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Assessment of soil nutrients and recommendation of balanced fertilizers for enhancing crop productivity using remote sensing and GIS

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Abstract
Soil test based fertility management for best suited crops can be used as an effective tool for enhanced productivity and crop production. The present study focussed on mapping spatial variability of soil nutrients. Soil samples were collected at 250 m grid spacing, analysed for soil reaction, salinity, organic carbon, major, secondary and micro nutrients at laboratory using standard methods. The data generated was processed in Arc-GIS platform to develop a database. Geostatistical analyst tool was used and kriging interpolation technique was adopted. The analysed data was interpolated to obtain a raster surface from points (grid points) to generate fertility maps using Arc-GIS. Fertilizer recommendations can be made for the crops to enhance their productivity. Soil test based application of balanced fertilizers would go a long way in enhancing soil fertility and productivity.

Keywords: fertility management, spatial distribution, kriging, interpolation, balanced fertilizers

1. Introduction
Soil is the basic requirement of life on earth. Soil nutrients play a vital role in crop production, its availability and spatial distribution need to be studied before planning for nutrient recommendation. Higher yields and intensive cropping make high demands for nutrients from soil, which leads to depletion of soil nutrient reserve. K removal by the intensive cropping is disproportionately higher than the amount of K added through fertilizer as evident from the results of Long term fertilizer experiments. The nutrients exported out of the farm in crop produces must be necessarily replenished to sustain soil fertility and therefore the production system for which balanced fertilizer application is the prerequisite and there is growing need for site specific balanced fertilizer recommendations according to the crop type, yield level and soil conditions.
Balanced fertilizer schedule were developed for rice, maize, cassava, peanut, potato, tobacco etc. by the applications of mathematical models and decision support systems. The soil salinity or sodicity hinders the crop growth and yield. The industrial by-product Ferro gypsum from the effluent treatment plant of titanium industry was evaluated as a substitute for gypsum to alleviate sodicity besides its effect on increasing crop yields in paddy and groundnut.
The challenge of crop nutrient management is to balance production and economic optimization with environmental impacts. Successful crop production is dependent upon effective nutrient management that includes identifying nutrient deficiencies and excesses. Soil sampling and soil testing provides an opportunity to check the “soil nutrient account” and is critical for developing a nutrient management plan. Knowing the nutrient requirements and nutrient removal by a crop is important for achieving a balance of nutrient inputs and crop removal outputs. Reliable nutrient recommendations are dependent upon accurate soil tests and crop nutrient calibrations based on extensive field research. The actual fertility status of soils has to be assessed before planning for any crop production, which will help in managing the nutrient/fertilizer application to various crops. The Geographic Information System (GIS) is an effective tool in the estimation of the spatial distribution in which interpolation can be undertaken utilizing simple mathematical models (e.g., inverse distance weighting, trend surface analysis and splines and Thiessen polygons), or more complex models (e.g., geo-statistical methods, such as kriging). The review of comparative studies of interpolation methods applied to soil properties demonstrates that the selection of method can significantly influence the map accuracy. The present study was conducted with the main objective of providing balanced nutrition through soil-test based fertilizer recommendation in Giddadapalya micro-watershed of Tumkur district.

2. Materials and Methods

2.1 Study Area

Tumkur district is located in the southern half of the State, lies between the latitudinal parallels of 12^0 45’ North and 14^0 22’ North and the longitudinal parallels of 76^0 24’ East and 77^0 30’ East with an area of 10,598 km^2. Tumkur district is situated right on the archaean complex and the geology of the area is fairly simple with rock formations belonging to the archaean complex represented by the crysalline schist, the granitic gneisses and the newer granites. Temperature ranges from 18 – 38 degree Celsius and normal annual rainfall is about 900 mm. Gidadapalya micro-watershed (Kalkere sub-watershed, Tumkur taluk, Tumkur district) is located at North latitude $13^0$7’19.19" and 13^0 9‘17.99' and East longitude 77^0 3' 18'‘ and 77^0 4’ 22.79' covering an area of about 485 ha, bounded by Thimmanapalya, Niduvalalu, Narayanakere, Doddaguni, Gangonahalli and Sulekuppe Kavalu villages.

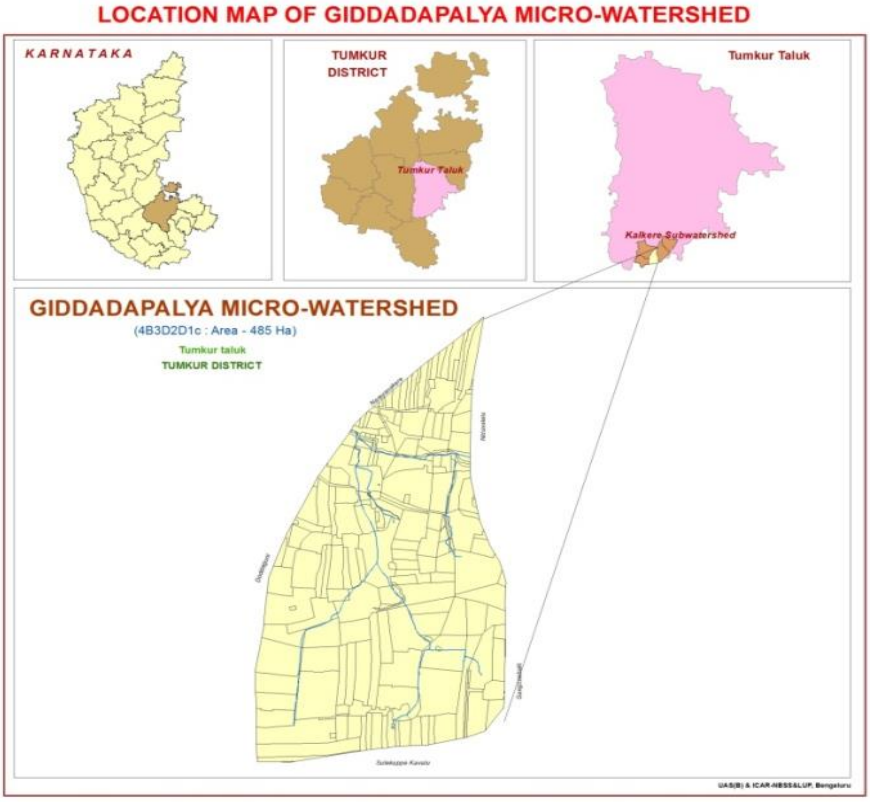


Fig 1: Location map of Giddadapalya micro-watershed.

2.2 Study area delineation in GIS Environment

Study area was delineated with the help of topographic map and watershed Atlas prepared by Karnataka State Remote Sensing Application Centre, Bangalore. Study area was extracted from the satellite imagery, permanent features like road, river, watershed boundary was extracted for preparation of base map. It is the base for preparation of thematic maps.

2.3 Soil Survey

The study area was delineated with the help of toposheet of 1:50,000 scale and soil survey was carried out using cadastral base map at 1:7920 scale and Cartosat-1 PAN 2.5mts and resourcesat-2 LISS-IV MX-merged satellite imagery. Seventy Seven surface soil samples were collected at 250 m grid spacing (Figure 2). These samples were subjected to analysis and the fertility data was generated.

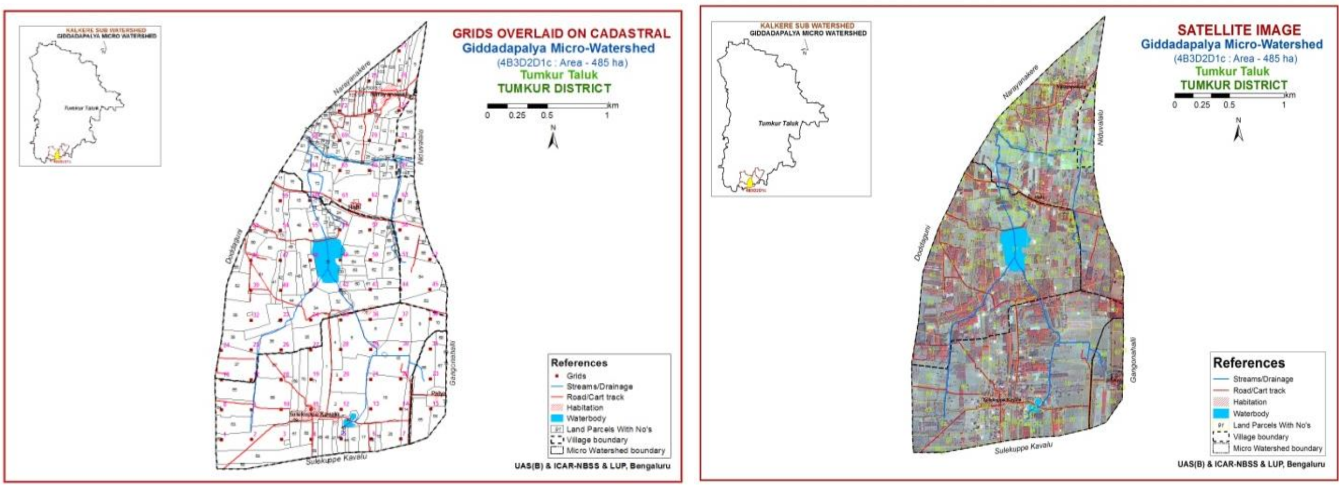


Fig 2: Cadastral map with grids and satellite map of Giddadapalya micro-watershed.

A detailed traverse of the micro watershed was made to identify the major landforms like uplands, midlands and lowlands. The transects for profile study were located and profiles were dug up to 150 cm depth or up to parent rock whichever was shallower, and studied for their morphological characteristics as per Soil Survey manual [6]. Pedons were identified on different landforms in transect along the slope from the upper to lower slope and soil series maps were generated.

2.4 Soil sample Analysis
Soil samples were collected were analysed for soil reaction, salinity, organic carbon, major, secondary and micro nutrients at laboratory using standard methods. The fertility data was generated and fed as input to the ArcGIS to create the fertility maps by interpolating the values.

3. Results and Discussion
3.1 Generation of soil fertility status
Seventy Seven surface soil samples collected, analysed and data was generated. The data generated was processed in ArcGIS platform to develop a database. Geostatistical analyst tool was used and kriging interpolation technique was adopted. The analysed data was interpolated to obtain a raster surface from points (grid points) to generate fertility maps using ArcGIS

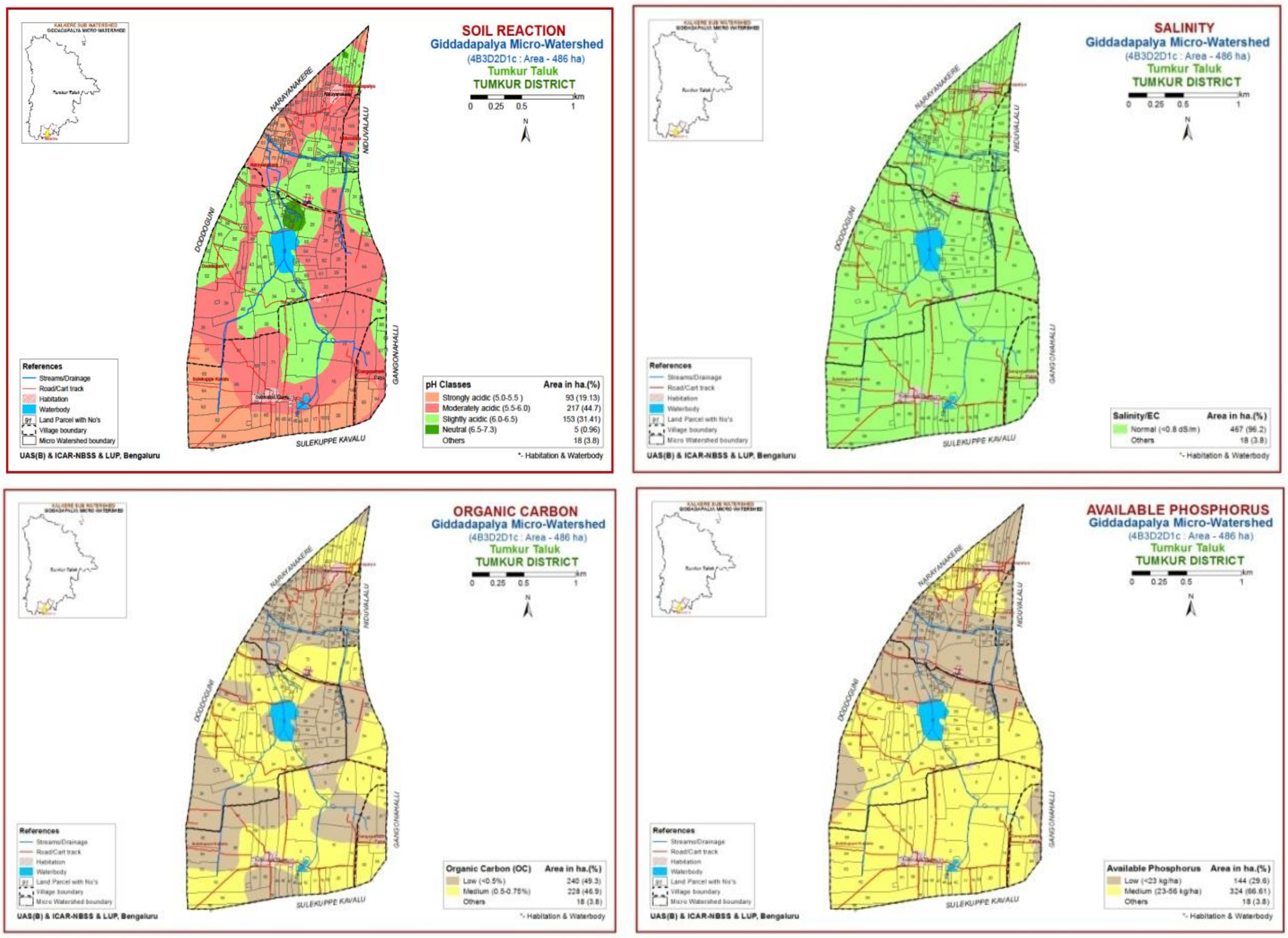
The fertility status maps were generated and majority of the area was low in Nitrogen, Phosphorus and Organic carbon, Potassium was medium, sulphur high, Calcium, Magnesium and micro nutrients were in sufficient quantities (Figure 3). Data range of various parameters depicted in the Table 1.

Table 1: Fertility data range in Rajapura (4B3D2E2e) micro-watershed.

Parameters	Soil reaction- pH	Salinity- dS/m	Organic carbon- %	Nitrogen - kg/ha	Phosphorus - kg/ha	Potassium - kg/ha
Range	5.01 - 7.94	0.10 - 0.99	0.16 - 0.76	210.19 - 413.58	12.36 - 39.84	123.48 - 492

Parameters	Sulphur - ppm	Iron - ppm	Manganese - ppm	Copper - ppm	Zinc - ppm
Range	6.52 - 22.75	0.72- 34.36	2.10 - 43.94	0.15 - 4.33	0.11 - 1.86

Parameters	Calcium - meq/100gm	Magnesium - meq/100gm
Range	1.3 - 8.6	0.1-4.5



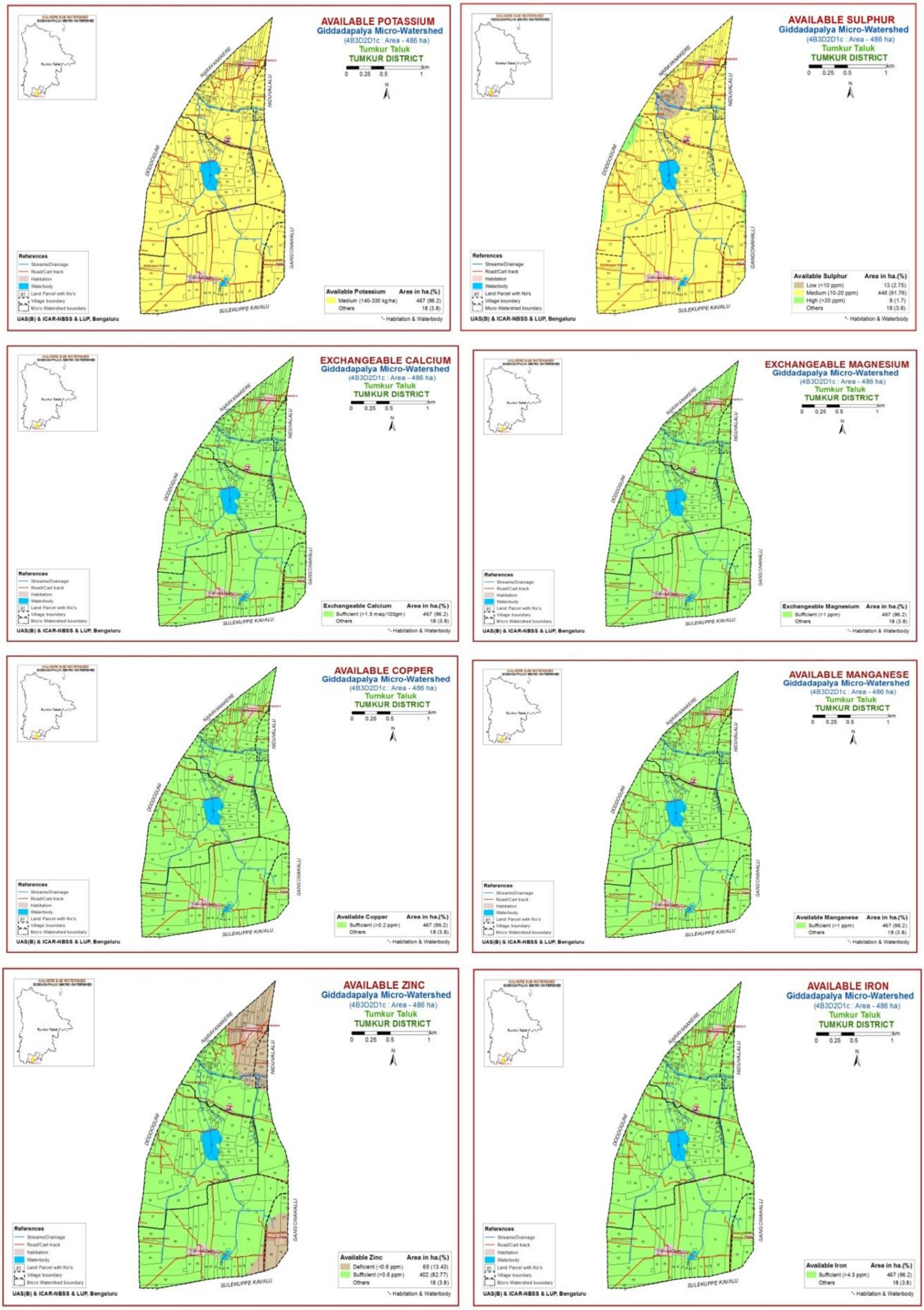


Fig 3: Fertility maps of Giddadapalya micro-watershed

4. Conclusion
The pH of the soils in this micro watershed ranged from strongly acidic to neutral where 44.7 per cent of area (217 ha) is moderately acidic followed by slightly acidic (31.41 %) and strongly acidic (19.13 %). Since major portion of watershed is acidic in nature, application of organic matter is recommended. In case of strongly acidic soils lime application is recommended. Organic carbon content and available phosphorus is low in 50 per cent and 29.6 per cent of the area whereas available potassium and sulphur are medium in range. The available zinc, iron and manganese are in sufficient range. The areas which are low in nutrient status (OC and P) needs to be improved by adding organic manures (FYM/Compost) and phosphatic fertilizers preferably rock phosphate in acidic soils.

5. Acknowledgement
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