Annals of Plant and Soil Research 26(2): 202-208 (2024)
https://doi.org/10.47815/apsr.2024.10352

Mapping of plant nutrients in the soils of Bandarupalli and Mannasamudram villages in Yerpedu Mandal of Tirupati District: A GIS Approach

M. INDHUJA[1], M. MOHAN[2], M. SREENIVASA CHARI AND M. SUNIL KUMAR

S. V. Agricultural College, Tirupati, Acharya N. G. Ranga Agricultural University, Guntur, Andhra Pradesh

Received, April, 2024; Revised accepted, May, 2024

ABSTRACT

The present investigation involves understanding of the site-specific nutrient content through nutrient maps and recommendation of fertilizers based on the soil test values. The Fertilizer recommendations based on soil fertility status is the key for ensuring the productivity and sustainability of the system. The generation of soil fertility maps at Rythu Bharosa Kendra (RBK) or Farmer Assurance Centres level helps in judicious use of chemical fertilizers. The present study was conducted in Bandarupalli and Mannasamudram villages of Tirupati district, Andhra Pradesh. The soil fertility parameters were mapped by using the Arc GIS ver 10 software for major and micro nutrients. The spatial analysis of fertility of the study area indicated that the soils of study area were slightly acidic to strongly alkaline (6.17 to 8.71). The electrical conductivity (EC) was non- saline and ranged from 0.08 to 0.46 dS m^{-1}. The organic carbon was low to medium status. The available nitrogen was ranged from low to medium (50.16 – 304.6 kg ha^{-1}), available phosphorous (13.4 – 89.6 kg ha^{-1}) and potassium (69 – 925 kg ha^{-1}) were ranged from low to high. The available calcium and magnesium were sufficient status ranged from 5.0 to 16.5 and 1.9 to 9.7 cmol (p^{+}) kg^{-1}, respectively. The available sulphur varied from deficient to sufficient (2.5 to 24 mg kg^{-1}). The DTPA extractable micronutrients viz., Cu, Mn and Zn were sufficient and ranged from 0.2 to 9.53, 1.33 to 9.37 and 0.62 to 9.32 mg kg^{-1}, respectively except iron which was in deficient to sufficient status (4.12 to 22.57 mg kg^{-1}).

Key words: Soil fertility mapping, Geographic Information System, soil nutrients, *Arc* GIS, DTPA extractable micronutrients

INTRODUCTION

The need for environmentally benign and socially acceptable development has put a heavy demand on the capabilities of land use planners because, planning and execution of development programmes require more accurate, reliable, and timely information and better tools for the management of such information. Indian soils not only show deficiency of NPK but also of secondary nutrients (sulphur, calcium and magnesium) and micro nutrients (Boron, Zinc, copper and iron *etc.*) in most parts of the country. The application of fertilizers by the farmers without prior knowledge of soil fertility status might result in adverse effects on the soil as well as crops in terms of nutrient deficiency and toxicity either by the inadequate or overdose of fertilizer application. To ensure sustainability of the present agriculture production system, management of soil resources and spatial soil fertility status is required. In the past, the plant and soil test were used as a criteria to delineate the deficient regions by random sampling methods without georeferencing the soil samples. In recent year with the invention of modern technologies of remote sensing, GIS and GPS, it is possible to monitor the changes in fertility status in spatial and temporal manner. The digital maps are very powerful tools for optimum fertilizer recommendations. Hence, thematic maps are essential for monitoring old quantifying change over a time scale and assisting in decision making in fertilizer recommendations.

To meet the increasing demand of food for increasing population, productivity of crops has to increase from present average by the year 2025. The nutrient depletion in soils adversely affects soil quality, reduces crop yield and consequently poses a potential threat to global food security and agricultural sustainability. Nutrient depletion can be attributed to insufficient fertilizer use and unbalanced fertilization (Tan *et al.,* 2005).The indiscriminate use of fertilizers over a period of time has resulted in buildup of nutrient elements like phosphorous and deficiency of sulphur in many locations (Sharma *et al.,* 2004). Hence, for sustainability of the present agricultural system and for management of our soil resources, a spatial database regarding the fertility status of soils is required.

The soil surveys provide the information

indhujamadhusoodhanan@gmail.com, m.madhanmohan@angrau.ac.in

on soil properties and spatial variation of different kinds of soils on the earth's surface. Like any other natural resource soil surveys too generate large volumes of data. The manual methods of handling often results in the loss of much of the primary data in the process of condensation necessary to produce return documents and printed maps. Computerized GIS with their capacity to hold and process large volumes of data provide the means to handle the large data sets generated through soil surveys. Keeping these in view, present study was taken up in Bandarupalli and Mannasamudram villages of Yerpedu mandal to study the spatial distribution of physico-chemical, macro and micro nutrient status.

MATERIALS AND METHODS

The present study area *i.e.,* Bandarupalli RBK is located in Yerpedu Mandal, Tirupati District of Andhra Pradesh (Fig.1). Its geographic limits ranged from 13° 36' to 13° 40' North latitude and 79° 18' to 79° 28' East longitude and 89 m above the mean sea level. Bandarupalli RBK is one of the model RBK of the mandal. It falls under southern agro- climatic zone of Andhra Pradesh. It is located 20 km towards east from district head quarters, Tirupati and 6 km from Yerpedu. Bandarupalli RBK comprises of two villages *viz.*, Bandarupalli and Mannasamudram. The total cultivated area in Bandarupalli RBK is 416 ha. The study area receives an average annual rainfall of 1203.66 mm. The major crops cultivated are groundnut, paddy, mango, sugarcane, fodder and vegetables crops. The forest trees like sag, jambul, behda, umber, teakwood, neem, bamboo, are planted on bunds.

Bandarupalli RBK of Yerpedu mandal was selected for carrying out the study to prepare GIS based thematic soil fertility maps. Latitude (Lat) and Longitude (Long) were recorded by GPS instrument from soil sampling places. The soils were collected by random grid sampling method, one sample each from an area of 2 ha. The V-shaped cut was made on the surface of the field after removing the pebbles and stubbles from the surface. Then a fine layer of soil was taken from the V cut made. By quartering process the soil quantity was reduced up to 1 kg. Total 120 numbers of GPS based soil samples from two villages (Bandarupalli and Mannasamudram) were collected. Soil samples were brought to the laboratory and air dried under shade avoiding contamination with foreign materials and then crushed with a wooden pestle. The sample is then screened through a 2mm sieve and the pebbles, stones and roots were rejected. About 0.5 to 1kg of air dried crushed soil sample was put in the plastic sample bottle, labelled and stacked on the open sample racks for analysis. The analysis of soil samples have been done by using standard methods *i.e*. pH (1:2.5) (Jackson 1973), EC (1:2.5) (Jackson, 1973) organic carbon (Walkley and Black method) (Jackson 1973), available nitrogen (Alkaline Permanganate method) by (Subbiah and Asija 1956), available phosphorus (Olsen's method) (Olsen *et al.,* 1954), available potassium (Ammonium acetate method) (Jackson, 1973), available calcium and magnesium (Versenate method), available sulphur (0.15%CaCl2 method) (Cottenie *et al.,* 1979) and available micronutrients *viz.,* Zn, Cu, Fe and Mn were determined in the DTPA extract of soil (pH 7.3) using Atomic Absorption Spectrophotometer as outlined by Lindsay and Norwell (1978). Base map of the study area was digitized and georeferenced. Polygons were superimposed on the geo-referred map. Latitude, longitude and analysis data were entered into attributed table and linked to *Arc*GIS software for making thematic soil fertility maps.

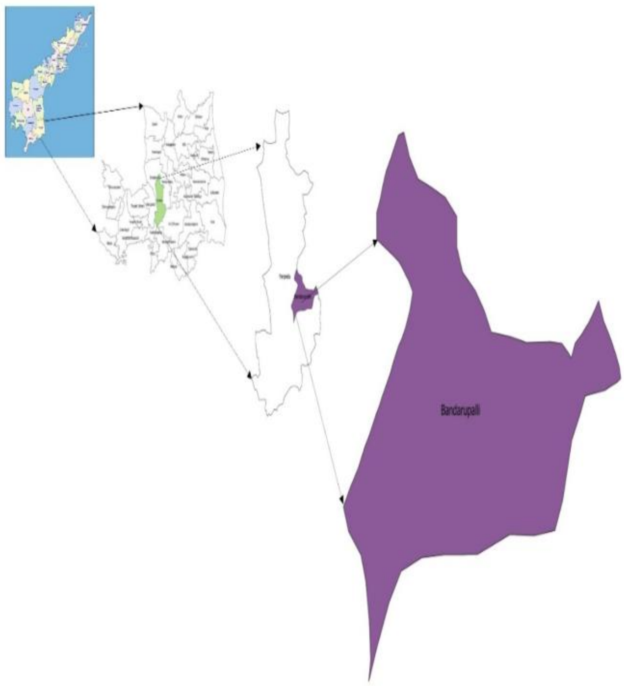

Fig.1. Location of the study area

RESULTS AND DISCUSSION

The physico-chemical and fertility characteristics of the study area was presented in Table:1. The soils of Bandarupalli RBK were slightly acidic to strongly alkaline (6.17 to 8.71). The neutral to alkaline soil reaction may be due to applied fertilizer material with soil colloid, which results in retention of basic cations on the exchangeable complex of soil. (Sharma *et al.,* 2008). The electrical conductivity was found to be non-saline (0.08 to 0.46 dSm^{-1}). A similar result was found by Chandrakala *et al.,* 2021 for soils in south Telangana plateau. The normal EC may be ascribed to leaching of salts to lower horizons. (Sharma *et al.,* 2008). The organic carbon of the study area varied from low to medium (0.11 to 0.69 %) (Vedadri and Naidu 2018). Most of the soils were low in organic carbon due to high rate of decomposition of applied organic manures under tropical climatic conditions. The available nitrogen varied from low to medium (50.2 to 304.6 kg ha^{-1}). The low range of available nitrogen might be attributed due to continuous cropping for longer periods with low system diversity and often with poor crop management practices results in deficiencies as documented by Dwivedi *et al.* (2001). The available phosphorous varied from low to high (13.4 to 89.6 kg ha^{-1}). The available potassium of Bandarupalli RBK varied from low to high (69 to 925 kg ha^{-1}). Some of the soil samples were moderately high in available potassium which might be attributed to the prevalence of potassium rich minerals like *illite* and *feldspar*. The similar results were also reported by Shivanna *et al*. (2014) in soils of Tiptur district of Karnataka. The available sulphur varied from deficient to sufficient (2.5 to 24 mg kg^{-1}). The sulphur was found to be sufficient in most of the soils due to regular application of SSP and ground water which contain sufficient amount of sulphur to meet the crop requirement. Similar status of sulphur was reported by Mohan *et al*., 2021 in rice growing soils of Tirupati revenue division. The available calcium was noticed as sufficient which ranged from 5.0 to 16.5 cmol (p^+) kg^{-1} of soil. The available magnesium was found to be sufficient which ranged from 1.9 to 9.7 cmol (p^+) kg^{-1} of soil. The available zinc content of the study area ranged from 0.62 to 9.32 mg kg^{-1}. The higher availability of zinc might be due to application of $ZnSO_4$ fertilizer. The available iron content ranged from 4.12 to 22.57 mg kg^{-1} which varied from deficient to sufficient. The majority of soil samples were sufficient in available iron content due to availability of iron by chelation effect which might have protected the iron from oxidation and precipitation, which consequently increased the availability of iron (Prasad and Sakal 1991). The available manganese content of the study area ranged from 1.33 to 9.37 mg kg^{-1} which was sufficient might be due to higher biological activity. The available copper content of the study area ranged from 0.2 to 9.53 mg kg^{-1} which was sufficient. This might be due to application of fertilizers containing copper.

Table 1: Soil fertility characteristics of the soils of Bandarupalli RBK (N=120)

Parameters	Min	Max	Mean	SD
pH	6.17	8.71	7.48	0.45
EC (dS m^{-1})	0.08	0.46	0.19	0.06
OC (%)	0.11	0.69	0.32	0.12
Available N (Kg ha^{-1})	50.16	304.6	150.6	55.4
Available P (Kg ha^{-1})	13.4	89.6	51.4	20.6
Available K (Kg ha^{-1})	69	925	276.4	182.1
Available S (mg kg^{-1})	2.5	24	10.52	4.76
Available Ca^{+2} (cmol(p^+) kg^{-1}	5.0	16.5	10.53	3.47
Available Mg^{+2} (cmol(p^+) kg^{-1}	1.9	9.7	5.43	1.82
Available Fe (mg kg^{-1})	4.12	22.57	13.01	3.36
Available Zn (mg kg^{-1})	0.62	9.32	3.09	2.12
Available Mn (mg kg^{-1})	1.33	9.37	5.57	1.75
Available Cu (mg kg^{-1})	0.2	9.53	2.57	1.87

The spatial analysis of fertility status indicated that the soils of study area had slightly acidic to strongly alkaline (6.17 to 8.71) with five soil reaction classes *viz.*, slightly acidic (6.1-6.5), neutral (6.6 - 7.3), slightly alkaline (7.4 - 7.8), moderately alkaline (7.9 - 8.4) and strongly alkaline (>8.5) representing 5, 42.5, 43.3, 6.6 and 2.5 per cent of study area, respectively (Fig.2). The EC was non- saline, ranged from 0.08 to 0.46 dS m^{-1}. The spatial analysis showed that 100 percent of the area was non-saline (Fig.3). The organic carbon was low to medium representing 92.4 and 7.6 per cent of the cultivated area, respectively (Fig.4). The available nitrogen was ranged from low to medium (50.16 – 304.6 kg ha^{-1}) status in 95.8 and 4.1 per cent of the study area, respectively (Fig.5). The available phosphorous (13.4 – 89.6 kg ha-1) and potassium (69 – 925 kg ha^{-1}) were ranged from low to high status representing 10, 56.6 and 33.3 per cent and 42.4, 21.5 and 36.1 per cent of the area, respectively (Fig.6 and 7). The available calcium and magnesium were sufficient status ranged from 5.0 to 16.5 and 1.9 to 9.7 cmol (p^+) kg^{-1}, respectively and total study area grouped under sufficient range (Fig.8 and 9). The available sulphur varied from deficient to sufficient (2.5 to 24 mg Kg^{-1}) representing 48.5 and 51.4 per cent of the study area, respectively (Fig.10). The DTPA extractable iron content was ranged from deficient to sufficient status (4.12 to 22.57 mg kg^{-1}) representing 1.8 and 98.2 per cent of the study area, respectively (Fig.11). The DTPA extractable Cu, Mn and Zn were sufficient status and ranged from 0.2 to 9.53, 1.33 to 9.37 and 0.62 to 9.32 mg kg^{-1}, respectively. The spatial analysis indicated that the study area categorized under sufficient range (Fig.12, 13 and 14).

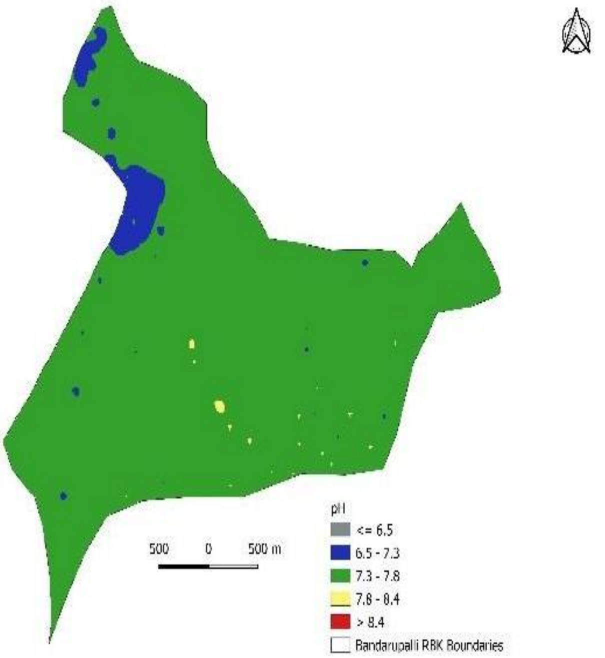

Fig 2: Soil reaction map of the study area

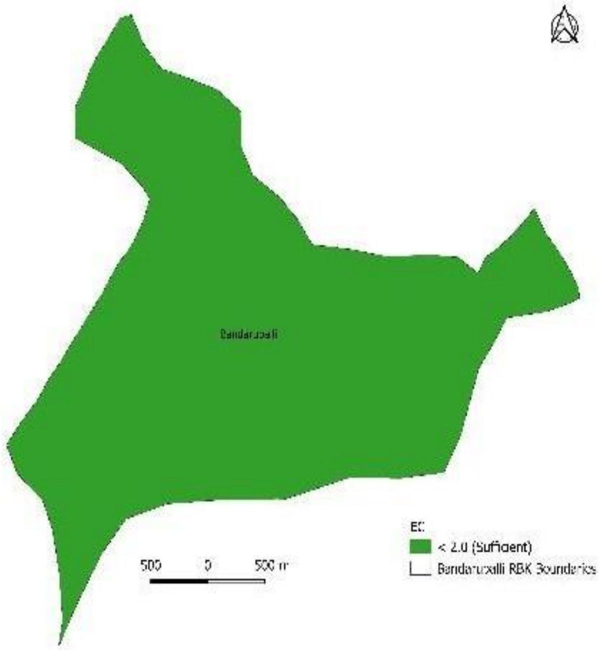

Fig 3: Electrical conductivity map of the study area

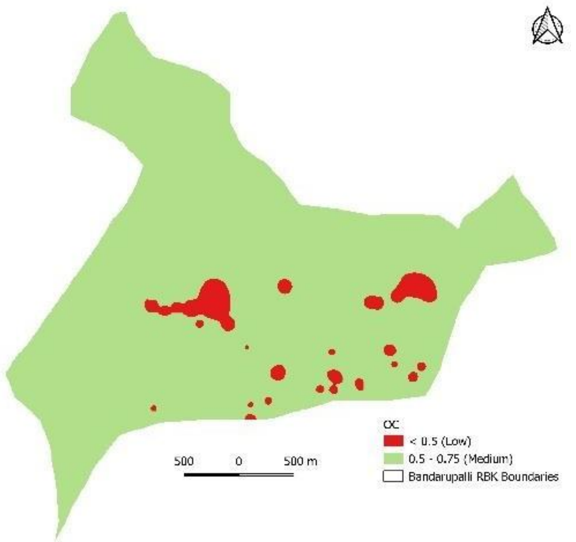

Fig 4: Soil organic carbon map of the study area

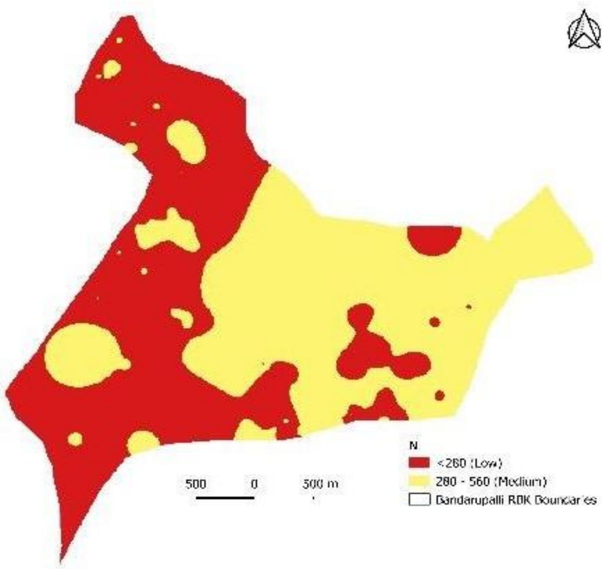

Fig 5: Available nitrogen map of the study area

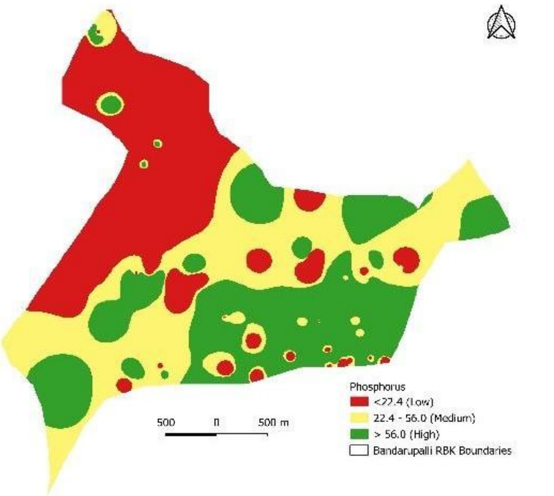

Fig 6: Available phosphorous map of the study area

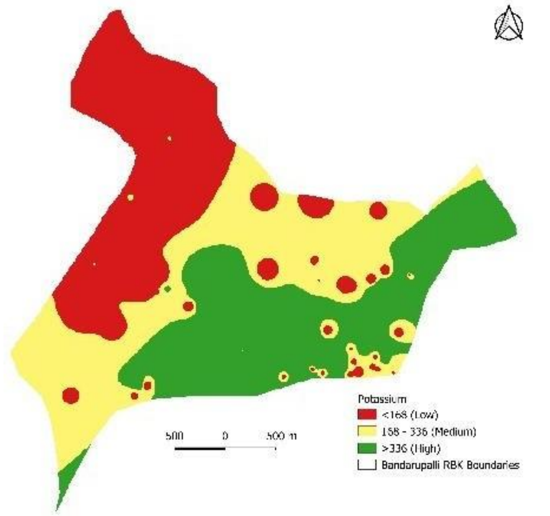

Fig 7: Soil available potassium map of the study area

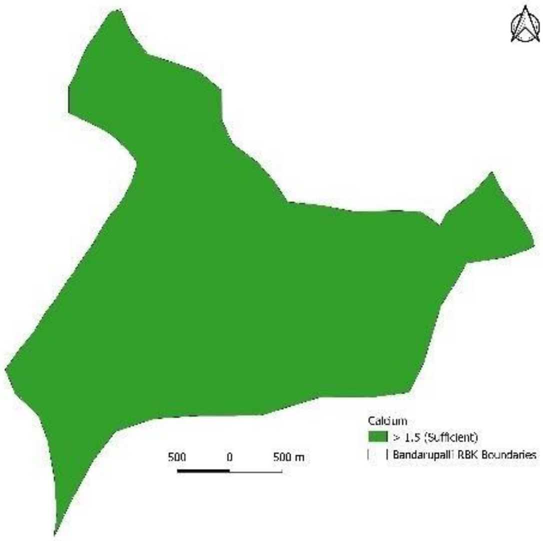

Fig 8: Available calcium map of the study area

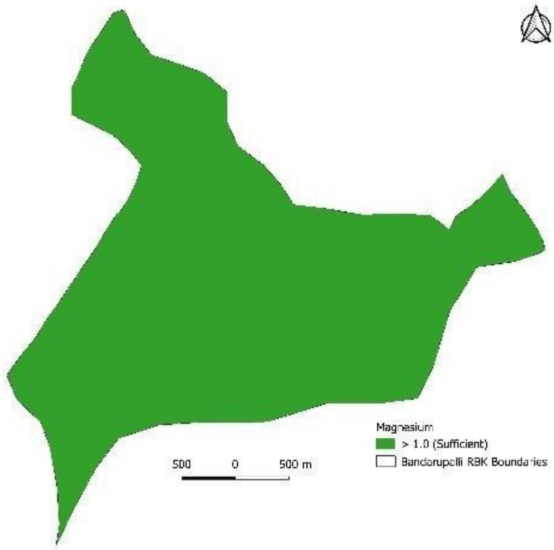

Fig 9: Available magnesium map of the study area

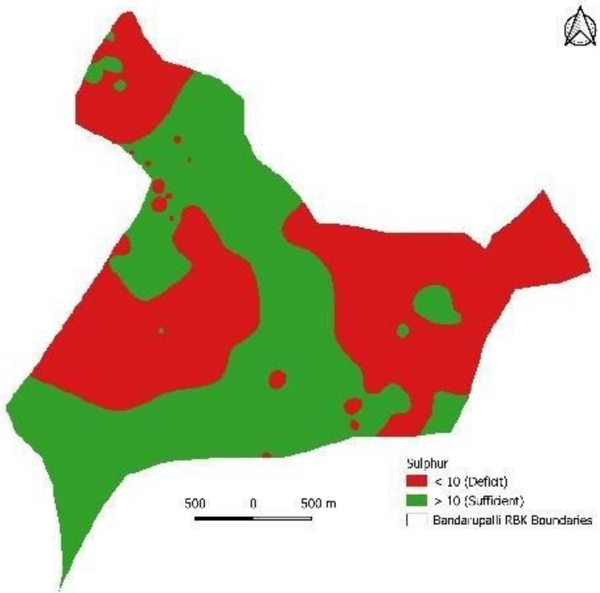

Fig 10: Available sulphur map of the study area

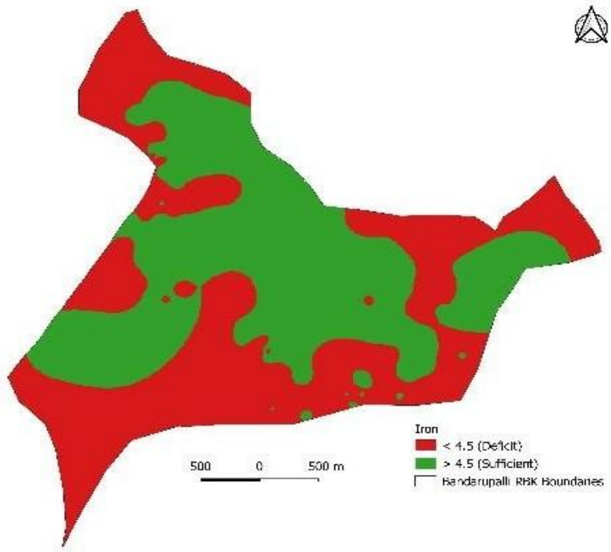

Fig 11: Soil available iron map of the study area

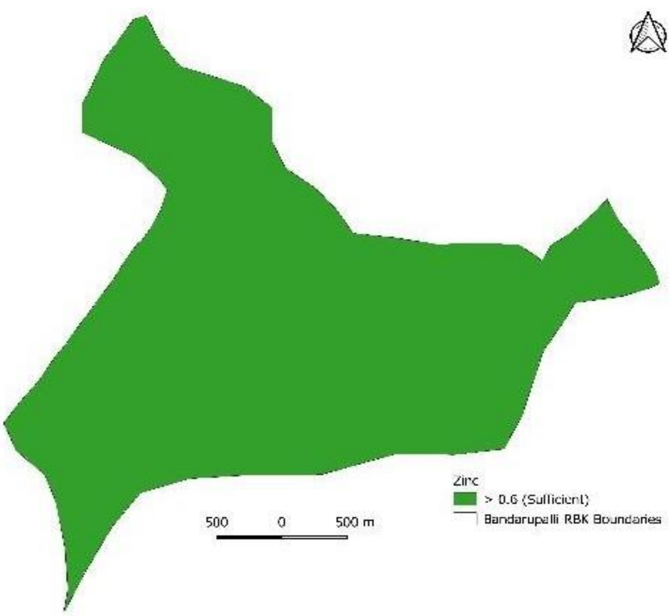

Fig 12. Soil available zinc map of study area

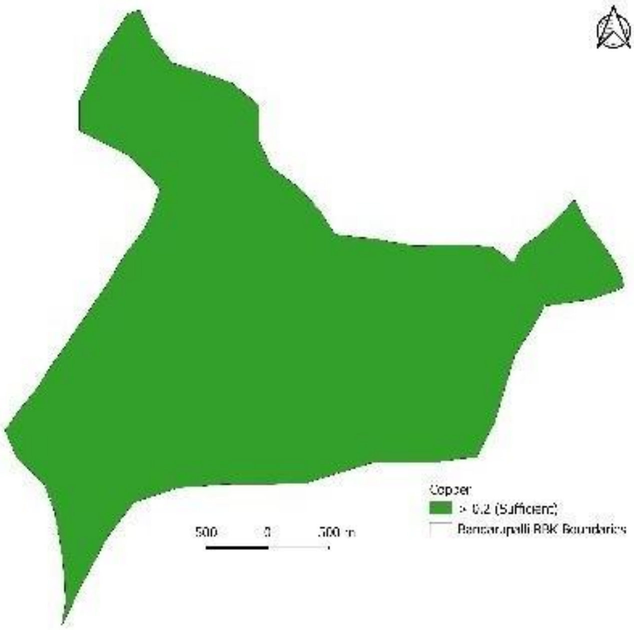

Fig 13. Soil available copper map of the study area

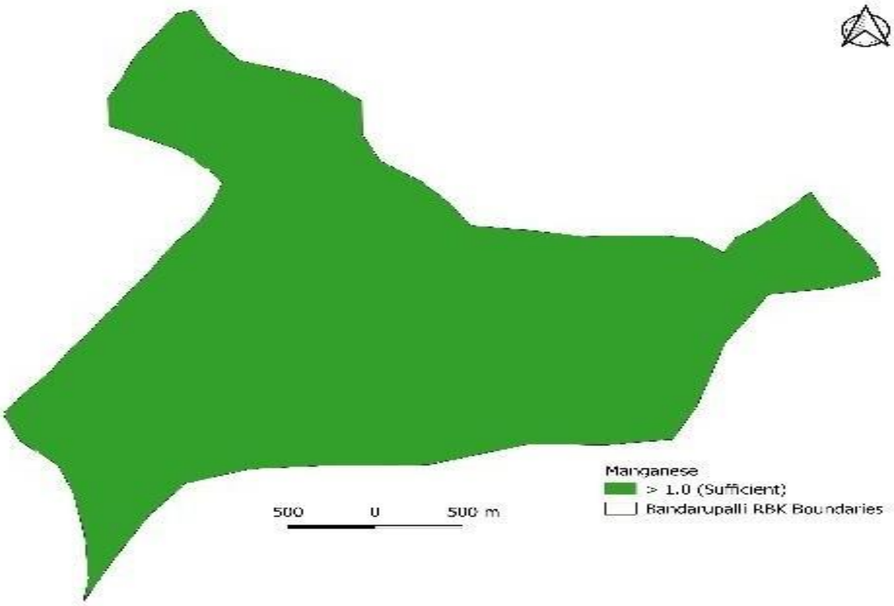

Fig 14: Soil available manganese map of study area

CONCLUSION

The present study involves preparation of fertility maps for paddy and groundnut crops in Bandarupalli RBK of Yerpedu mandal using GIS. The study concluded that the soils of Bandarupalli RBK were slightly acidic to strongly alkaline with five soil reaction classes *viz.*, slightly acidic, neutral, slightly alkaline, moderately alkaline and strongly alkaline representing 5, 42.5, 43.3, 6.6 and 2.5 per cent of study area, respectively. The soils of the area were non-saline and 92.4 per cent soils having low organic carbon and 7.6 per cent soils have medium status. The available nitrogen was low in 95.8 per cent and medium in 4.1 per cent of the study area. The available phosphorous and potassium were categorized as low (10 and 42.4 per cent), medium (56.6 and 21.5 per cent) and high (33.3 and 36.1 per cent) status. The available calcium and magnesium were sufficient range. The available sulphur was deficient in 48.5 per cent of the study area. The DTPA extractable micronutrients *viz.,* Cu, Mn and Zn were sufficient in entire study area except iron in 4.1 per cent study area.

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