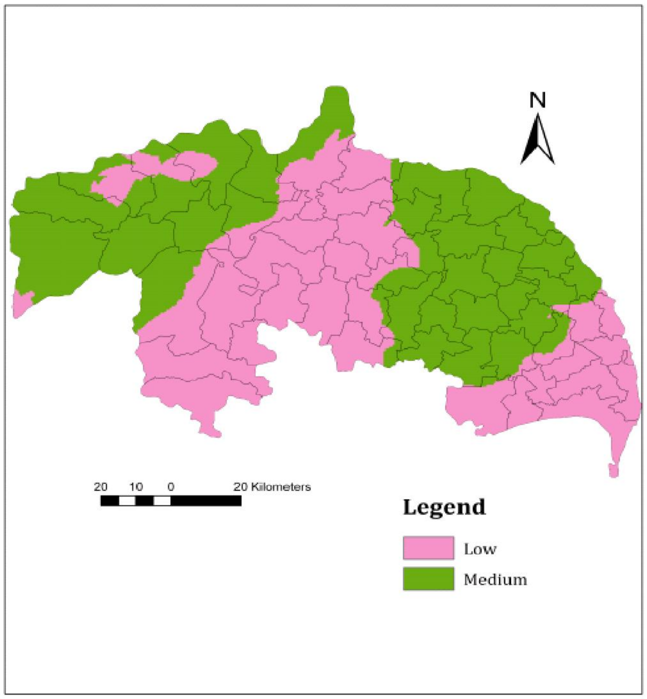

Fig. 1 Map showing organic carbon status ofrice growing soils in Guntur district

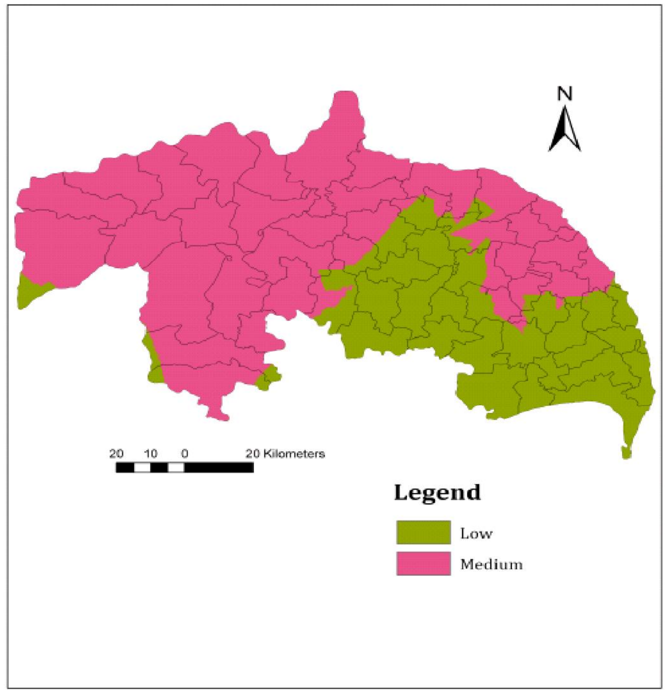

Fig. 2 Map showing available nitrogen status ofrice growing soils in Guntur district

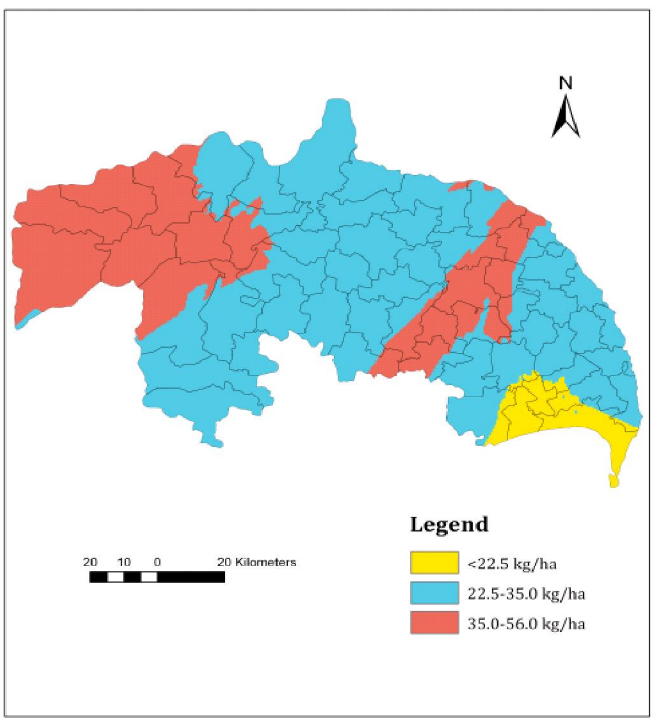

Fig. 3 Map showing available phosphorus status ofrice growing soils in Guntur district

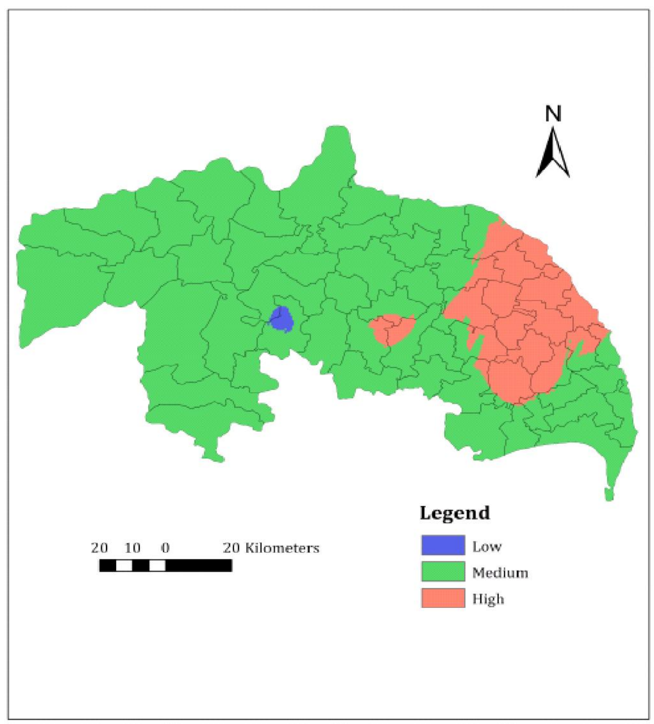

Fig. 4 Map showing Available potassium status ofrice growing soils in Guntur district

Table 3. Spatial distribution of availability of nutrients in Guntur district.

Category	Available nitrogen (N)		Available phosphorus (P_2O_5)		Available potassium (K_2O)		Organic carbon	
	Area ha	Percent area	Area ha	Percent area	Area ha	Percent area	Area ha	Percent area
Low	106361	43.4	7110	2.9	307	0.13	118553	48.4
Medium	138471	56.6	237721	97.1	209447	85.5	126276	51.6
High	-	-	-	-	35078	14.3	-	-

high in available potassium. The variations in potassium were mapped under GIS environment (Fig 4). However, out of total rice growing area 307 ha of the area (0.13per cent) were low in category, 209447 ha (85.5 per cent) were medium in category and 35078 ha (14.3 per cent) were in high category (Table 3).There was decrease in available potassium with increasing depth. The available potassium in subsurface soils ranged from 73 to 324 kg ha^{-1} with a mean value of 174. The standard deviation of 66.6 shows variability of this nutrient. Adequate available K in these soils may be attributed to the prevalence of potassium rich minerals like illite and feldspars (Sharma *et al.* 2008). Black soils shown high values due to predominance of K rich micaceous and feldspar minerals in parent material. Similar results were observed by Ravi Kumar (2006).

Cation exchange capacity:

The results revealed that the cation exchange capacity of surface soils under the study were in a range of 10.0to 55.8 c mol (p^+) kg^{-1}soil with a mean value of 31.0 c mol (p^+) kg^{-1} soil. The CEC content of the subsurface soils varied from 17.4 to 57.3 c mol (p^+) kg^{-1} soil, with a mean value of 39.1 and standard deviation of 10.7. The increasing trend in CEC with depth was due to increased clay content in deeper layers besides higher accumulation of fine clay in deeper layers. The CEC of the soils is related to clay and organic carbon content of the soils. Similar results were reported by Gangopadhyay *et al.* (1998) and Mandal *et al.* (2003).

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