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# Assessment of Spatial Variability in Fertility Status and Nutrient Recommendation in Alanatha Cluster Villages, Kanakapura Taluk, Ramanagara District, Karnataka Using GIS Techniques

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**A B S T R A C T**

Knowledge of spatial variability in soil fertility is important for site specific nutrient management. In this study, spatial variability in properties that influence soil fertility such as soil organic carbon (OC), available N, available $P_2O_5$ and available $K_2O$, secondary and micro nutrients in surface soils (0-30 cm depth) of 67 farmers' fields of Alanatha Cluster Villages, Kanakapura Taluk, Ramanagara District, Karnataka (India) were quantified and the respective thematic maps were prepared on the basis of ratings of nutrients. Arc Map with spatial analyst function of Arc GIS software was used to prepare soil fertility maps. Soils were strongly acidic to slightly acidic in reaction with normal Electrical Conductivity (EC). Soil organic carbon content was low to high, available nitrogen in soil was low to medium, available phosphorus was low to high, available potassium was low to high. Soil sampled area were found to be 100 per cent sufficient in exchangeable calcium, 97 per cent area was found to be sufficient in exchangeable magnesium. Available sulphur status was found to be low to high. The entire area was found to be sufficient in available manganese and copper, 86.57 per cent area was sufficient in zinc and 85.02 per cent area was sufficient in iron in surface soils. The observed spatial variability in various soil properties that influence soil fertility was used for deciding nutrient application to crop. Thus providing balanced nutrients to crop based on analysis of fertility of each parcel of land, which has resulted in enhanced crop productivity and net returns in both finger millet and groundnut cropping system.

**Keywords**

Geospatial technology, Nutrient mapping, Soil fertility status, soil testing and fertilizer recommendation.

**Article Info**

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## Introduction

The ability of soil to support crop growth for optimum crop yield is one of the most important components of soil fertility that determine the productivity of agricultural systems. Many of the processes that influence the soil fertility and productivity are controlled by different characteristics of soil. A proper understanding of the physical, chemical and biochemical properties of soil will throw greater insight into the dynamics of these soils. By characterization of these soils one can clearly understand the inherent capacity of soil for crop production as well as problems that arise in successful management of such soils for achieving higher production.

Soil fertility is one of the important factors controlling yield of the crops. Soil characterization in relation to evaluation of fertility status of the soil of an area or region is an important aspect in the context of sustainable agricultural production because of imbalanced and inadequate fertilizer use coupled with low efficiency of other inputs. The response (production) efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years (Yadav and Meena, 2009). Introduction of high yielding varieties in Indian Agriculture forced the farmers to use high dose of NPK without micronutrient fertilizers. This declined the level of some micronutrients in the soil at which productivity of crops cannot be sustained. The deficiencies of micronutrients have become major constraints to productivity, stability and sustainability of soils. Nutrients strength and their relationship with soil properties affect the soil health. Micronutrients play a vital role in maintaining soil health and also productivity of crops. These are needed in very small amounts. The soil must supply micronutrients for desired growth of plants and synthesis of human food.

Geographic Information System (GIS) is a computer based information system capable of capturing, storing, analyzing, and displaying geographically referenced information, i.e. the data identified according to a particular location/region. And Global Positioning System (GPS) is a satellite-based navigation and surveying system for determination of precise position and time, using radio signals received from the satellites, in real-time or in post-processing mode. The use of GIS, which is capable to analyze regional areas based on spatial distribution, is well known. As more and more data become available in a digitized format it is possible to develop software routines that can perform identification of Index soil properties and preparation of thematic maps of soil type, nutrient content in conjunction with a GIS.

Knowledge of spatial variability in soil fertility is important for site specific nutrient management. In this study, spatial variability in properties that influence soil fertility such as soil organic carbon (OC), available N, available $P_2O_5$ and available $K_2O$, secondary and micro nutrients in surface soils of 67 farmers field of Alanatha Cluster Villages, Kanakapura Taluk, Ramanagara District, Karnataka (India) were quantified and the respective thematic maps were prepared on the basis of ratings of nutrients

## Materials and Methods

### Study area

The Alanatha cluster villages (Alanatha, Mahadevapura, Arjunahalli, Arjunahalli thandya and Eregowdana Doddi) is under the revenue administration of Bannimukodlu gram panchayat in Kanakapura taluk of Ramanagara district, Karnataka situated in Eastern Dry Zone (Zone No.5) of Karnataka, located at $12^0$ $23^,$ N Latitude, $77^0$ $31^,$ E Longitude and 968 m above mean sea level. The soils are sandy loamy in texture.

### Collection of soil samples and analysis

Soil samples (0–30 cm) were collected at one sample for 5–6 ha covering cultivated area of the village during 2013. The co-ordinates were recorded using GPS for all the soil samples collected in the study area. The soil samples were air dried and processed for analysis.

Processed soil samples were analysed for nutrient availability by following standard analytical techniques. The pH and electrical conductivity of soil samples were determined in 1:2.5, soil: water suspension (Jackson 1973). Soil was finely grounded and passed through 0.2 mm sieve and organic carbon was determined by Walkely and Black (1934) wet-oxidation method as described by Jackson (1973) and expressed in percentage. Available nitrogen was analyzed by potassium permanganate method of Subbiah and Asija (1956).

Available phosphorus, available potassium, exchangeable calcium and magnesium were determined as per the standard procedures (Jackson, 1973). The method of Lindsay and Norvell (1978) was used for the estimation of micronutrients (Fe, Mn, Cu and Zn) in AAS using DTPA extract. Available boron was estimated by using Azomethine-H method as describe by John *et al.*, (1975). Fertility status of N, P, K and S are interpreted as low, medium and high and that of zinc, iron, copper and manganese interpreted as deficient, sufficient and excess by following the criteria (Table 1).

## Preparation of soil fertility maps and fertilizer recommendation

The fertility maps showing nutrient status was generated using the analytical data of individual nutrient. The point data collected using GPS was then transformed into polygon data using krigging interpolation technique in Arc GIS software.

The fertilizers were recommended based on the soil test results to the selected farmers. After harvest of the crop, yield observation was recorded to study the impact of soil test based fertilizer use in sustaining the yield.

## Results and Discussion

### Soil reaction

The soil reaction in surface soils of Alanatha cluster village ranged from 4.70 to 6.61 (Table 2). The soil reaction of the surface soil was acidic in nature and results also indicated 26.86 per cent area was moderately acidic (pH 5.5–6.0), 61.00 per cent area was strongly acidic (pH 5.0–5.5) and 11.14 per cent area was slightly acidic (pH 6.0–6.5) (Fig. 1). The lowest value of pH under the cultivated land may be due to the depletion of basic cations in crop harvest and drainage to streams in runoff generated from accelerated erosions as reported by Foth and Ellis (1997). This may also be because of formation of these soils from acidic parent material rich in basic cations as reported by Mali and Raut (2001). Similar results were reported by Ram *et al.*, (1999).

### Electrical conductivity

The electrical conductivity of surface soil samples varied from 0.02 to 0.144 $dSm^{-1}$ in with a mean of 0.057 $dSm^{-1}$ in Alanatha cluster village. All the soil samples were found to be normal in electric conductivity (Fig. 2).

### Organic carbon

The Organic carbon content of the surface soils ranged from 0.15 to 0.93 per cent with mean of 0.48 per cent in Alanatha cluster village (Table 2). About 52.30 per cent area was low, 37.30 per cent area was medium and 10.40 per cent area was high in organic carbon content (Fig. 3). Low organic carbon in the soil was due to low input of FYM and crop residues as well as rapid rate of decomposition due to high temperature.

The monocropping of cereals practiced by many farmers might be one of the reasons for low organic carbon in these areas. The high content of organic carbon reported in some parts of project villages might be due to addition of organic matter and its subsequent decomposition. These results were in confirmatory with results reported by Waikar *et al.*, (2004).

**Table.1** Critical limits for different soil parameters

| **Parameter** | Critical limits |
|---|---|
| pH | Acidic – <6.5<br>Neutral - 6.5-7.5<br>Alkaline - >7.5 |
| EC | Normal - <0.8 $dSm^{-1}$<br>Critical for sensitive crops- 0.8-1.6 $dSm^{-1}$<br>Critical for salt tolerant crops- 1.6-2.5 $dSm^{-1}$<br>Injurious for many crops- >2.5 $dSm^{-1}$ |
| Organic carbon | Low - 0.5 %<br>Medium - 0.5–0.75%<br>High - > 0.75 % |
| Available N | Low - <280 kg/ha<br>Medium – 280–560 kg/ha<br>High - >560 |
| Available $P_2O_5$ | Low - 22.5 kg/ha<br>Medium - 55.5–56 kg/ha<br>High - >56 kg/ha |
| Available $K_2O$ | Low - 141 kg/ha<br>Medium - 141-336 kg/ha<br>High - >336 kg/ha |
| Exchangeable Ca | Deficient - < 1.5 meq/100g<br>Sufficient - >1.5 meq/100g |
| Exchangeable Mg | Deficient - < 1.0 meq/100g<br>Sufficient - >1.0 meq/100g |
| Available S | Low - <10 ppm<br>Medium – 10–20 ppm<br>High - > 20 ppm |
| Available Zn | Low - < 0.5 ppm<br>Marginal - 0.5–0.75ppm<br>Adequate - 0.75–1.50 ppm<br>High - > 1.5 ppm |
| Available B | Low - <0.5 ppm<br>Medium - 0.5–1.0 ppm<br>High - > 1.0 ppm |
| Available Cu | Deficient - < 0.2 ppm<br>Sufficient - > 0.2 ppm |
| Available Mn | Deficient - < 1 ppm<br>Sufficient - > 1 ppm |
| Available Fe | Deficient - < 4.5 ppm<br>Sufficient - > 4.5 ppm |

**Table.2** Status of major nutrients in surface soil samples of Alanatha cluster village

| | pH | EC (dS $m^{-1}$) | OC(%) | Av. N | Av. $P_2O_5$ | Av. $K_2O$ |
|---|---|---|---|---|---|---|
| | | | | kg $ha^{-1}$ | | |
| Range | 4.7-6.61 | 0.020.14 | 0.15-1.93 | 200.50 | 12.8-261.5 | 83-620 |
| Mean | 5.48 | 0.0567 | 0.48 | 200.47 | 78.0 | 313.1 |

**Table.3** Status of secondary and micronutrient nutrients in surface soil samples of Alanatha cluster village

| | Excha Ca | Ex cha Mg | Av.S | Fe | Cu | Zn |
|---|---|---|---|---|---|---|
| | meq/100g | | ← ppm → | | | |
| Range | 1.3-6 | 0.2-4.50 | 2.08-58.17 | 0.471-34.36 | 0.655-5.223 | 0.515-1.940 |
| Mean | 2.94 | 1.78 | 28.28 | 9.490 | 1.711 | 0.958 |

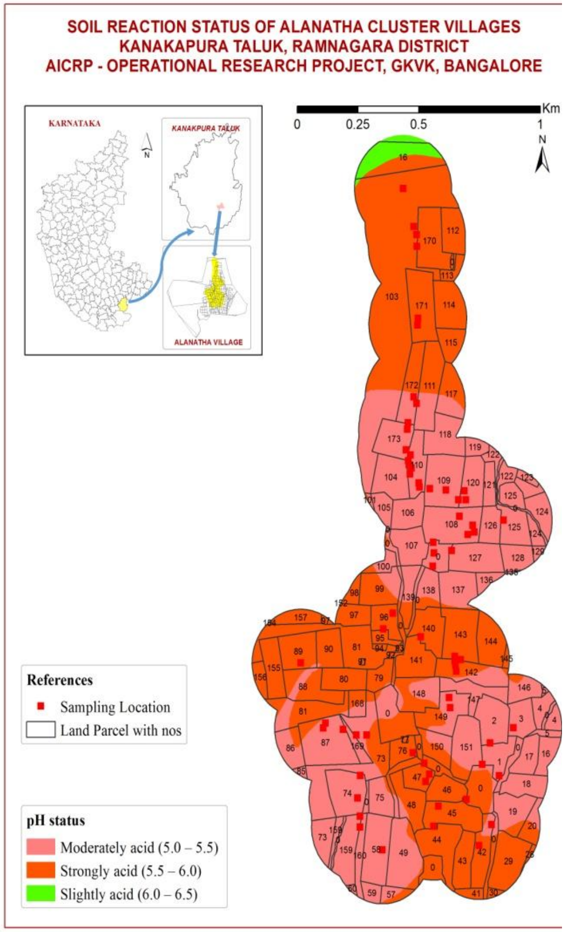
**Table.4** Comparisons between general recommendation and soil test based fertilizer recommendation

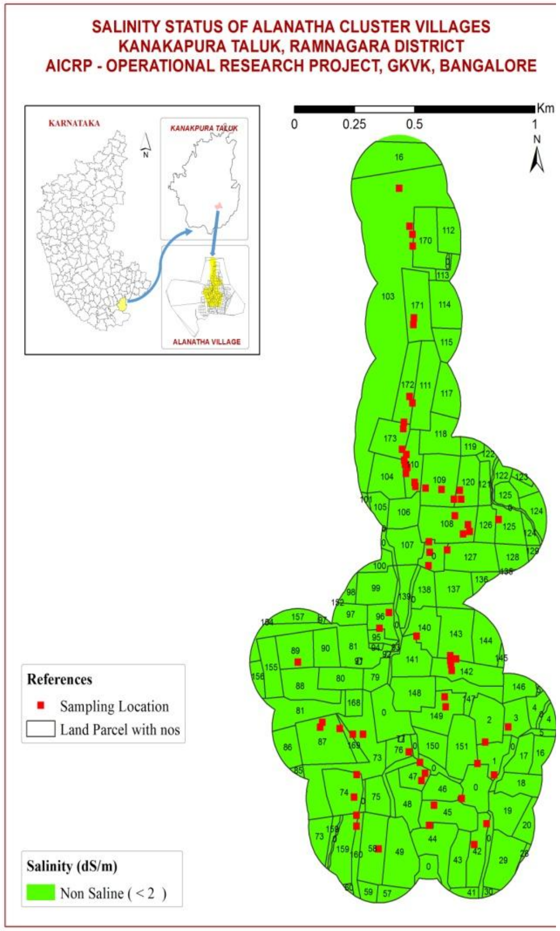
| Cropping system | Normal recommendation (NPK kg $ha^{-1}$) | Based on soil test (NPK kg $ha^{-1}$) | Yield (kg/ha) | Net returns (Rs.) | BC ratio |
|---|---|---|---|---|---|
| Groundnut based cropping system | ---- | 25:37.5:25 | 1163 | 35017 | 2.00 |
| | 25:50:25 | ---- | 950 | 22237 | 1.63 |
| Finger millet based cropping system | ---- | 62.50:27.50:50 | 2541 | 37934 | 2.48 |
| | 50:40:37.50 | ---- | 1831 | 20184 | 1.78 |

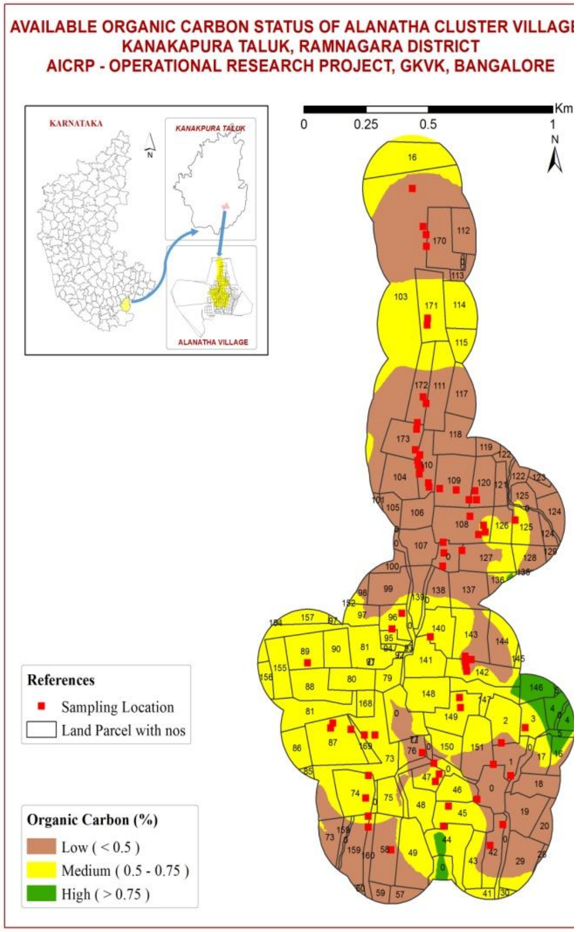
**Table.5** Comparison between quantity and cost of fertilizer under general recommendation and soil test based fertilizer recommendation

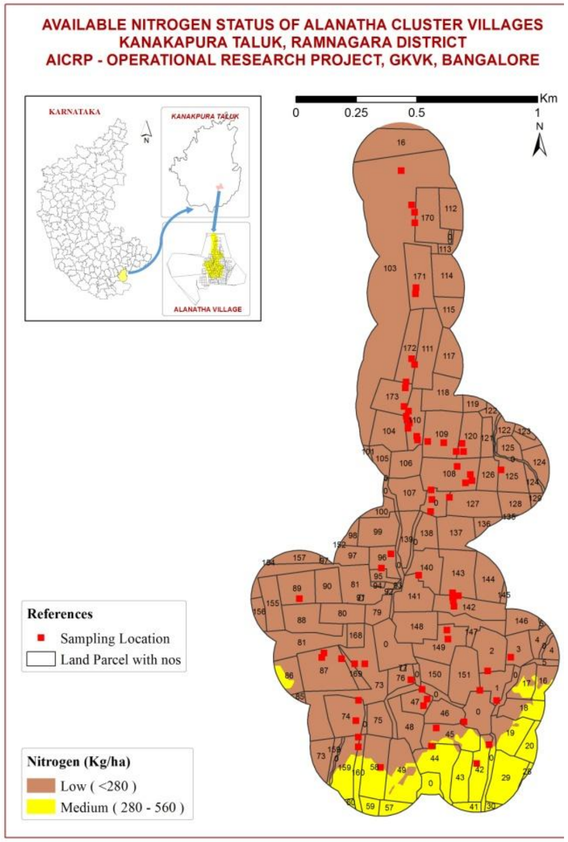
| | Finger millet (21.6 ha) | | Groundnut (12.8 ha) | |
|---|---|---|---|---|
| | Soil test based fertilizer recommendation | UAS package fertilizer recommendation | Soil test based fertilizer recommendation | UAS package fertilizer recommendation |
| **Urea (kg)** | 1261 | 1613 | 461 | 153 |
| **DAP (kg)** | 1415 | 1879 | 1109 | 1382 |
| **MOP(kg)** | 1153 | 1350 | 464 | 532 |
| **Cost (Rs)** | 59,268 | 75,471 | 36,548 | 42,512 |

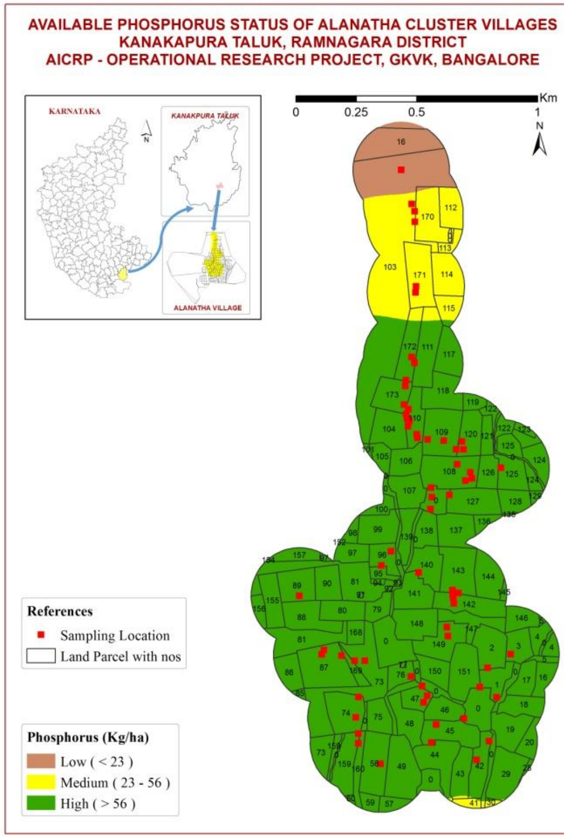
Note: Urea- Rs 5.44/ kg, DAP- Rs 24 /kg and MOP- Rs 16 /kg

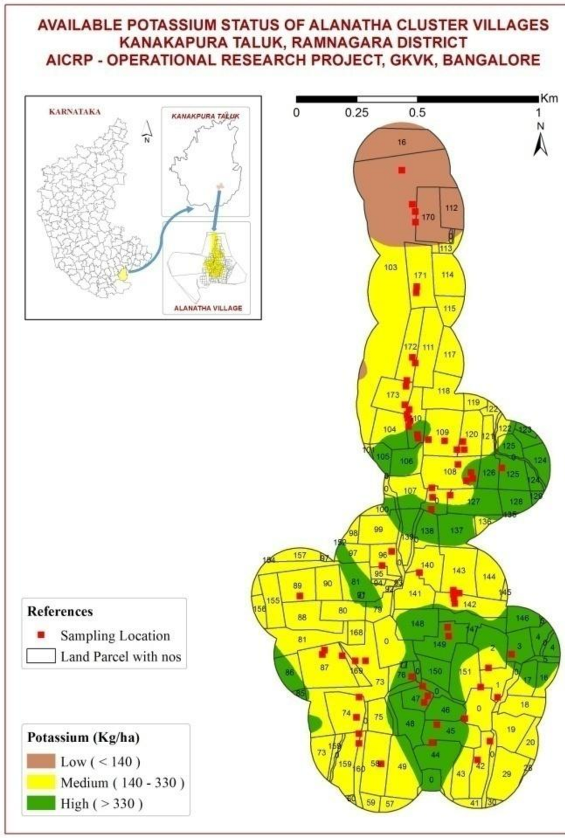

SOIL REACTION STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
KARNATAKA
KANAKPURA TALUK
ALANATHA VILLAGE
0 0.25 0.5 1 Km
N
References
Sampling Location
Land Parcel with nos
pH status
Moderately acid (5.0 – 5.5)
Strongly acid (5.5 – 6.0)
Slightly acid (6.0 – 6.5)

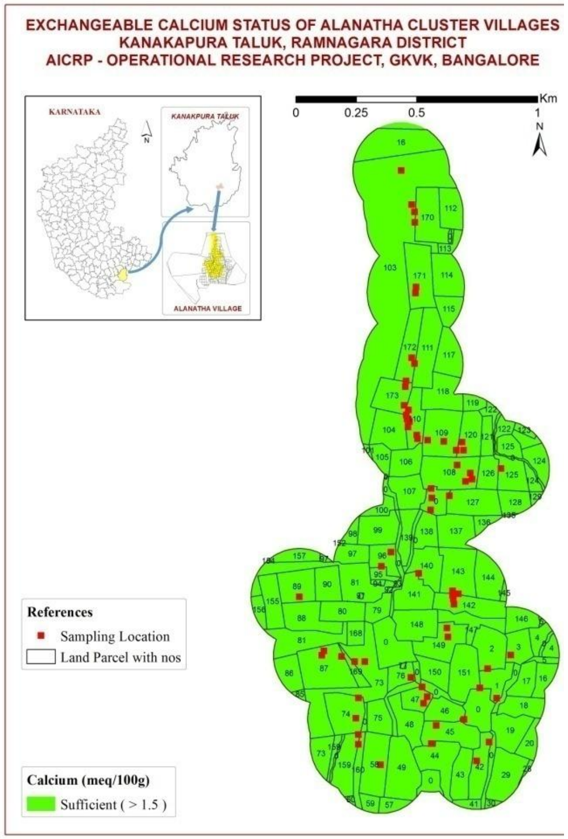

SALINITY STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
KARNATAKA
KANAKPURA TALUK
ALANATHA VILLAGE
0 0.25 0.5 1 Km
N
References
Sampling Location
Land Parcel with nos
Salinity (dS/m)
Non Saline ( < 2 )

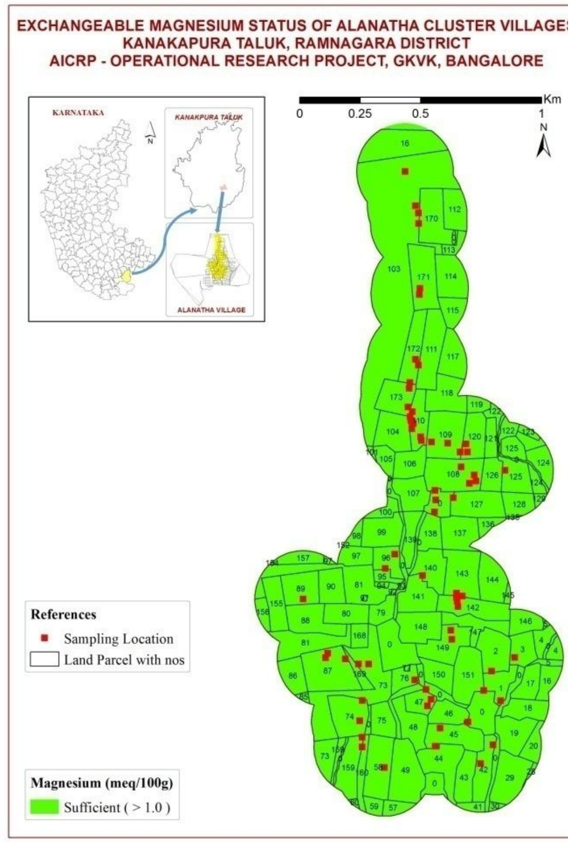

AVAILABLE ORGANIC CARBON STATUS OF ALANATHA CLUSTER VILLAGI
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
KARNATAKA
KANAKPURA TALUK
ALANATHA VILLAGE
0 0.25 0.5 1 Km
N
References
Sampling Location
Land Parcel with nos
Organic Carbon (%)
Low ( < 0.5 )
Medium ( 0.5 - 0.75 )
High ( > 0.75 )

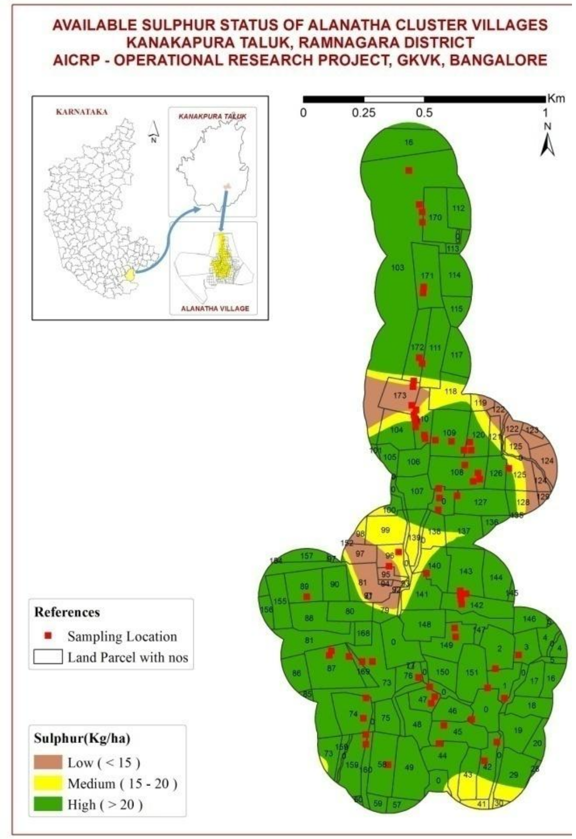

AVAILABLE NITROGEN STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
References
Sampling Location
Land Parcel with nos
Nitrogen (Kg/ha)
Low ( <280 )
Medium ( 280 - 560 )

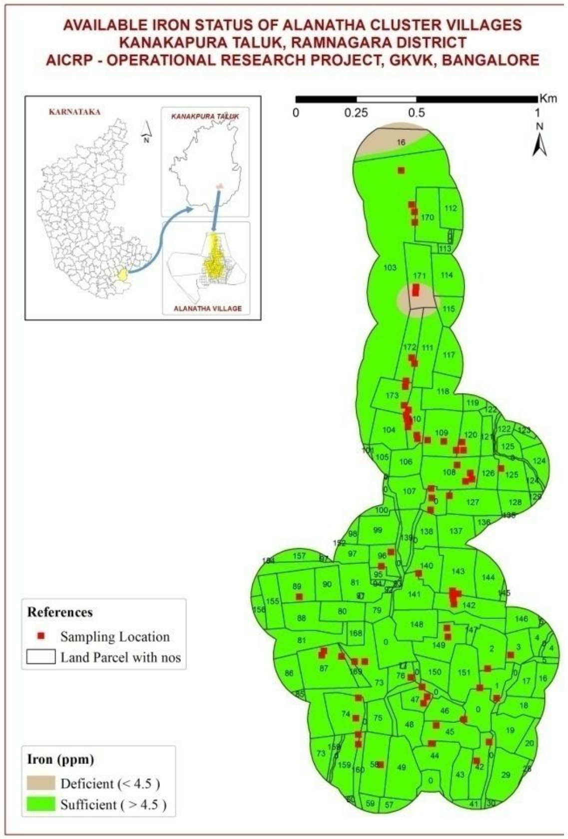

AVAILABLE PHOSPHORUS STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
References
Sampling Location
Land Parcel with nos
Phosphorus (Kg/ha)
Low ( < 23 )
Medium ( 23 - 56 )
High ( > 56 )

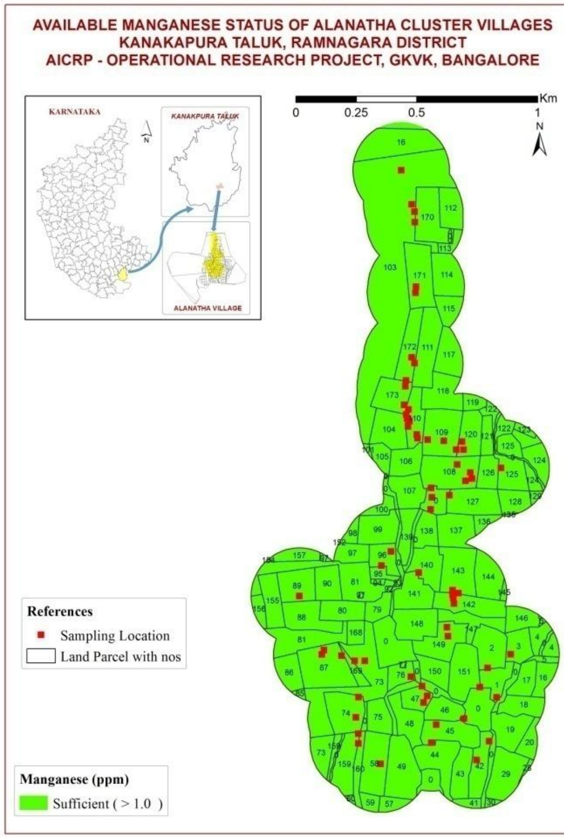

AVAILABLE POTASSIUM STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
References
Sampling Location
Land Parcel with nos
Potassium (Kg/ha)
Low ( < 140 )
Medium ( 140 - 330 )
High ( > 330 )

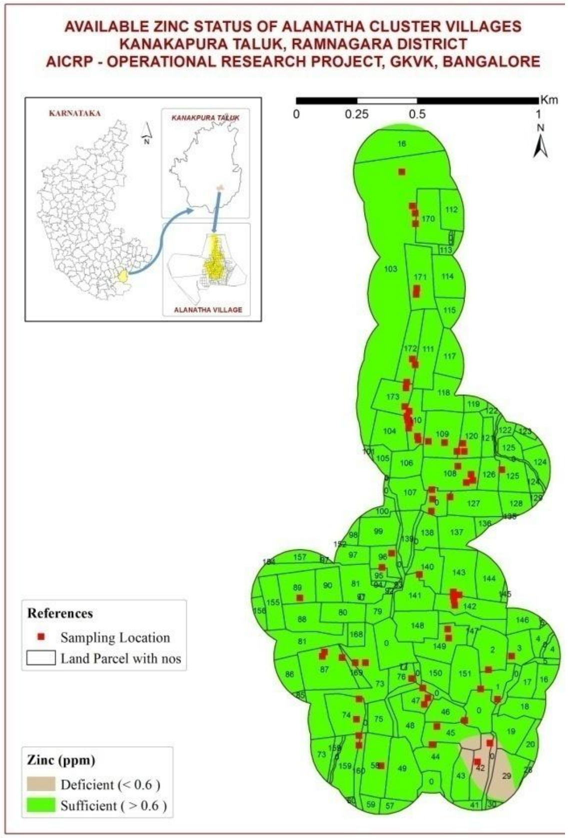

EXCHANGEABLE CALCIUM STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
References
Sampling Location
Land Parcel with nos
Calcium (meq/100g)
Sufficient ( > 1.5 )


EXCHANGEABLE MAGNESIUM STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
References
Sampling Location
Land Parcel with nos
Magnesium (meq/100g)
Sufficient ( > 1.0 )


AVAILABLE SULPHUR STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
References
Sampling Location
Land Parcel with nos
Sulphur(Kg/ha)
Low ( < 15 )
Medium ( 15 - 20 )
High ( > 20 )


AVAILABLE IRON STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
KARNATAKA
KANAKPURA TALUK
ALANATHA VILLAGE
0 0.25 0.5 1 Km
N
References
Sampling Location
Land Parcel with nos
Iron (ppm)
Deficient (< 4.5 )
Sufficient ( > 4.5 )


AVAILABLE MANGANESE STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
KARNATAKA
KANAKPURA TALUK
ALANATHA VILLAGE
0 0.25 0.5 1 Km
N
References
Sampling Location
Land Parcel with nos
Manganese (ppm)
Sufficient ( > 1.0 )


AVAILABLE ZINC STATUS OF ALANATHA CLUSTER VILLAGES
KANAKAPURA TALUK, RAMNAGARA DISTRICT
AICRP - OPERATIONAL RESEARCH PROJECT, GKVK, BANGALORE
KARNATAKA
KANAKPURA TALUK
ALANATHA VILLAGE
0 0.25 0.5 1 Km
N
References
Sampling Location
Land Parcel with nos
Zinc (ppm)
Deficient (< 0.6 )
Sufficient ( > 0.6 )

### Available nitrogen

The available nitrogen content of surface soil samples in Alanatha cluster villages varied from 88.2 to 403.20 kg $ha^{-1}$ in the study area. About 79.10 per cent area was low, 20.90 per cent area was medium (Fig. 4). Similar to organic carbon content, available nitrogen was also low in these soils. The variation in N content was related to soil management, application of FYM and fertilizer to previous crop (Ashok Kumar, 2000).

### Available phosphrous

The available $P_2O_5$ ranged from 12.8 to 261.5 kg $ha^{-1}$ in Alanatha cluster village (Table 2). About 34.32 per cent area was medium and 62.68 per cent area was high in available phosphorus content (Fig. 5). The commonly used phosphorus fertilizer in the area is DAP. The farmers tend to apply excess of DAP fertilizer without knowing the crop requirement and soil availability. Hence, in most of the areas higher available phosphorus was observed. Also variations in available P content in soils are related with the intensity of soil weathering or soil disturbance, the degree of P- fixation with Fe and Ca and continuous application of mineral P fertilizer sources as indicated by Paulos (1996).

### Available potassium

The available potassium content of surface soil samples varied from 83.00 to 620 $K_2O$ kg $ha^{-1}$ in Alanatha cluster village (Table 2). About 4.47 per cent area was low in available potassium content, 74.62 per cent area was medium in available potassium content and 20.90 per cent area was high in available potassium content (Fig. 6). As reported by Patiram and Prasad (1991), the high K status in these soils is associated with the presence K rich minerals in soil.

### Exchangeable calcium and magnesium

In surface soil samples of Alanatha cluster village exchangeable calcium varied from 1.3 to 6.0 meq/100g with mean of 2.94meq/100g respectively (Table 3). Soil samples were found to be sufficient in exchangeable calcium (Fig. 7).

Exchangeable magnesium content in surface soil samples varied from 0.2 to 4.50 meq/100g in Alanatha cluster village (Table 3). In general about 97 per cent area was found to be sufficient and 3.0 per cent area was found to be deficient in exchangeable magnesium (Fig. 8).

### Available sulphur

The available sulphur status in surface soil samples of Alanatha cluster village 2.08-58.17 with mean of 28.28, about 26.87 per cent was low in available sulphur, 25.36 per cent area was medium in available sulphur content and 47.77 per cent area was high in available sulphur content (Fig. 9).

### DTPA extractable micronutrients

The available iron in these soils varied from 0.471 to 34.36 mg $kg^{-1}$ with mean of 9.490 mg $kg^{-1}$ (Table 3). About 14.92 per cent area was found to be deficient and 85.02 percent area found to be sufficient in iron (Fig. 10). This high Fe content in soil may be due to presence of minerals like Feldspar, Magnetite, Hematite and Limonite which together constitute bulk of trap rock in these soils (Vijaya Kumar *et al.*, 2013).

The available manganese content found to be ranged from 4.953 to 17.45 mg $kg^{-1}$ with mean of 12.729 mg $kg^{-1}$ (Table 3). This indicating 100 per cent area was found to be sufficient (Fig. 11). The relative high content of Mn in these soils could be due to the soils derived from basaltic parent material which contained higher ferromagnesium minerals. Similar results were reported by Hundal *et al.*, (2006).

The available copper content in surface soil samples varied from, 0.655 to 5.223 mg $kg^{-1}$ with mean of 1.711 mg $kg^{-1}$ (Table 3). It is also indicating 100 per cent area was found to be sufficient (Fig. 12). Brady and Weilm (2002) indicated that the solubility, availability and plant uptake of Cu is more under acidic conditions (pH of 5.0 to 6.5).

Available zinc content in these soils varied from 0.515 to 1.940 mg $kg^{-1}$ with mean of 0.958 mg $kg^{-1}$ (Table 3). About 13.43 per cent area was found to be deficient and 86.57 percent area was found to be sufficient in zinc (Fig. 13). According to Krauskopf (1972) the main source of micronutrient elements in most soils is the parent material, from which the soil is formed.

## Nutrient management and fertilizer recommendations

Application of fertilizers based on soil test results would help in providing balanced nutrients to crop, reduce excess application, reduces over mining of nutrients from the soil and also reduces the cost of cultivation.

The soil test results were used for management of soil and fertilizer recommendation to various crops. The organic carbon level of the soil in cluster villages was low to medium. In order to maintain organic carbon level in soil, application of organic matter is recommended through various sources like FYM, vermicompost, green manuring and incorporation of crop residues into the soil so as to improve soil physical, chemical and biological properties of soils.

The availability nitrogen in the project area soils was low to medium, hence wherever available nitrogen was low, 12.5 kg $ha^{-1}$ of additional dose of nitrogen fertilizer is recommended along with recommended fertilizer in case of finger millet and groundnut (Table 2).

Phosphorus fertilizer (DAP) is very expensive and also nearly 62.68% area is high in available $P_2O_5$ where it was suggested to reduce the dose of $P_2O_5$ by 12.5 kg $ha^{-1}$ from recommended fertilizer for finger millet and groundnut. In areas where $P_2O_5$ is low, in addition to recommended dose, 12.5kg/ha along with fertilizer was suggested in case of finger millet and groundnut.

The cluster villages showed 20.90 per cent area as high in available potassium content in soil, hence, 12.5 kg $ha^{-1}$ less potassium ($K_2O$) was recommended to reduce the luxury consumption.

A total of 63.32 per cent area was found to be high in available zinc status as most of the farmers are already applying 12.5 kg $ha^{-1}$ $ZnSO_4$ to the crops. Wherever the soil is showing lower availability of zinc, 12.5 kg $ha^{-1}$ of $ZnSO_4$ is recommended along with organic manure and NPK in the cluster villages.

## Soil test based fertilizer recommendation

The fertilizer recommendation was made based on the site specific nutrient status to all the beneficiary farmers of operational research project being operated in these villages. With the adoption of this method, only required fertilizers are provided to specific field and crop. In comparison with the fertilizer recommendation made as per UAS, Bengaluru package of practices. The site specific nutrient recommendation provides all the major nutrients based on the availability of these nutrients in soil and crop need. This has ensured providing only required quantity of nutrients, balanced nutrition and in some cases reducing fertilizer cost.

## Groundnut based cropping system

The nutrient status in farmer's field (Mr. Madhuranaik) was medium in available nitrogen and potassium and, high in available phosphorus. The recommendation as per UAS, Bengaluru, package of practice for ground nut crop was 25:50:25 kg NPK per ha, but, recommendation of fertilizer based on soil test was 25:37.5:25 (DAP: 81.52, Urea: 22, MOP: 41.66 kg). With this, there is reduction in cost of cultivation up to Rs 635 $ha^{-1}$, also maintained the balanced nutrition and increased the productivity of groundnut with additional returns of 1135 kg $ha^{-1}$.

The total quantity of fertilizers in terms of urea, DAP and MOP based on soil test fertilizer recommendation was 461, 1109 and 464 kg instead of general recommendation of 153, 1382 and 532 kg for 12.8 ha comprising of 20 farmers. There was reduction in total cost of fertilizer up to Rs 5,964.

## Fingermillet based cropping system

The nutrient status in Mr. Shivashankaraiah's field was low in available nitrogen, high available phosphorus and medium available potassium. The recommendation as per UAS, Bengaluru, package of practice for finger millet crop was 25:40:37.5 kg NPK per ha, where as recommendation of fertilizer based on soil test for finger millet was 67.5:27.5:37.5 kg $ha^{-1}$ (DAP: 59.78, Urea: 12.3.34, MOP: 25 kg). The approach helped in reducing the cost on fertilizers by Rs 420.58 $ha^{-1}$, in addition to maintaining balanced nutrition and increased the productivity of fingermillet with additional returns of 2542 kg $ha^{-1}$.

The total quantity of fertilizers in terms of urea, DAP and MOP based on soil test fertilizer recommendation was 1261, 1415 and 1153 kg instead of general recommendation of 1613, 1879 and 1350 kg for 21.6 ha comprising of 46 farmers. There was reduction in total cost of fertilizer up to Rs 16,203. The comparison made with farmers practice and site specific nutrient recommendation clearly showed the advantage of providing balanced nutrition which helped in the availability of nutrients to crop for better growth and yield (Smaling and Braun, 1996).

If the soil test based fertilizer recommendation is adopted in total cultivated area under finger millet (6.38 lakh ha) and groundnut (5.08 lakh ha) in Karnataka then we can reduce considerable cost on fertilizers and provide balance nutrition to crop. It can be concluded that, the geospatial technologies helps in preparing soil nutrient status maps which facilitates management of nutrients.

In the present study, soils of Alanatha cluster village, Kanakapura, Ramanagara, Karnataka were low to medium in soil organic carbon content and available nitrogen. Available phosphorus, available potassium and available sulphur were low to high.

Available iron, zinc was deficient to sufficient whereas, available copper and manganese were sufficient in these soils. Based on the status of nutrients, fertilizer recommendations were made which has resulted in enhancing the yield and reducing the cost of fertilizers in addition to proving balanced nutrients so as to improve availability of nutrients to crop for better growth and yield.

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