RESEARCH ARTICLE

GIS AIDED SPATIAL VARIABILITY MAPPING OF SECONDARY NUTRIENTS FOR DECISION SUPPORT IN COCONUT RESEARCH STATION, ALIYARNAGAR, TAMIL NADU

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Abstract: GIS aided spatial variability mapping in research stations is imperative to comprehend the native nutrient supply power of the soil and to assess the temporal and spatial variability so as to undertake decision support. A study was undertaken at Coconut Research Station, Tamil Nadu Agricultural University, Aliyar nagar to characterize the spatial variability of secondary nutrients Ca, Mg, S and free $CaCO_3$. Two hundred and fifty eight geo - referenced soil samples were collected from the surface (0-15 cm) and subsurface (15- 30 cm) layers of A, B and C blocks of the farm. The farm is predominantly sandy textured belonging to the taxonomic class Typic / Fluventic Ustropept. GIS aided fertility maps were prepared for all the parameters employing kriging. Exchangeable Ca and Mg were sufficient throughout the farm, deficiency of available sulphur was witnessed across 5 % of the farm area. The farm is moderately calcareous with sporadic spots of intense calcareousness. Thus spatial variability mapping employing GIS techniques is an ideal tool for the researchers and policy planners in decision support for crop selection and land use planning.

Keywords : Aliyarnagar, GIS, Spatial variability, Secondary nutrients

INTRODUCTION

Natural resource management is of immense importance to the national economy. Soil is a precious natural resource on which life forms flourish and perish. Soil properties varying spatially from a small to larger area might be due to effect of intrinsic *viz*., parent materials and climate and extrinsic factors such as soil management practices, indigenous fertility status, crop rotation and nature of standing crop (Cambardella and Karlen, 1999). There are various techniques for soil fertility evaluation, of which soil testing is the most widely accepted tool in the world (Havlin *et al*., 2010). Scientific tools and techniques like Remote Sensing, Global Positioning System (GPS) and Geographical Information System (GIS) are essential for holistic analysis of the whole gamut of resources and quick retrieval of the data (Sharma, 2004). These tools coupled with simulation models enable taking management decisions in real time for upscaling, weather forecasting and contingency planning (Dipak Sarkar, 2011). GIS is a potential tool used for easy access, retrieval and manipulation of voluminous data of natural resources often difficult to handle manually. It facilitates manipulation of spatial and attributes data useful for handling multiple data of diverse origin (Mandal and Sharma, 2009). GIS holds great promise in soil health monitoring through mapping soil quality parameters towards identifying site specific problems for alternate land use. GIS mapping helps to compare and monitor the temporal variability in soil fertility so as to tailor fertilizer application. Secondary micronutrients *viz*., calcium, magnesium and sulphur are inevitable in crop production and are increasingly becoming an important limiting factor in intensive crop production systems especially in soils fertilized only with primary nutrients. Secondary nutrients have been consistently depleted of their native status due to continuous cultivation.

At Coconut Research Station, Aliyarnagar, Tamil Nadu, research on crops *viz*., coconut, groundnut, cocoa, nutmeg, pepper and fodder crops with varying requirements of secondary nutrients is in vogue. Hence assessing the status of secondary nutrients is indispensable in research institutes where agrotechnologies are generated. Thus a study was undertaken to assess, document and map the spatial variability in secondary nutrients calcium (Ca), magnesium (Mg), sulphur (S) and free $CaCO_3$ at Coconut Research Station, Aliyarnagar.

MATERIALS AND METHODS

Coconut Research Station, Aliyarnagar is located in the Western Zone of Tamil Nadu at 10°28’ N latitude and $76^0$58’E longitude at an altitude of 288 m. The mean maximum and minimum temperatures are 34°C and 24°C respectively. The station has a total area of 21.7 ha with a cultivable area of 18.7 ha. The soils are sandy loam to sandy clay loam in texture taxonomically classified as Typic / Fluventic Ustropept. The major and predominant geological formations of Aliyar are of granite gneiss, biotite gneiss and charnockite (Sudhalakshmi and Kumaraperumal, 2017). The station comprises of A,

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B and C blocks. Georeferenced surface (0-15 cm) and subsurface (15-30 cm) soil samples were collected from A (14 fields), B (17 fields) and C blocks (12 blocks) @ six samples per field in three locations L_1, L_2 and L_3, thus totaling 258 samples. Exchangeable Na (Stanford and English, 1949), Ca and Mg (Dewis and Freitas, 1970), available S (Williams and Steinberg, 1959) and free $CaCO_3$ (Dewis and Freitas, 1970) were estimated adopting the standard procedures.

Figure 1. Farm map of CRS, Aliyarnagar overlaid over Quick Bird Satellite Imagery

The farm map was overlaid over Quick Bird Satellite imagery (Figure 1) and digitized. A database file consisting of data for X and Y coordinates was created in Microsoft excel. A shape file showing the sampling locations was created in Arc GIS software. The database file was joined to the point data. Thematic maps on available nutrient status (N, P and K) were generated by categorizing the fertility status as 'low', 'medium' and 'high' by kriging (Song *et al*., 2013). Descriptive statistics (mean, range, standard deviation, standard error, coefficient of variation) of soil parameters were computed. The coefficient of variation was also ranked for determination of nutrient variability according to the procedure of (Aweto, 1982) where, CV ≤ 25% = low variation, CV >25 ≤ 50% = moderate variation, CV >50% = high variation.

RESULTS AND DISCUSSION

Exchangeable Na (kg ha^{-1})

Sodium (Na) is essential to maintain the osmotic potential of the plants and higher exchangeable sodium is deleterious for soil. Exchangeable sodium content in the soil samples (Table 1) ranged from 37 kg /ha in A10 to 134 kg/ha in the sub surface soil of C4 field with a mean value of 84.1 kg /ha in the surface and 83.5 kg /ha in the subsurface samples. The variability of sodium content between the samples was low (< 25 %). Sodium content was found to be non hazardous irrespective of the depth and location of sampling (Figure 2). It may be concluded that the soils of CRS, Aliyar Nagar farm are non sodic (< 15 %) and doesnot pose hazard for crop growth.

Figure 2. Spatial variability of exch. Na sodium (kg ha^{-1}) in the surface & subsurface samples of CRS, Aliyar Nagar

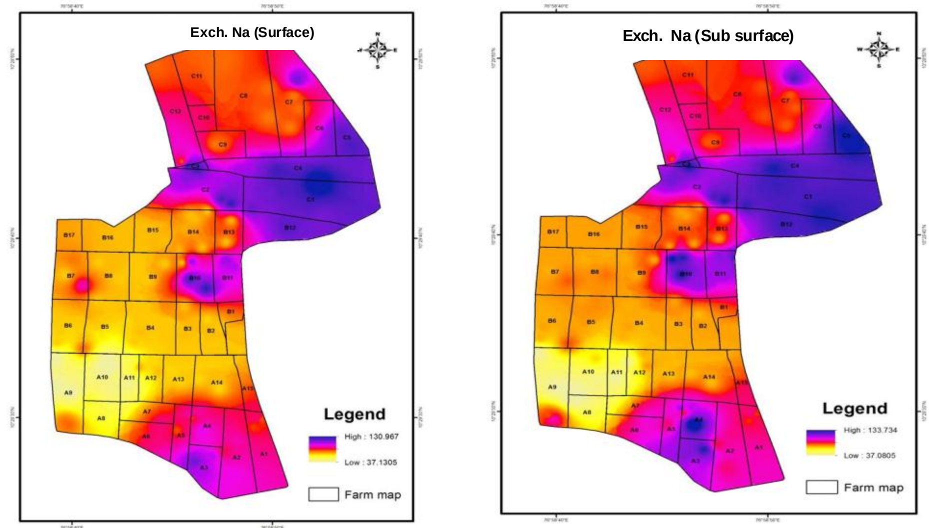

Figure 2. Spatial variability of exchangeable sodium at CRS, Aliyarnagar

Exchangeable Ca (meq / 100 g)

Exchangeable calcium (Ca) content varied from 2.0 meq / 100 g in the sub surface soil of B5 to 23.6 meq / 100 g in the surface soil of C11 with a mean value of 8.15 meq /100g (Table 1, Figure 3). Exchangeable Ca content exhibited moderate variability of 50 % variation among the samples. Scrupulous application of gypsum and calcareous nature of the soil would have attributed for the high calcium content. No consistent trend was observed between the surface and sub surface soils with respect to exchangeable calcium content. Higher exchangeable Ca content favours the growth of coconut and is equally beneficial for groundnut crop cultivated in the station.

Exchangeable Mg (meq / 100 g)

Magnesium (Mg) is an element of momentum in coconut because it is normally recommended to the root (wilt) affected coconut gardens @ 500 g per palm per year. Exchangeable magnesium content varied from 0.1 meq / 100 g in the sub surface soil of A11 to 26.2 meq / 100 g in the sub surface soil of A5 (Table 1, Figure 4). The mean exchangeable Mg content was 25.9 meq / 100 g in the surface and 26.2 meq / 100 g in the subsurface samples. Magnesium deficiency was not prominent in the soils of the farm and the content was higher in the groundnut growing fields compared to coconut growing fields which need further investigation. Hence the variability was very high to the tune of 104.3 % in the surface and 111 % in the subsurface samples.

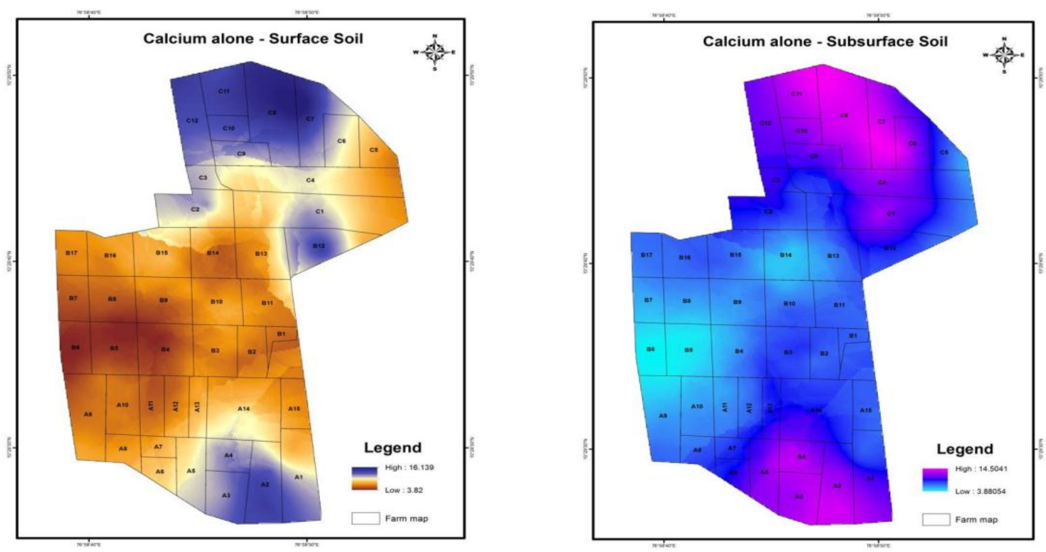

Figure 3. Spatial variability of exchangeable calcium at CRS, Aliyarnagar

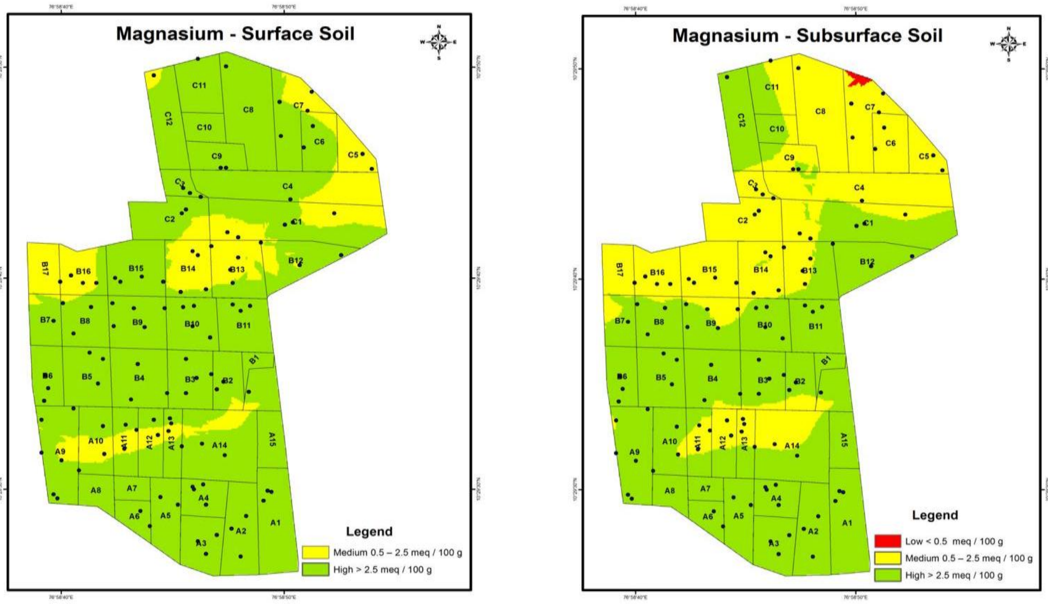

Figure 4. Spatial variability of exchangeable magnesium at CRS, Aliyarnagar

Avalable sulphur (ppm)

Sulphur is essential to enhance the oil content of copra. Available sulphur content was sufficient (> 10 ppm) in almost all the surface and subsurface samples analysed (Table 1, Figure 5). Although fluctuations in content were observed across the farm, almost all the soil samples were sufficient in available sulphur content with only 3 % in the surface and 5% of samples in the sub surface encountering sulphur deficiency. The mean sulphur content was 20.7 ppm in the surface and 18.8 ppm in the subsurface. Because of the addition of sulphur to the system through gypsum, phosphatic fertilizers and micronutrient fertilizers, sulphur was found to be satisfactory in the soil samples analysed. Variability between samples were moderate to the tune of 25.3 % in the surface and 27.5 % in the subsurface.

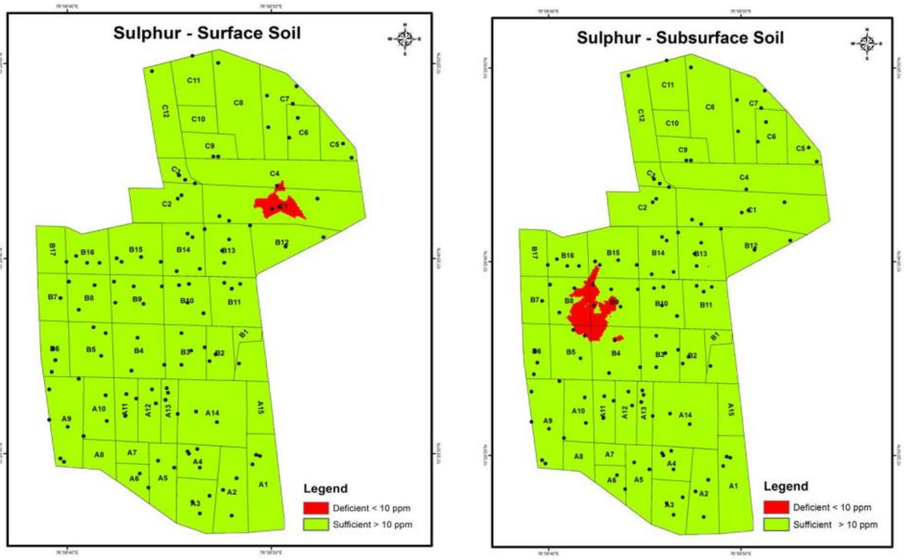

Figure 5. Spatial variability of available sulphur at CRS, Aliyarnagar

Free calcium carbonate content (%)

Almost all the soil samples analysed were moderately calcareous with 1-5 % $CaCO_3$ content with a mean content of 2.0 % in surface and subsurface samples (Table 1, Figure 6**)**. Soil samples collected from the fields A2, A5, C8 and C10, some spots of A14, B2, B5 & C1, C10 showed brisk effervescence on testing with dilute HCl. Spatial variability of free $CaCO_3$ was moderate to the tune of 28.7 – 34.0 % in the surface and subsurface samples respectively. However the calcareous nature of the soils is highly favourable for the cultivation of coconut and deleterious for cocoa.

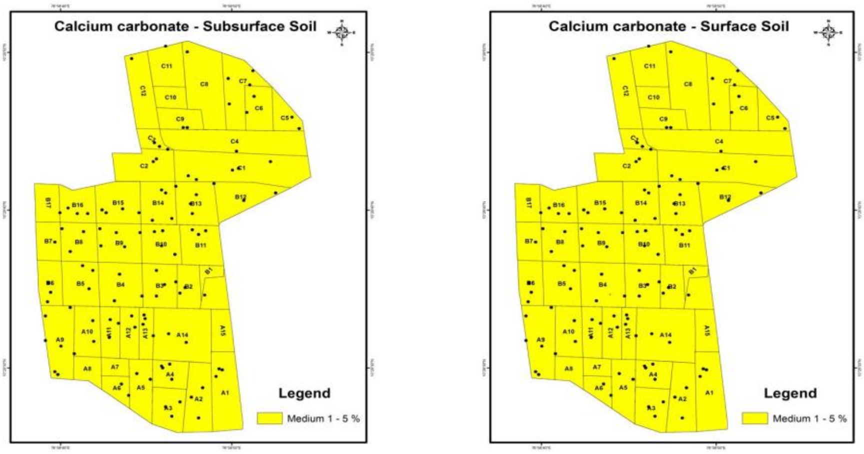

Figure 6. Spatial variability of free $CaCO_3$ at CRS, Aliyarnagar

CONCLUSION

In addition to primary nutrients, secondary nutrients like calcium, magnesium and sulphur are gaining momentum in the recent past in the context of increasing deficiencies. At Coconut Research Station, Aliyarnagar, secondary nutrients Ca and Mg were not deficient whilst available sulphur deficiency was noticed across 5 % of the farm area. Free $CaCO_3$ was moderately calcareous with sporadic spots of intense calcareousness which is highly suitable for coconut but not for crops like nutmeg, pepper and cocoa. Thus mapping secondary nutrients of research station will help in assessing the temporal and spatial variability so as to formulate research strategies, to tailor fertilizer application across farm fields, for decision support towards choice of crops and to undertake judicious land use planning.

Table 1. Status of secondary nutrients and free $CaCO_3$ in Coconut Research Station, Aliyarnagar

Descriptive Statistics	Exchangeable Sodium (kg /ha)		Exchangeable Calcium (meq / 100 g)		Exchangeable Magnesium (meq / 100 g)		Available S (ppm)		Free $CaCO_3$ (%)	
	0-15 cm	15 – 30 cm	0-15 cm	15 – 30 cm	0-15 cm	15 – 30 cm	0-15 cm	15 – 30 cm	0-15 cm	15 – 30 cm
Minimum	37.0	37.0	2.0	2.5	0.1	0.1	7.52	6.05	0.94	0.77
Maximum	1331	134	23.6	18.3	25.9	26.2	34.4	35.5	4.30	4.66
Mean	84.1	83.5	8.2	8.1	5.6	4.9	20.7	18.8	2.0	1.9
Standard Deviation	19.2	20.5	4.1	3.8	5.8	5.4	5.2	5.2	0.6	0.6
Coefficient of Variation	22.8	24.6	50.6	46.7	104.3	111.0	25.3	27.5	28.7	34.0
Standard Error Mean	1.73	1.80	0.364	0.331	0.514	0.477	0.461	0.456	0.494	0.056

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