International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 4383-4389

Received: 19-07-2019
Accepted: 21-08-2019

B Jeevitha
Department of Soils and Environment, AC & RI, Madurai, Tamil Nadu, India

A Rathinasamy
Agricultural College & Research Institute, Eachangkottai, Thanjavur, Tamil Nadu, India

PP Mahendran
Department of Crop Management, Kudumiyanmalai, Tamil Nadu, India

P Kannan
Department of Soils and Environment, AC & RI, Madurai, Tamil Nadu, India

Corresponding Author:
B Jeevitha
Department of Soils and Environment, AC & RI, Madurai, Tamil Nadu, India

Assessment of available sulphur status in major green gram growing blocks of Madurai district of Tamil Nadu and creation of thematic map using GIS

B Jeevitha, A Rathinasamy, PP Mahendran and P Kannan

Abstract
The study was conducted in major green gram growing blocks of Madurai district with a vision to assess the soil available sulphur status, since, sulphur plays a vital role in pulses crop production. Among thirteen blocks of Madurai district, pulses were grown predominantly in five blocks *viz.,* Thirumangalam, Usilampatti, T. Kallupatti, Sedapatti and Kalligudi according to their area, production and productivity. Two hundred and fifty soil samples were collected from green gram cultivating villages of those five major blocks. Overall soil available sulphur status in those five blocks ranged from 3.10 mg kg^{-1} to 18.20 mg kg^{-1} with a mean value of 10.65 mg kg^{-1}. Overall soil samples results were categorized, in this 67 per cent of soil samples found low in available sulphur status, 21 per cent of soil samples is medium status and 12 per cent of soil samples under high status. Among the five blocks, Thirumangalam block soil samples has registered high percentage of low available sulphur status (84%) which is followed by Usilampatti showed 82 percent low in available sulphur content. Simple correlation and multiple regression analysis were also done to determine the most influencing soil properties on available Sulphur, which inturn aids to ascertain the degree of relationship between them.

Keywords: Available sulphur, GIS approach, soil, green gram

Introduction
Pulses occupy a unique position in Indian farming as a sole crop, catch crop, cover crop, green manure and inter crop. Pulses recognized as a restorer of soil fertility by virtue of its ability to fix atmospheric nitrogen in the soil through root nodules. Green gram (*Vigna radiata* L.) attained its commercial importance in Indian agriculture. Green gram ranks third among all the pulses in India after chickpea and pigeonpea. It is grown in about 34.4 lakh hectares in India with total production of 14.00 lakh tonnes, with the productivity of 407 kg ha^{-1} (Koneni, 2015) [4]. It is rich in protein (24-25%). For green gram production, next to phosphorus, sulphur plays a key role in its production. Sulphur is essential in the structural and enzymatic components in plants. Sulphur is a key component of some essential amino acids and is needed for protein synthesis. Chlorophyll synthesis also requires S. Sulphur is not readily translocated within plants, so all plants need a continuous supply of sulphur from emergence to crop maturity. Therefore, in S-deficient plants, older leaves may appear more healthy, while newer leaves and tissue may have stunted growth and a lighter green or even yellow appearance. A sulphur deficiency at any growth stage can result in reduced crop growth and yield. Adequate S results in rapid crop growth and earlier maturity (Agri-facts, 2013) [1]. By knowing the importance of sulphur in green gram production, the present study was undertaken to assess the available sulphur status in green gram growing areas through GPS. Results obtained from this study will help to develop sulphur recommendation for green gram growing under sulphur deficient areas and which alleviate the sulphur deficiency and enhance the green gram yield.

Material and Methods
Study Area
Madurai district is situated in the south of Tamil Nadu state. It is bounded on the north by the districts of Dindigul., Thiruchirapalli and on the East by Sivagangai and on the west by Theni and south by Vridhunagar. It lies in north latitude between 9°30’ and 10°30’ and east latitude between 77°00’ and 78°30’.

The mean annual rainfall for the Madurai district is about 857.6 mm with the mean annual temperature of 28.8 °C. Madurai district comprises seven Taluks and thirteen blocks. Among them, five are major green gram growing blocks viz., Thirumangalam, Usilampatti, T.Kallupatti, Sedapatti and Kalligudi. The thematic map for the study area are given in the Figure 1.

Collection of soil samples

A total of 250 samples were collected from predominantly green gram growing villages in majorly green gram cultivated blocks of Madurai district (Thirumangalam, Usilampatti, T.Kallupatti, Sedapatti and Kalligudi). Each block, fifty soil samples were collected from selected villages by using GPS – Garmin Etrex Vista HCX model.

Analysis of soil analysis

The collected soil samples were air-dried, ground and sieved through 2-mm sieve (0.2 mm sieve for organic carbon), labeled and stored. The samples processed were analyzed for chemical parameters *viz.,* pH and $CaCO_3$ (Piper method, 1966) [10].

Available sulphur analysis

Available sulphur was analyzed by 0.15 per cent $CaCl_2$ extraction method (Williams and Steinbergs, 1959) [17] at 420 nm. Based on analytical results, the soil samples were categorized as low (<10 mg kg^{-1}), medium (10 – 15 mg kg^{-1}) and high (> 15 mg kg^{-1}) according to critical level of available sulphur.

Statistical and Spatial Analysis

The Pearson correlation coefficients were estimated for all possible paired combinations of the response variables to generate a correlation coefficient matrix. These statistical parameters were calculated with SPSS 16.0® software (SPSS Inc., Chicago, III., USA). In this research, the study area is wrested from the base map, the GPS points and values (chemically analysis results) are coupled. The location of sampling sites was fed into the GIS environment and digitized using ArcGIS-10 software, they are validated for digitization errors, polygonized and finally transformed in to thematic map (Krige, 1951) [3].

Results and Discussion

Soil physico-chemical properties

The overall mean of pH in soils of green gram growing blocks in Madurai district ranged from 6.09-8.88 with a mean of 7.49 representing that the soils are ranging from acidic to strongly alkaline in soil reaction (Table.1). The interpretations on pH of soils indicated that 4 per cent samples were slightly acidic (6.0 – 6.5), 19.6 per cent showed neutral, 66.4 per cent found mildly alkaline to alkaline (7.4 – 8.4) and 10 per cent samples represented strongly alkaline (8.5 – 9.0). Relatively higher pH of the soils might be owing to the higher degree of base saturation in the soils. Similar findings were reported by Waghmare *et al.* (2008) [15] and Singh *et al.* (2014) [14].

The electrical conductivity (EC) of the soil indicates total soluble salts concentration. The EC of the soil indicated in Table 1, ranged from 0.02 to 2.08 dS m^{-1} with a mean of 1.05 dS m^{-1}. According to Bali *et al.* (2010) [2], soils having EC of < 0.80 dS m^{-1} are categorized under non-saline soil. The overall results showed that 92.8 per cent soils are non-saline and 7.2 per cent of samples were found under saline classification. The non-saline nature of a major per cent of the soil samples might be due to proper management and inherent properties of soil. The results are found similar to the findings of Sharma *et al*. (2008) [13].

Organic Carbon

The overall organic carbon content in the soils ranged from 0.03 to 0.54 per cent with a mean value of 0.29 per cent signifying that the soils of green gram growing areas are medium in its status (Table.1). About 98.8 per cent of the soil samples were under low status (<0.50%), rest of the 1.2 per cent samples indicated medium status (0.50 – 0.75%) and none of the soil samples found in high status (>75%). The results are categorized under low, medium and high as per the organic carbon fertility rating reported by Muhr *et al.* (1965) [8]. Major per cent of soil samples were found low in organic carbon content which might be primarily due to high temperature leading to higher rate of organic matter decomposition which furtherly leads to extreme high oxidation conditions (Kameriya, 1995) [7] and also due to little or no organic matter additions (Rego *et al.* 2003) [12].

Free $CaCO_3$

The overall percentage of $CaCO_3$ in soils of major green gram growing blocks were found 70.8 per cent which comes under non-calcareous nature and remaining 29.2 per cent showed calcareous nature as per the rating limit suggested by FAO (1973) [5]. The range of $CaCO_3$ indicated in Table 1. varied from 2.04 to 6.48 with a mean value of 4.26 (non-calcareous). The lesser or non-calcareous nature of the soils might be due to the presence of powdery form of $CaCO_3$ and hyper hermic temperature regimes (Sharma *et al.,* 2008) [13]. Calcareous nature in soils might be due to water scarcity which may leads to less leaching or no leaching of insoluble salts which further might facilitate the deposition of $CaCO_3$ (Qadir *et al.,*1996) [11].

Available Sulphur

The critical level of available sulphur in soil is 10 mg kg^{-1}. The range and mean values of
soil sulphur for major green gram growing blocks are listed in Table 2. Available sulphur content varied from 3.10 to 16.10, 3.20 to 16.20, 3.80 to 17.20, 3.40 to 16.80, 3.70 to 18.20 mg kg^{-1} with corresponding mean values of 9.60, 9.70, 10.50, 10.10 and 10.95 mg kg^{-1} in Thirumangalam, Usilampatti, T. Kallupatti, Sedapatti and Kalligudi blocks respectively. The results represented that Thirumangalam, Usilampatti, T.Kallupatti, Sedapatti and Kalligudi block soil samples has registered low sulphur status as 84, 82, 58, 60 and 50 per cent respectively. Among the five blocks, the overall sample mean values of Thirumangalam (9.60 mg kg^{-1}) and Usilampatti (9.70 mg kg^{-1}) observed below critical level whereas remaining three blocks *viz.,* T.Kallupatti, Sedapatti and Kalligudi having 10.50, 10.10 and 10.95 mg kg^{-1} mean data respectively indicated medium in available sulphur status. By combining those five major green gram growing blocks, the results registered that 67, 21 and 12 per cent as low, medium and high respectively in sulphur status. The overall five block sulphur content ranged from 3.10 to 18.20 with a mean value of 10.65 which has showed a medium (10-15 mg kg^{-1}) sulphur fertility rating. Low sulphur fertility rating in soils might be due to unawareness among pulses growing farmers about the importance of sulphur nutrient and fertilizer in pulses production that leads to not applying of sulphur fertilizer to the crop. High sulphur rating in soils could be due to the continuous addition of S containing agrochemicals which

contain sufficient amount of S to meet the requirement of the growing plants (Patel and Patel, 2008) [9].

Inter-relationship with other soil properties

To measure the influence of soil properties *viz.,* pH, EC, OC and free CaCO3 on available sulphur, the correlation studies have been worked out in Table 3. The correlation studies revealed that the sulphur content in the soil was negatively correlated with the soil parameters viz. pH (r = -0.723**), EC (r = -0.135*), free $CaCO_3$ (r = -0.657**) and positively with OC (r = 0.506**). It infers that there is an increase in available sulphur content with an increase in organic carbon content of the soil.

Thematic maps

The thematic maps were generated at village level in five major green gram growing blocks of Madurai district to depict the available Sulphur status in those areas based on soil analytical results. The available soil sulphur status in five major green gram growing blocks of Madurai district is given in the Figure. 2, 3, 4, 5 and 6.

Conclusion

It can be concluded that the soils are low to medium in available sulphur content. The study results revelaed that the sulphur availability decreases with increase in pH, EC, free CaCO3 content and increases with increase in organic carbon content. Hence, in order to increase the sulphur content in soil and to meet out the crop requirement, adoption of soil test crop response based integrated plant nutrition system (STCR-IPNS) to pulse crops would enhance the crop productivity. And also, sulphur free fertilizers have to be substituted with sulphur containing fertilizers. Regular application of organic amendments to the organic carbon deficient soil are also recommended to enhance it. The georeferenced sampling sites can be revisited with the aid of GPS which further helps in montoring the soil fertility changes that takes place in the agricultural field over long run. It would be valuable soil resource information to the researchers, farmers, State Department of Agriculture and extension workers.

Table 1: Range and mean values of the soil properties in major green gram growing blocks of different blocks of Madurai district

Sl. No.	Name of the blocks	Soil properties			
		pH	EC (dS m-1)	Organic. C (per cent)	Free CaCO3 (per cent)
1	Thirumangalam	6.72-9.30 (8.01)	0.02-1.42 (0.72)	0.50-5.26 (2.88)	2.04-6.25 (4.15)
2	Usilampatti	7.45-8.88 (8.12)	0.03-0.41 (0.22)	0.31-5.21 (2.77)	2.86-6.25 (4.80)
3	T. Kallupatti	7.51-8.60 (8.01)	0.11-2.08 (1.10)	0.62-4.20 (2.46)	2.92-6.48 (4.70)
4	Sedapatti	6.62-8.65 (7.64)	0.06-1.48 (0.77)	1.02-5.42 (3.22)	2.16-6.38 (4.27)
5	Kalligudi	6.09-8.41 (7.25)	0.10-0.84 (0.47)	0.51-4.30 (2.41)	2.09-5.72 (3.91)
Overall Mean		6.09-8.88 (7.49)	0.02-2.08 (1.05)	0.31-5.42 (2.87)	2.04-6.48 (4.26)

( ) values in parentheses indicate the mean values

Table 2: Range and mean values of soil available sulphur in major green gram growing blocks of different blocks of Madurai district

S. No	Block name	$CaCl_2$ –S (mg kg^{-1})			Fertility rating
		Min.	Max.	Mean	
1	Thirumangalam	3.10	16.10	9.60	Low
2	Usilampatti	3.20	16.20	9.70	Low
3	T. Kallupatti	3.80	17.20	10.50	Medium
4	Sedapatti	3.40	16.80	10.10	Medium
5	Kalligudi	3.70	18.20	10.95	Medium
	Overall Mean	3.10	18.20	10.65	Medium

< 10 mg kg^{-1} – Low; 10 – 15 mg kg^{-1} – Medium; > 15 mg kg^{-1} – High

Table 3: Simple correlation on available sulphur with soil properties in major green gram growing soils of Madurai district

	pH	EC	OC	Free $CaCO_3$	Av. S
pH	1				
EC	0.199**	1			
OC	-0.465**	-0.104	1		
Free $CaCO_3$	0.823**	0.123	-0.527**	1	
Av. S	-0.723**	-0.135*	0.506**	-0.657**	1

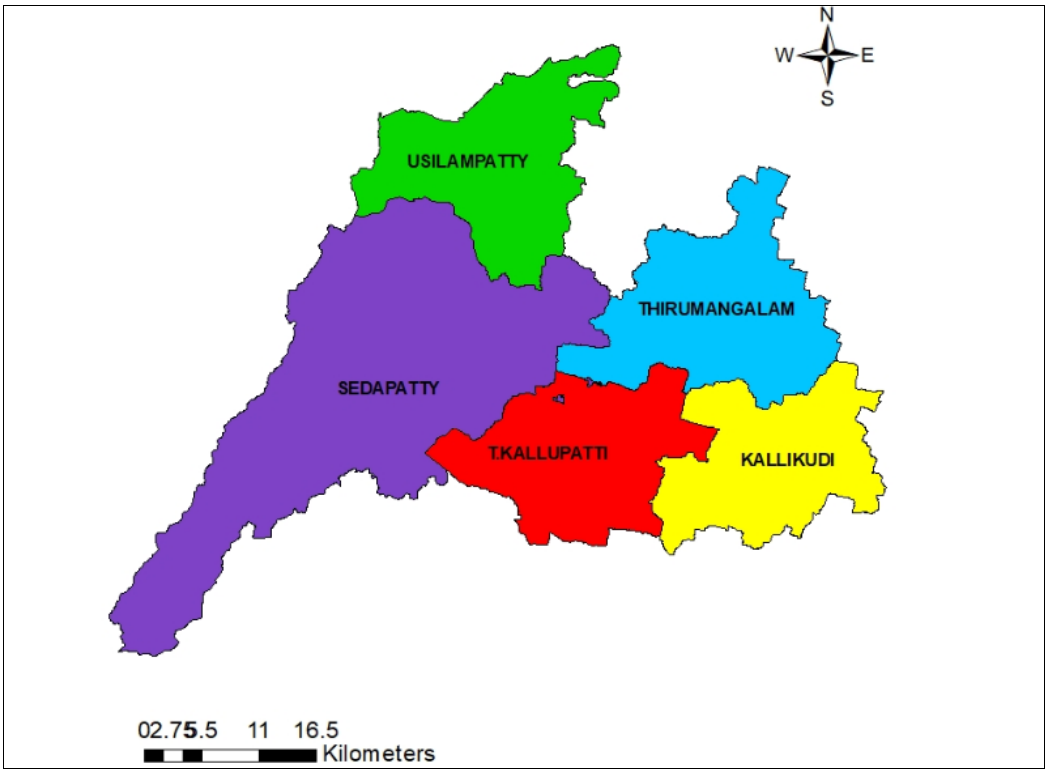

Fig 1: Study area Map

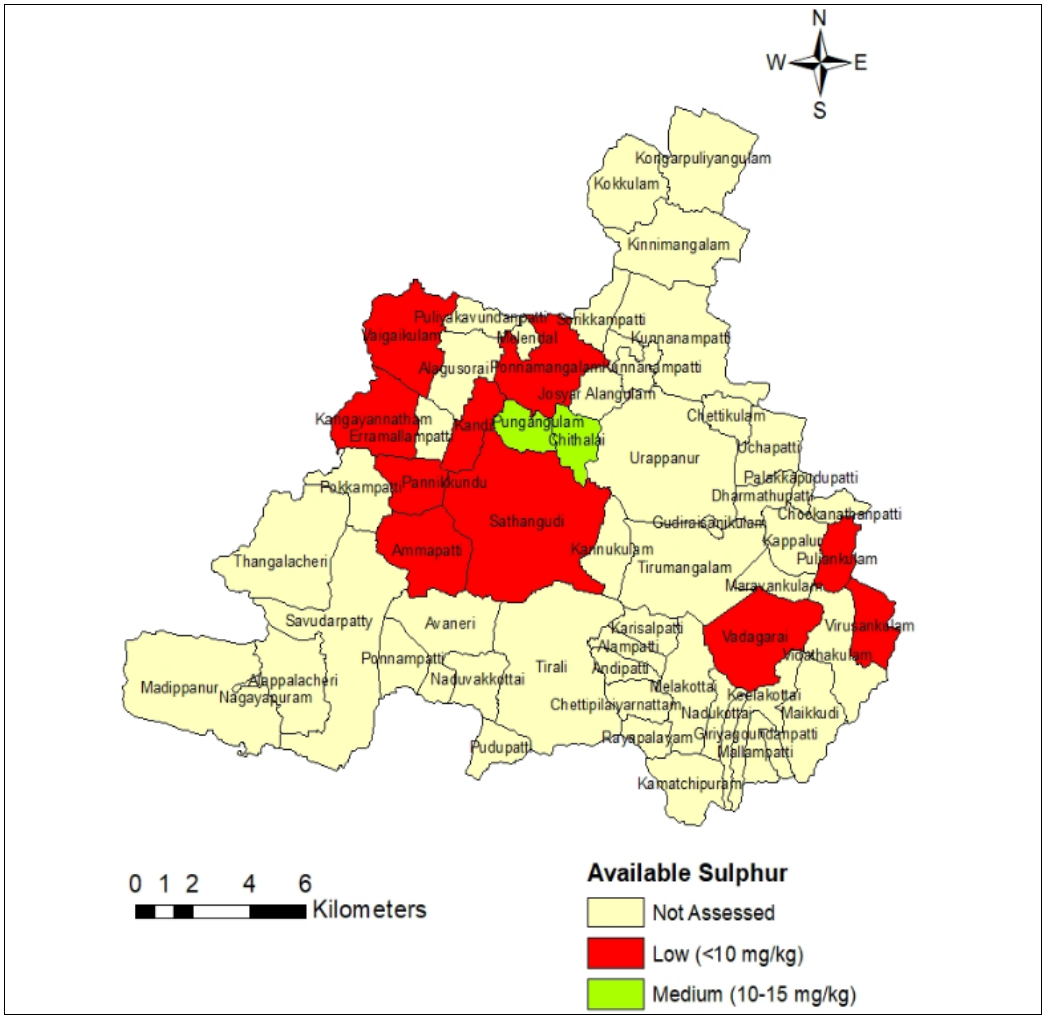

Fig 2: Available sulphur status of major green gram growing areas in Thirumangalam block of Madurai district

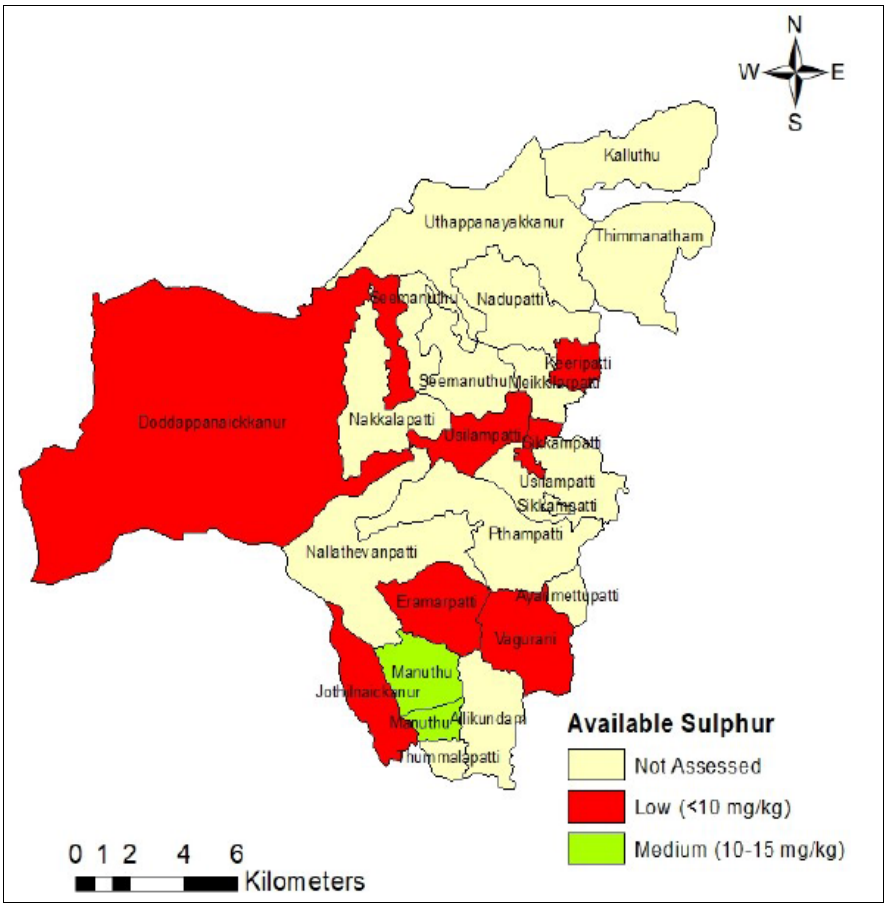

Fig 3: Available sulphur status of major green gram growing areas in Usilampatti block of Madurai district

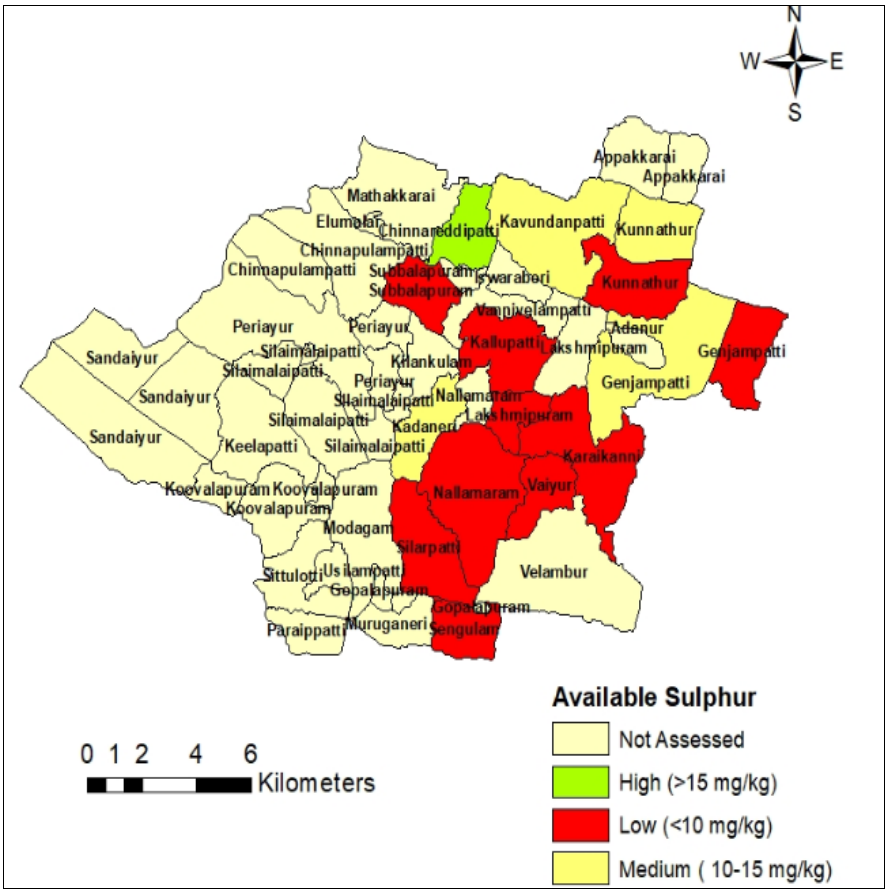

Fig 4: Available sulphur status of major green gram growing areas in T.Kallupatti block of Madurai district

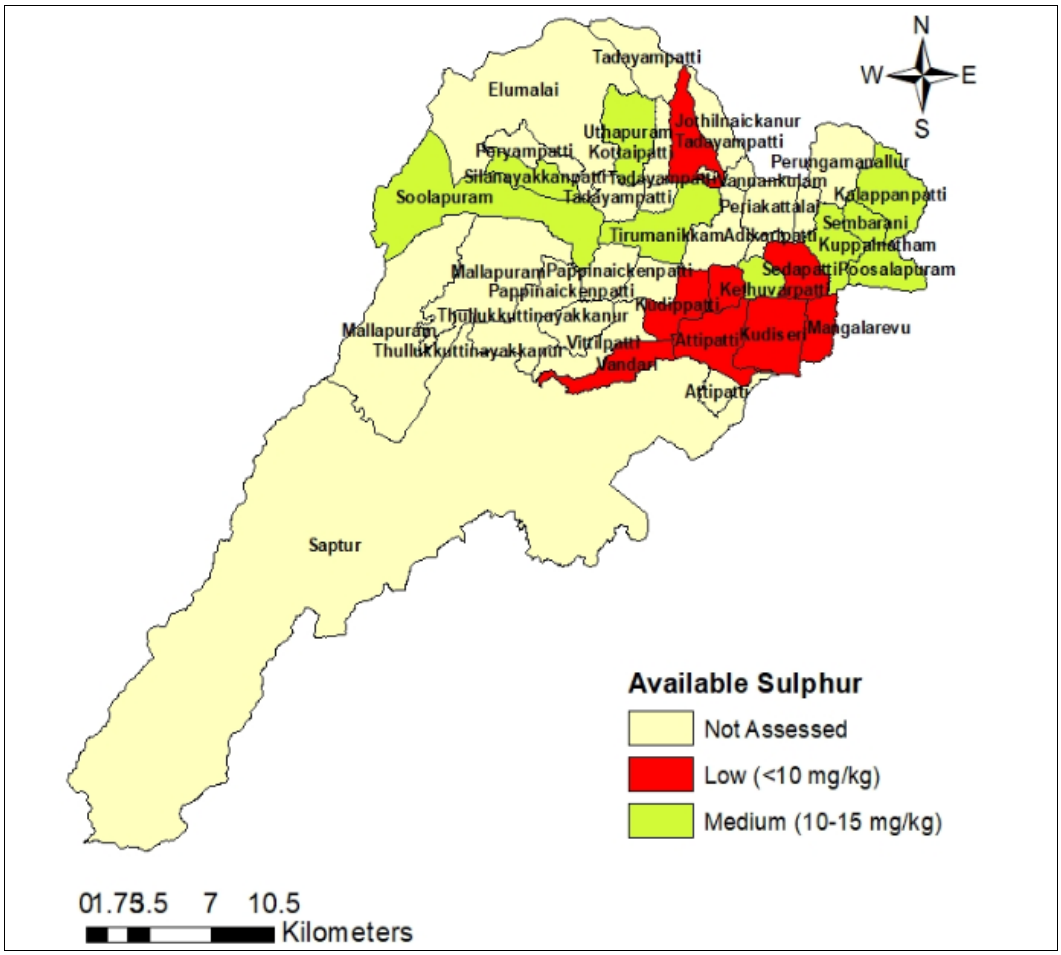

Fig 5: Available sulphur status of major green gram growing areas in Sedapatti block of Madurai district

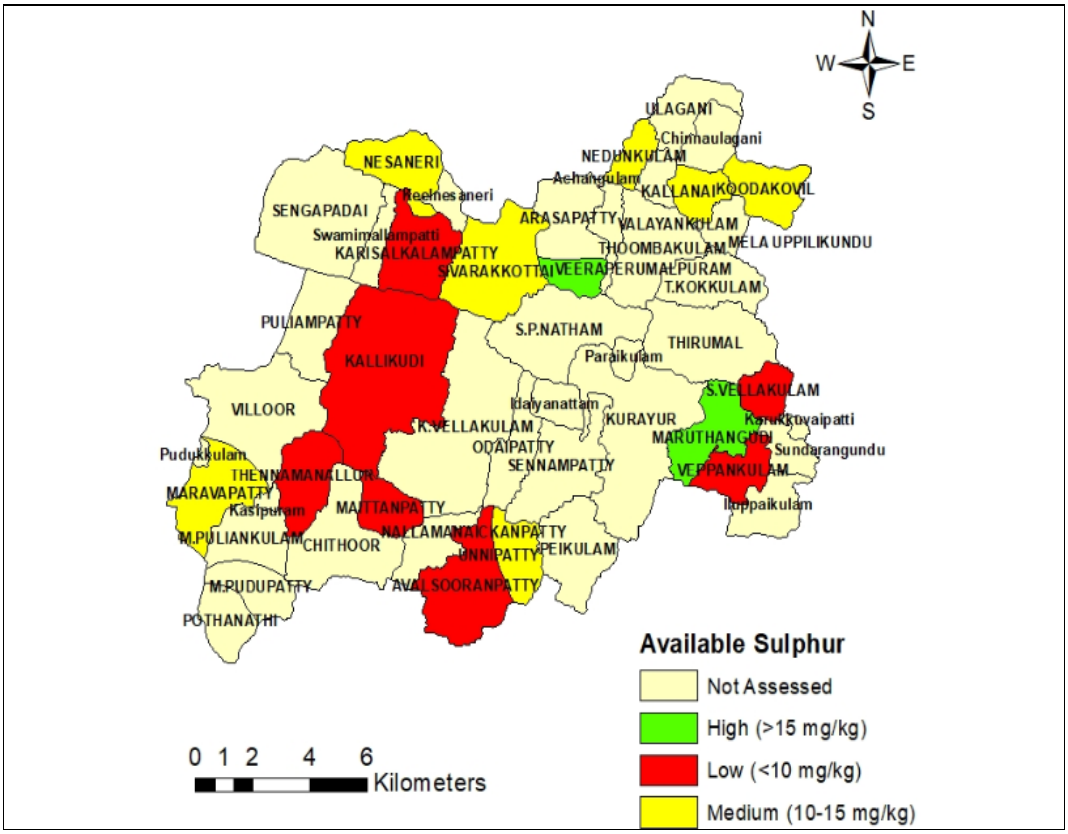

Fig 6: Available sulphur status of major green gram growing areas in Kalligudi block of Madurai district

References

1. Agri-Facts. Sulphur Fertilizer Application in Crop Production, 2013, Agdex 542-10.
2. Bali SK, Kumar R, Hundal HS, Singh K, Singh B. GIS aided Mapping of DTPA Extractable Zinc and soil characteristics in the status of Punjab. J Indian Soc. Soil Sci. 2010; 58(2):189-199.
3. Krige DE. A statistical approach to some basic mine valuation problems on the Witwatersr Journal of the Chemical, Metallurgical and Mining Society of South Africa. 1951; 52:119-139,
4. Koneni S. Sunanda Moka, Shinde, V.S, Kote, G.M. Nutrient uptake, quality and economics of green gram (*Vigna radiata* L.) as influenced by phosphorus management. Annals of Plant and Soil Research. 2015; 17:241-244.
5. FAO. Food and Agriculture Organization of the United Nations (FAO): Calcareous soils: Report of the FAO/UNDP regional seminar on reclamation and management of calcareous soils (FAO Soils Bulletin 21). Cairo, Egypt, 1973.
6. Jackson ML. Soil Chemical Analysis. Advance Course, University of Wisconisn, Madison, 1973.
7. Kameriya PR. Characterization of soils of agro climatic zone of transitional plain of inland drainage (Zone II-A) of Rajasthan, Ph.D. Thesis, R.A.U., Bikaner, 1995.
8. Muhr GR, Datta NP, Sankarasubramani H, Leley VK, Donahue RL. Soil testing in India. 2nd Ed. USAID Mission to India, New Delhi, 1965.
9. Patel JC, Patel KC. Profile distribution of different forms of sulphur in prominent soil series of south Gujarat. An Asian Journal of Soil Science. 2008; 3:24-29.
10. Piper C. Soil and plant analysis. University of Adelaide, Australia: Hans Publishers, Bombay, India, 1966.
11. Qadir M, Qureshi R, Ahmad N, Ilyas M. Salt-tolerant forage cultivation on a saline-sodic field for biomass production and soil reclamation. Land Degradation and Development. 1996; 7(1):11-18.
12. Rego TJ, Rao VN, Seeling B, Pardhasaradhi G, Kumar Rao JVDK. Nutrient balances a guide to improving sorghum and groundnut based dry land cropping systems in semiarid tropical India. Field Crops Research. 2003; 81:53-68.
13. Sharma Y, Singh B, Upadhyay S. Advancements in development and characterization of biodiesel: A Review. Fuel. 2008; 87(12):2355-2373.
14. Singh YP, Raghubanshi BPS, Tomar RS, Verma SK, Dubey SK. Soil fertility status and correlation of available macro and micronutrients in Chambal region of Madhya Pradesh. Journal of the Indian Society of Soil Science. 2014; 62(4):369-375.
15. Waghmare MS, Indulkar BS, Mali CV, Takankhar VG, Bavalgave VG. Chemical properties and micronutrients status of some soils of Ausa tehsil of Latur, Maharashtra. An Asian Journal of Soil Science. 2008; 3**:**236-241.
16. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil science. 1934; 37(1):29-38.
17. Williams C, Steinbergs H. Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. Australian Agricultural Research. 1959; 10:340-352.s