



Assessment of Spatial Variability in Fertility Status and Nutrient Recommendation in Alanatha Cluster Villages, Ramanagara District, Karnataka using GIS

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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 nitrogen (N), available phosphorus (P), available potassium (K) and secondary and micronutrients in surface soils (0-30 cm depth) of 67 farmers' fields of Alanatha Cluster Villages, Kanakapura Taluk, Ramanagara District, Karnataka was 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 OC content was low to high, available N low to medium and available P and available K low to high. The soil of 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, 86.5 per cent area was sufficient in zinc and 85.0 per cent area was sufficient in iron in surface soils. The observed spatial variability in soil properties that influence soil fertility was used for deciding nutrient application to finger millet and groundnut. Thus, providing balanced nutrients to crops based on soil of fertility status resulted in enhanced crop productivity and net returns in both groundnut and finger millet cropping systems.

Key words: Fertilizer recommendation, soil fertility mapping, soil testing

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 biological 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 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 chemical fertilizer mainly nitrogen (N), phosphorus (P) and potassium (K) 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.

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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. 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 that can perform identification of soil properties and preparation of thematic maps of soil type, nutrient content in conjunction with a GIS.

Material 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°23' N latitude, 77°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 @ 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 analyzed for nutrient availability by following standard analytical techniques. The pH and electrical conductivity (EC) of soil samples were determined in 1:2.5::soil: water suspension (Jackson 1973). Soil was finely ground and passed through 0.2 mm sieve and organic carbon (OC) was determined by Walkely and Black (1934). Available N was analyzed by potassium permanganate method of Subbiah and Asija (1956). Available P, available K, exchangeable calcium (Ca) and magnesium (Mg) 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 atomic absorption spectrophotometer (AAS) using DTPA

extract. Available boron (B) 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 Zn, Fe, Cu and Mn interpreted as deficient, sufficient and excess by following the criteria (Table 1).

Table 1. Critical limits used for classification of different soil parameters

Parameter	Critical limits
pH	Acidic <6.5 Neutral 6.5-7.5 Alkaline >7.5
EC	Normal <0.8 dS m ⁻¹ Critical for sensitive crops 0.8-1.6 dS m ⁻¹ Critical for salt tolerant crops 1.6-2.5 dS m ⁻¹ Injurious for many crops >2.5 dS m ⁻¹
Organic carbon	Low 5 g kg ⁻¹ Medium 5-7.5 g kg ⁻¹ High > 7.5 g kg ⁻¹
Available N	Low <280 kg ha ⁻¹ Medium 280-560 kg ha ⁻¹ High >560 kg ha ⁻¹
Available P	Low 22.5 kg ha ⁻¹ Medium 55.5 -56 kg ha ⁻¹ High >56 kg ha ⁻¹
Available K	Low 141 kg ha ⁻¹ Medium 141-336 kg ha ⁻¹ High >336 kg ha ⁻¹
Exchangeable Ca	Deficient < 1.5 cmol(p ⁺)kg ⁻¹ Sufficient >1.5 cmol(p ⁺)kg ⁻¹
Exchangeable Mg	Deficient < 1.0 cmol(p ⁺)kg ⁻¹ Sufficient >1.0 cmol(p ⁺)kg ⁻¹
Available S	Low <10 mg kg ⁻¹ Medium 10-20 mg kg ⁻¹ High > 20 mg kg ⁻¹
Available Zn	Low < 0.5 mg kg ⁻¹ Marginal 0.5-0.75 mg kg ⁻¹ Adequate 0.75-1.50 mg kg ⁻¹ High > 1.5 mg kg ⁻¹
Available B	Low <0.5 mg kg ⁻¹ Medium 0.5-1.0 mg kg ⁻¹ High > 1.0 mg kg ⁻¹
Available Cu	Deficient < 0.2 mg kg ⁻¹ Sufficient > 0.2 mg kg ⁻¹
Available Mn	Deficient < 1 mg kg ⁻¹ Sufficient > 1 mg kg ⁻¹
Available Fe	Deficient < 4.5 mg kg ⁻¹ Sufficient > 4.5 mg kg ⁻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.

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

	pH	EC (dS m ⁻¹)	OC (g kg ⁻¹)	Available N	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O
Range	4.7-6.61	0.02-0.14	1.5-19.3	200	12.8-261.5	83-620
Mean	5.48	0.0567	4.8	200	78.0	313

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.

Result 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 indicated that 26.9% area was moderately acidic (pH 5.5-6.0), 61.0% strongly acidic (pH 5.0-5.5) and 11.1% 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 EC of surface soil samples varied from 0.02 to 0.14 dS m⁻¹ in with a mean of 0.06 dS m⁻¹. All the soil samples were found to be normal in EC (Fig. 2).

**Fig. 1.** Soil reaction status of Alanatha cluster villages**Fig. 2.** Salinity status of Alanatha cluster villages

Organic carbon

The OC content of the surface soils ranged from 1.5 to 9.3 g kg⁻¹ with mean of 4.8 g kg⁻¹ in Alanatha cluster village (Table 2). About 52.3% area was low,

37.3% area was medium and 10.4% area was high in OC content (Fig. 3). Low OC 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 OC in these areas. The high content of OC 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).



Fig. 3. Available organic carbon status of Alanatha cluster villages

Available nitrogen

The available N content of surface soil samples in Alanatha cluster villages varied from 88.2 to 403.2 kg ha⁻¹ in the study area. About 79.1% area was low and 20.9% area was medium (Fig. 4). Similar to OC content, available N 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).

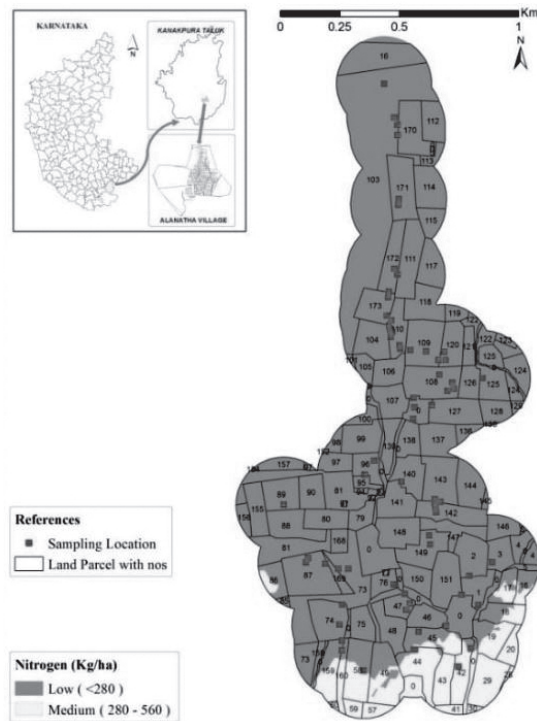


Fig. 4. Available nitrogen status of Alanatha cluster villages

Available phosphorus

The available P ranged from 12.8 to 261.5 kg P₂O₅ ha⁻¹ in Alanatha cluster village (Table 2). About 34.3% area was medium and 62.7% area was high in available P content (Fig. 5). The commonly used P

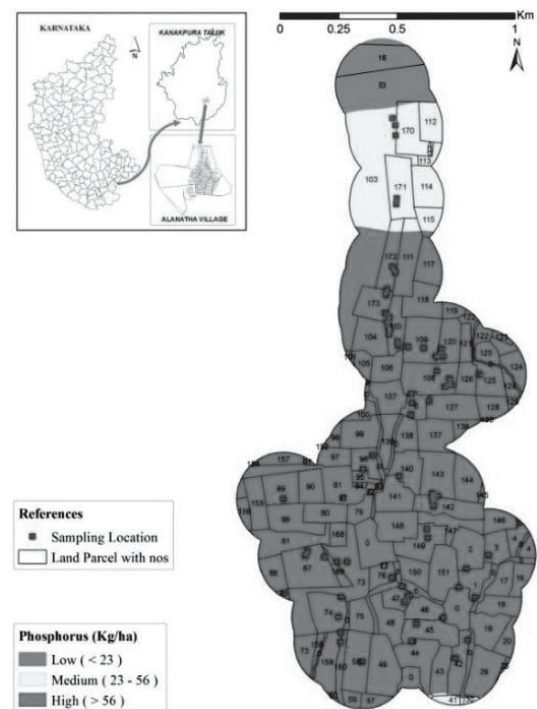


Fig. 5. Available phosphorus status of Alanatha cluster villages

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 P 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 K content of surface soil samples varied from 83.0 to 620 kg K₂O ha⁻¹ in Alanatha cluster village (Table 2). About 4.47% area was low in available K content, 74.6% area was medium in available K content and 20.9% area was high in available K 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.

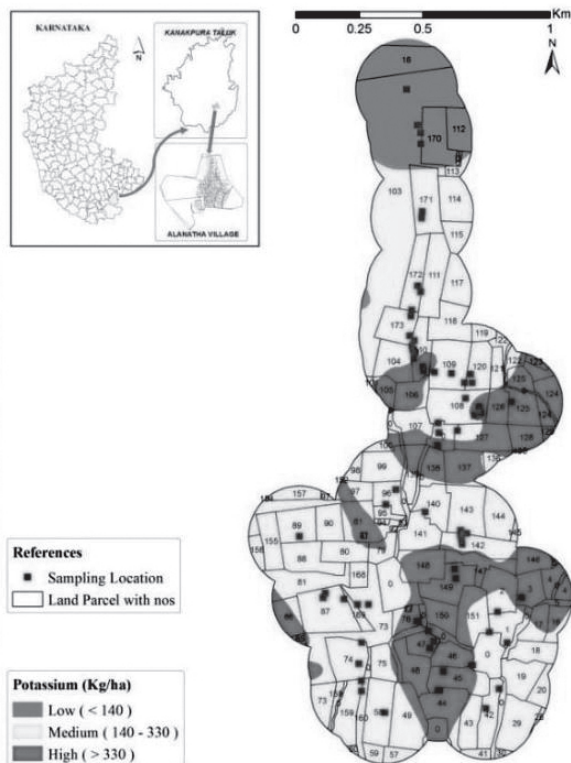


Fig. 6. Available potassium status of Alanatha cluster villages

Exchangeable calcium and magnesium

The exchangeable Ca content varied from 1.3 to 6.0 cmol(p⁺)kg⁻¹ with mean of 2.94 cmol(p⁺)kg⁻¹ soil (Table 3). Soil samples were found to be sufficient in exchangeable calcium (Fig. 7).

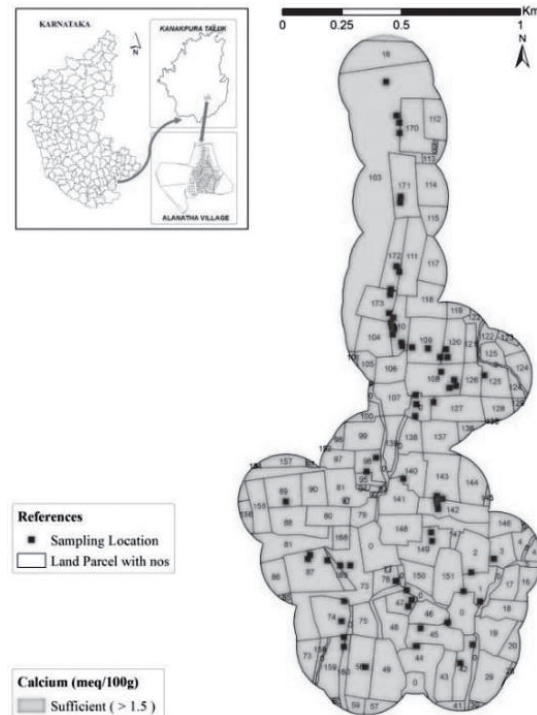


Fig. 7. Exchangeable calcium status of Alanatha cluster villages

Exchangeable Mg content in varied from 0.2 to 4.50 cmol(p⁺)kg⁻¹ soil in Alanatha cluster village (Table 3). In general about 97% area was found to be sufficient and 3.0% area was found to be deficient in exchangeable Mg (Fig. 8).

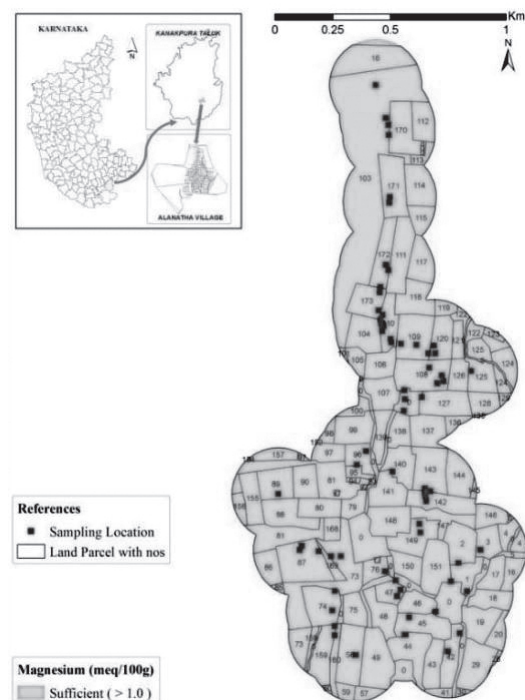


Fig. 8. Exchangeable magnesium status of Alanatha cluster villages

Available sulphur

The available S status in soils of Alanatha cluster village varied from 2.08-58.1 mg kg⁻¹ with mean of 28.3 mg kg⁻¹. About 26.8% was low in available S, 25.3% area was medium in available S content and 47.8% area was high in available S content (Fig. 9).

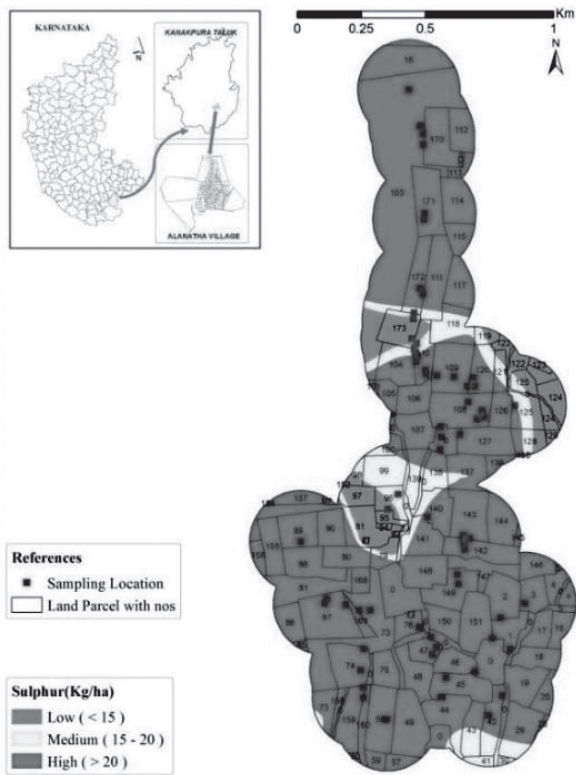


Fig. 9. Exchangeable sulphur status of Alanatha cluster villages

DTPA extractable micronutrients

The available Fe in these soils varied from 0.47 to 34.3 mg kg⁻¹ with mean of 9.49 mg kg⁻¹ (Table 3). About 14.9% area was found to be deficient and 85.0% area found to be sufficient in Fe (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 Mn content found to be ranged from 4.95 to 17.45 mg kg⁻¹ with mean of 12.72 mg kg⁻¹ (Table 3). This indicating 100% 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).

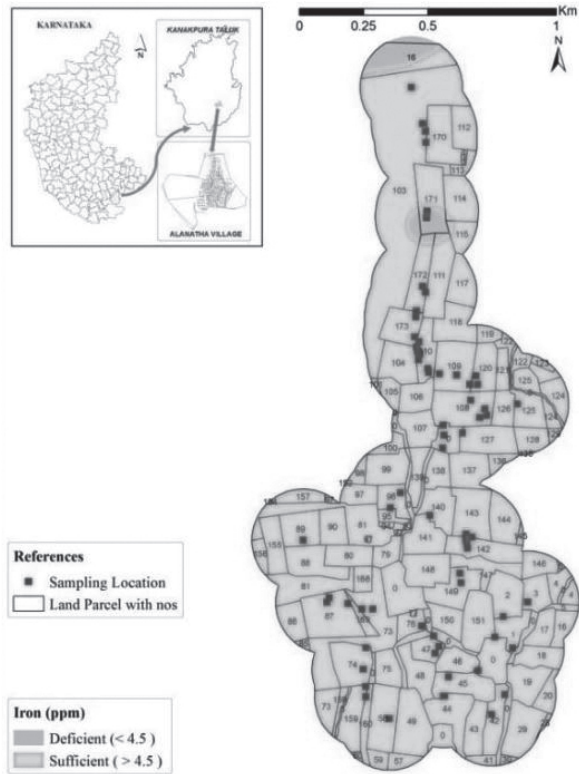


Fig. 10. Available iron status of Alanatha cluster villages

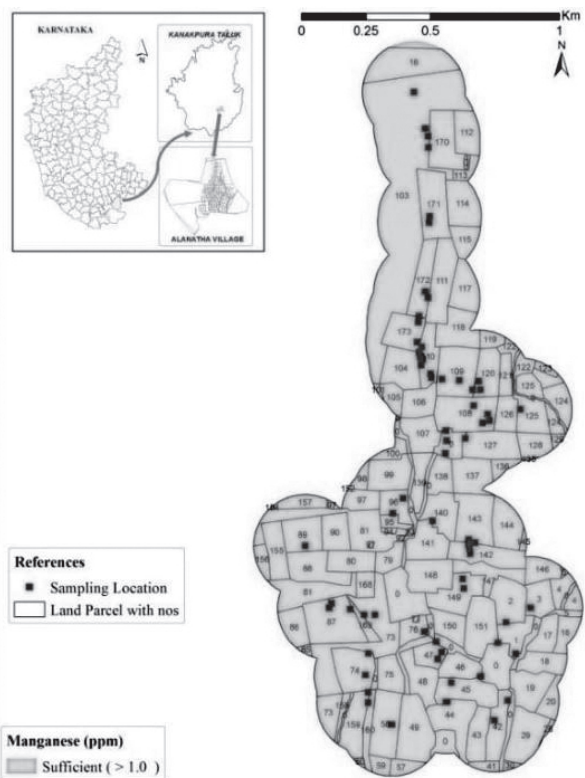


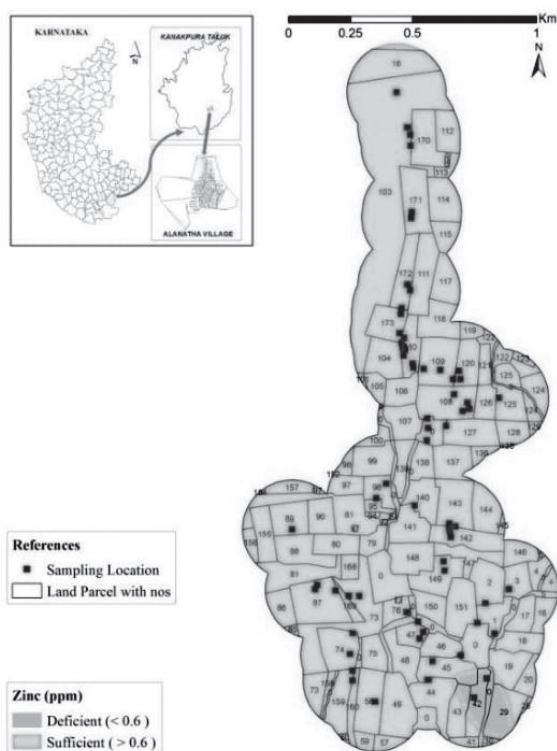
Fig. 11. Available manganese status of Alanatha cluster villages

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

	Exch Ca —[cmol(p ⁺)kg ⁻¹]	Exch Mg	Available S	DTPA-Fe mg kg ⁻¹	DTPA-Cu	DTPA-Zn
Range	1.3 - 6.0	0.2 - 4.50	2.08 - 58.1	0.47 -34.3	0.65 - 5.22	0.51 - 1.94
Mean	2.94	1.78	28.3	9.49	1.71	0.96

The available Cu content in surface soil samples varied from, 0.65 to 5.22 mg kg⁻¹ with mean of 1.71 mg kg⁻¹ (Table 3). It is also indicating 100% area was found to be sufficient. 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 Zn content in these soils varied from 0.51 to 1.94 mg kg⁻¹ with mean of 0.96 mg kg⁻¹ (Table 3). About 13.4% area was found to be deficient and 86.6% area was found to be sufficient in Zn (Fig. 12). According to Krauskopf (1972) the main source of micronutrient elements in most soils is the parent material, from which the soil is formed.

**Fig. 12.** Available zinc status of Alanatha cluster villages

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 OC level of the soil in cluster villages were low to medium. In order to maintain OC 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 available N in soils was low to medium, hence wherever available N was low, 12.5 kg ha⁻¹ of additional dose of N fertilizer is recommended along with recommended fertilizer in case of finger millet and groundnut (Table 4).

Phosphorus fertilizer (DAP) is very expensive and also nearly 62.7% area is high in available P where it was suggested to reduce the dose of P by 12.5 kg P₂O₅ ha⁻¹ from recommended fertilizer for groundnut and finger millet. In areas where available P is low, in addition to recommended dose, 12.5 kg P₂O₅ ha⁻¹ along with fertilizer was suggested in case of finger millet and groundnut.

The cluster villages showed 20.9% area as high in available K content in soil, hence, 12.5 kg ha⁻¹ less K₂O was recommended to reduce the luxury consumption.

A total of 63.3% area was found to be high in available Zn status as most of the farmers are already applying 12.5 kg ZnSO₄ ha⁻¹ to the crops. Wherever the soil is showing lower availability of Zn, 12.5 kg ha⁻¹ of ZnSO₄ is recommended along with organic manure and NPK.

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

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 ⁻¹)	Net returns (Rs.)	B:C 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⁻¹, DAP- Rs 24 kg⁻¹ and MOP- Rs 16 kg⁻¹

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 N and K and, high in available P. The recommendation as per UAS, Bengaluru, package of practice for groundnut crop was 25:50:25 kg NPK ha⁻¹, but, recommendation of fertilizer based on soil test was 25:37.5:25 (DAP: 81.5, Urea: 22, MOP: 41.6 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 (Table 5). There was reduction in total cost of fertilizer up to Rs. 5,964.

Finger millet based cropping system

The nutrient status in Mr. Shivashankaraiah's field was low in available N, high in available P and medium in available K. The recommendation as per UAS, Bengaluru, package of practice for finger millet crop was 25:40:37.5 kg NPK ha⁻¹, whereas recommendation of fertilizer based on soil test for finger millet was 67.5:27.5:37.5 kg ha⁻¹ (DAP: 59.8, Urea: 12.3, MOP: 25 kg). The approach helped in reducing the cost on fertilizers by Rs. 420.6 ha⁻¹, in

addition to maintaining balanced nutrition and increased the productivity of finger millet with additional returns of Rs. 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 (Table 5). 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 crops for better growth and yield (Smaling and Braun 1996).

If the soil test based fertilizer recommendation is adopted in total cultivated area under groundnut (5.08 lakh ha) and finger millet (6.38 lakh ha) in Karnataka then we can reduce considerable cost on fertilizers and provide balance nutrition to crops.

Conclusions

It can be concluded that the GIS 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, potassium and sulphur were low to high. Available iron and 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 providing balanced nutrients so as to improve availability of nutrients to crop for better growth and yield.

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