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Soil fertility mapping by geographical information system (GIS) in different blocks of Gariaband district, Chhattisgarh

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Abstract
Soil fertility mapping of the district, grid based 546 soil samples were taken from 91 selected villages (13 % of total 911villages) covering entire district using Simple Random Sampling without Replacement (SRSWOR). From each selected village, six farmers {(two of each category) *viz.* large (>3ha), medium (1-3 ha), and small (<1ha)} were selected for sampling. Among the different methods of spatial interpolation of soil properties, kriging method was followed which is an optimal interpolation method. Kriging is a widely used method of geo-statistical interpolation that assumes no regional trend exists in the data.

The soil pH ranged from 5.4 – 7.6 and 80 percent of the soil samples were categorized under slightly acidic to neutral range which is suitable for all major crops of the district. Among the different soil parameters tested under study which recorded for fertility mapping of the district. Based on the total soil samples analyzed in the range and mean values shown in parenthesis for organic C as 0.21- 0.76 (0.50 %), available N as 100 - 376 (260 kg ha^{-1}), available P as 3.9 - 35.0 (15.9kg ha^{-1}), available K as 112 - 482 kg ha^{-1}(314 kg ha^{-1}), available Ca status as 1032 to 6384 (3893 kg ha^{-1}), available Mg as 269-2882(1261 kg ha^{-1}), available S as 7.56–92.12 (33.96kg ha^{-1}), DTPA extractable Zn content as 0.04 -1.68 (0.75mgkg^{-1}), DTPA extractable Fe content as 3.30 to 57.54 (26.05 mg kg^{-1}), DTPA extractable Cu as 0.20 -10.32 (1.81 mg kg^{-1}), DTPA extractable Mn as 0.68 - 61.66 (30.15 mg kg^{-1}) and hot water extractable B as 0.31 - 1.71 (0.77 mg kg^{-1}). The fertility ratings categorized based on nutrient index value for different parameters were recorded as low for organic C and available N, medium for available P, S, Zn and B and high ratings for available K, Ca, Mg, Fe, Cu and Mn status.

The block wise statuses of different soil parameters were also monitored in details.

It was estimated that 18.6 % of the total cultivable area (0.270 lakh ha) of the district was found to be under moderately acid soil, 0.582 lakh ha area under low organic C level. More than 70 % area (1.031 lakh ha) with available N, 36% area (0.495 lakh ha) with available P, 30 % (0.436 lakh ha) with available S and 32% area (0.452 lakh ha) with available Zn were observed to be deficient and marked as productivity constraints which are required to manage for the optimum crop production.

Keywords: Geographic information system, Global positioning system, Soil fertility mapping, Soil fertility status

Introduction
Soil is the uppermost layer of variable depth of the earth consisting of loose material, which is the main support for natural vegetation and other life forms of our planet. Soil is an independent dynamic body of nature that acquires properties in accordance with the forces which act upon it. The important soil forming factors such as parent material, climate, relief, organism and time have direct impact on soil properties. The soil forming processes as oxidation, reduction, eluviations and illuviation are related to soil solution and further on stages of soil development (Tamgadge *et al.*, 2002) [3].

Crop yield is a function of many factors in which soil fertility is an important one and must be periodically monitored due to continuous crop removal of plant nutrients. In order to achieve higher productivity and profitability, it should be realized that fertility levels are periodically monitored to ensure balanced nutrition for high production level and soil health maintenance. The other trace elements like Fe, Cu, Mn, and B may be sufficient for low to medium production level but may starts limiting the crop growth at high level of crop production. The optimum crop yield can only be achieved when high yielding crop varieties are properly nourished i.e. all limiting nutrients are provided in correct amount and proper ratios. The use of plant nutrients in a balanced proportion is the prime factor for efficient fertilizer program. Balanced nutrient use ensures high production level and helps to maintain the soil health. Use of optimum dose of fertilizer in the agricultural field is the most important agricultural input for increasing crop production. Soil testing is now considered as an important tool for the recommendation of the fertilizers doses for various crops in India Soil fertility maps are meant for highlighting the nutrient needs, based on fertility status of soils (and adverse soil conditions which need improvement) to realize good crop yields. Obviously, a soil fertility map for a particular area can prove highly beneficial in guiding the farmers, manufacturers and planners (associated with fertilizer marketing and distribution) in ascertaining the requirement of various fertilizers in a season/year and making projections for increased requirement based on cropping pattern and intensity.

The recent technologies like GIS and GPS have much to offer for preparing soil fertility maps. Once the soil fertility maps are created, it is possible to transform the information from STCR model into spatial fertilizer recommendation maps. Several approaches have been used for fertilizer recommendation based on soil test so as to attain maximum yield per unit of fertilizer use. The targeted yield approach has been found popular in India. The theory of formulating optimum fertilizer recommendation for targeted yield was first given by Truog (1960) [4], which was further modified by Ramamoorthy *et al*., (1967) [2]. The targeted yield concept is based on quantitative idea of fertilizer need based on yield and nutritional requirement of the crop, per cent contribution of the available nutrient and applied fertilizer. This method not only estimates soil test based fertilizer doses but also the level of yields the farmers can achieve with that particular dose.

The application of fertilizer on the basis of soil test will not only considerably reduce the cost of inputs for fixed targeted yields but also help in balanced fertilizer application that will lead to better soil health and sustainable production. The fertilizer doses for targeted yield can be prescribed to the farmers by locating his field/area on the map with the help of latitude/longitude information. This also helps to monitor the changes in micronutrients status over a period of time as sampling sites can be revisited with help of GPS.

Materials and Methods

Location & District profile

Chhattisgarh state has been divided into three agro-climatic zones viz. Chhattisgarh plains, Plateau, and Northern hills zone covering 51, 28 and 21% of the geographical area, respectively. The location of the state is such that it is close to the Bay of Bengal, which is instrumental in bringing monsoon in the Northern part of the country. The state is comprised of 27 districts, bordered by Jharkhand and Uttar Pradesh in the north, Andhra Pradesh in the south, Orissa in the east and Madhya Pradesh and Maharashtra in the west. The state lies at 17°46' N to 24°5'N latitude and 80°15' E to 84°20' E longitude.

Gariyaband district is situated in the fertile plains of Chhattisgarh Region. This district is situated between 20º 57' N and 81º 53' E and at an altitude of 292 meters MSL. The Gariyaband district is surrounded by district Raipur, Mahasamund, Dhamtari and Orissa State in the East. The present investigation was carried in 91 villages out of 710 villages of five blocks (viz., Fingeshwar, Chhura, Gariyaband, Mainpur and Devbhog) in Gariyaband district of Chhattisgarh. (Fig. 1).

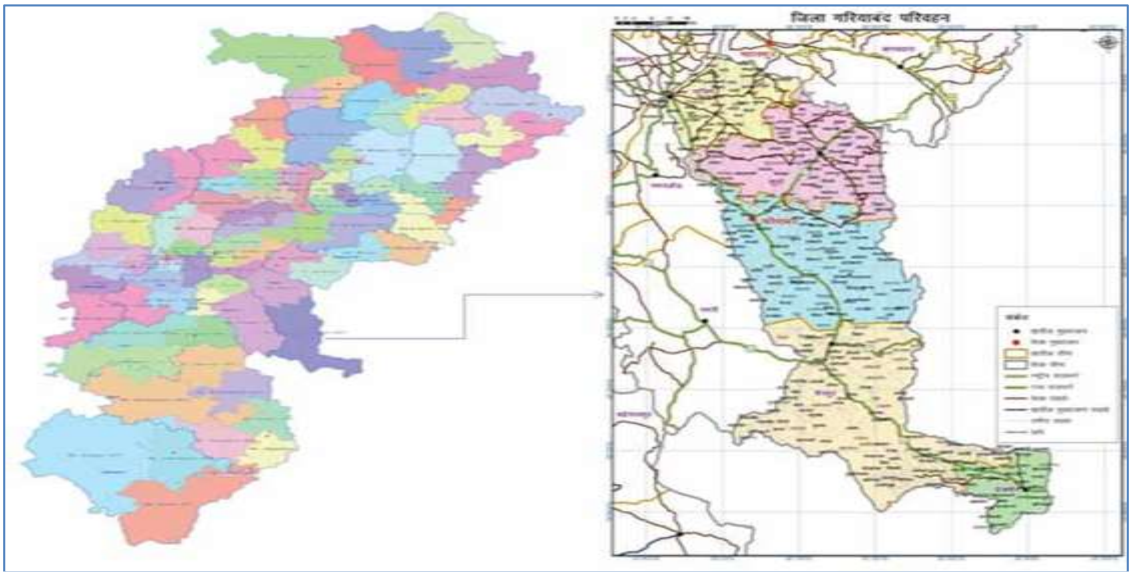

Fig 1: Location map of the study area

Sampling technique for fertility mapping Gariyaband district was considered as strata and about 12-15 % of the total villages were selected using Simple Random Sampling without Replacement (SRSWOR). From each selected village, six farmers {(two of each category) *viz.* large (>3ha), medium (1-3 ha), and small (<1ha)} were selected for sampling and other basic information about the farmers were collected. From each selected field, standard procedure of sampling was followed and sampled fields were located as latitude longitude position using GPS. Among the different methods of spatial interpolation of soil properties, kriging is an optimal interpolation method. This method has been reported by Singh *et al.*, (2009). Sampling point of district are indicated in Fig. 2.

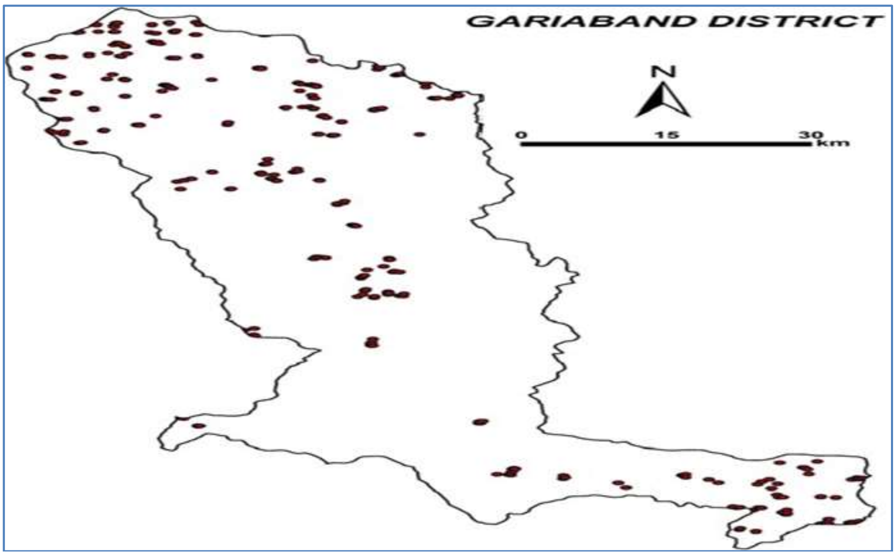

Fig 2: Distribution of sampling points in Gariyaband district

Result and Discussion

The results of the present investigations entitled "Soil Fertility Mapping by Geographical Information System (GIS) in different districts of Gariaband, Chhattisgarh." have been presented and discussed here with the help available published research work. The assessment of the soil fertility status of five blocks namely Fingeshwar, Chhura, Gariyaband, Mainpur, and Devbhog of Gariyaband district have been presented with the help of appropriate tables and illustrated through figures and maps. Furthermore, the soil's group under the study area has also been evaluated for profile characteristics and nutrient availability in respect of the major and micro elements. The soil test values recorded for the entire study area for fertility mapping and nutrient index figures were worked out for categorization of soils into different fertility status.

Soil fertility status

Total 91 villages of Gariyaband district were selected for sampling to represent the whole district, out of which 546 soil samples were analyzed for the assessment of soil fertility status of the district. Soil reactions (pH), soluble salt content (EC), organic carbon content, available major nutrients (N, P and K), secondary nutrients (Ca, Mg and S) and micronutrients (Fe, Mn, Cu, Zn, and B) were analyzed for their status and these parameters were transformed in to the fertility maps of the target district**.**

Descriptive statistics of soil parameters

The descriptive statistics of soil parameters are shown in Table 1 which suggested that they were all normally distributed. Kriging is a widely used method of geo-statistical interpolation that assumes no regional trend exists in the data. This method utilized the co-regionalization structure of soil properties and provided unbiased estimates and minimum variance (Ali and Malik, 2010) [1]. The available N, P and K varied from 100.35 to 376.32 kg/ha, 3.942 to 35.03 kg/ha and 18.42 to 482.16 kg/ha, respectively. The available micronutrients Cu, Fe, Mn, Zn and B range from 0.2 to 10.32, 3.3 to 57.54, 0.68 to 61.66, 0.04 to 2.84, and 0.31 to 1.71, respectively. The greatest and the smallest standard deviation were observed in the available potassium (84.45) and available phosphorus (6.225), respectively in case of macro nutrients. In case of micro nutrients, highest SD were found for Mn (12.59) whereas, it was lowest for Zn (0.447). Skewness is the most common form of departure from normality. If a variable has positive skewness, the confidence limits on the variogram are wider than they would otherwise be and consequently, the variances are less reliable. A logarithmic transformation is considered where the coefficient of skewnessis greater than one (Webster and Oliver, 2001) [5]

Table 1: Descriptive statistics of soil parameters (0-15 cm) depth of 546 soil samples

Parameters	Minimum	Maximum	Mean	Median	Std. dev.	Skewness	Kurtosis
N (kg/ha)	100	376	249	251	57	-0.085	2.36
P_2O_5 (kg/ha)	3.94	35.03	16.54	17.69	6.225	0.265	2.86
K_2O (kg/ha)	18.42	482.16	311.81	327.43	84.44	-0.574	3.41
*Cu (mg/kg)	0.20	10.32	1.84	1.64	1.20	2.909	17.57
Fe (mg/kg)	3.30	57.54	27.17	26.08	10.59	0.358	2.60
Mn (mg/kg)	0.68	61.66	31.10	30.56	12.59	0.085	2.30
*Zn (mg/kg)	0.04	2.84	0.81	0.68	0.44	2.108	8.29
* B (mg/kg)	0.31	1.71	0.73	0.68	0.22	1.801	6.90
* S (kg/ha)	7.56	89.32	33.50	29.24	16.072	1.089	3.95
Ca (kg/ha)	1032	6384	3898.3	3920	923.51	-0.21	3.00
Mg (kg/ha)	268.8	2881.6	1257.1	1176	476.95	0.404	2.68

*Non-normal variables

Thematic or Soil Fertility Maps

The thematic maps depicting the soil fertility status of Gariyaband District have been generated using sampling point data and by kriging. The maps pertaining to all the 14 chemical parameters are depicted in Figs 3 – 16.

With regard to soil pH, the soils are predominantly moderately acid and neutral. Out of the total geographical area 52.61 and 47.38 % of the area is under moderately acidic and neutral, respectively. In the case of EC, 100 % of the area is under non-saline and no area is reported under slightly saline and saline conditions. The organic carbon status was predominantly medium accounting to 74.52% of the total area followed by low (25.47%) and no area was found with high OC. With regard to available N, about 86.84% of the total area was predominantly under low category and only 13.15 % was under medium status and no high category was reported. In case of available P, the status was predominantly under medium representing 96.13% of the total area followed by low in 3.86 % of the area. With respect to available K was predominantly under medium representing 65.20% of the total area followed by low in 34.79 % of the area.

High content of available Ca and Mg were observed in whole area (100%). In case of sulphur, 63.15 % area of district comes under medium status followed by 26% area under high categories and only 10.43 % showed low sulphur status. As far as available micronutrients are concerned, Zn status was found to be sufficient in 96.22 and low level in 3.00 % of the area. In case of available Cu, high content was observed in whole area (100%). With regard to available Fe, predominantly high status was recorded in 99% of the area followed by moderate in 1%. In the case of available Mn also 98% area was covered with high Fe content followed by 2% under medium category.

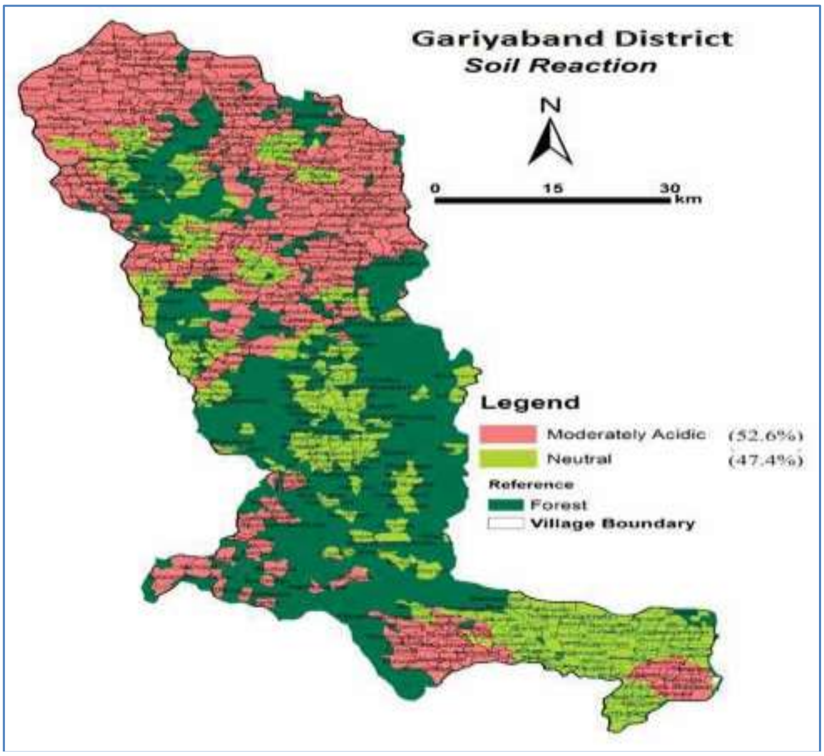

Fig 3: Status of Soil reaction (pH) in soils of Gariyaband district

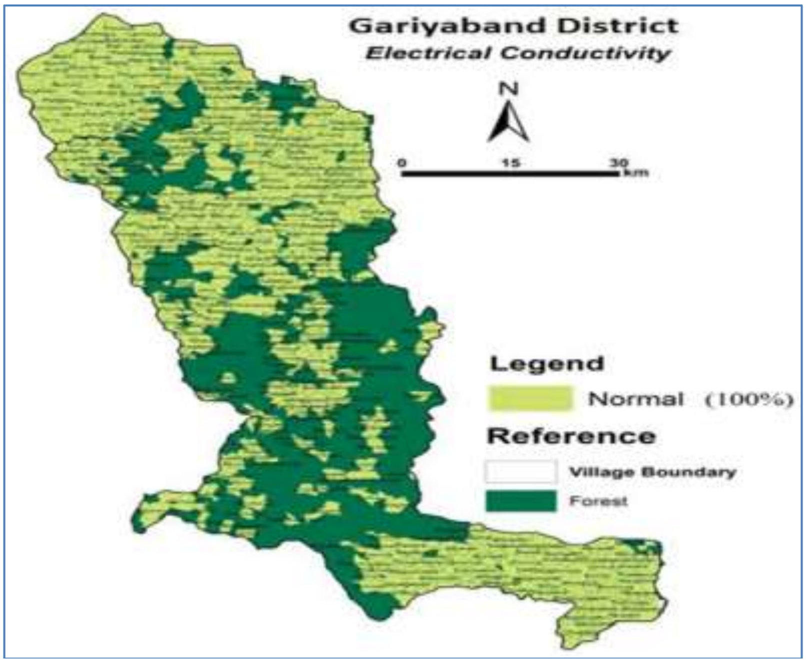

Fig 4: Status of Electrical Conductivity (dSm^{-}1) in soils of Gariyaband district

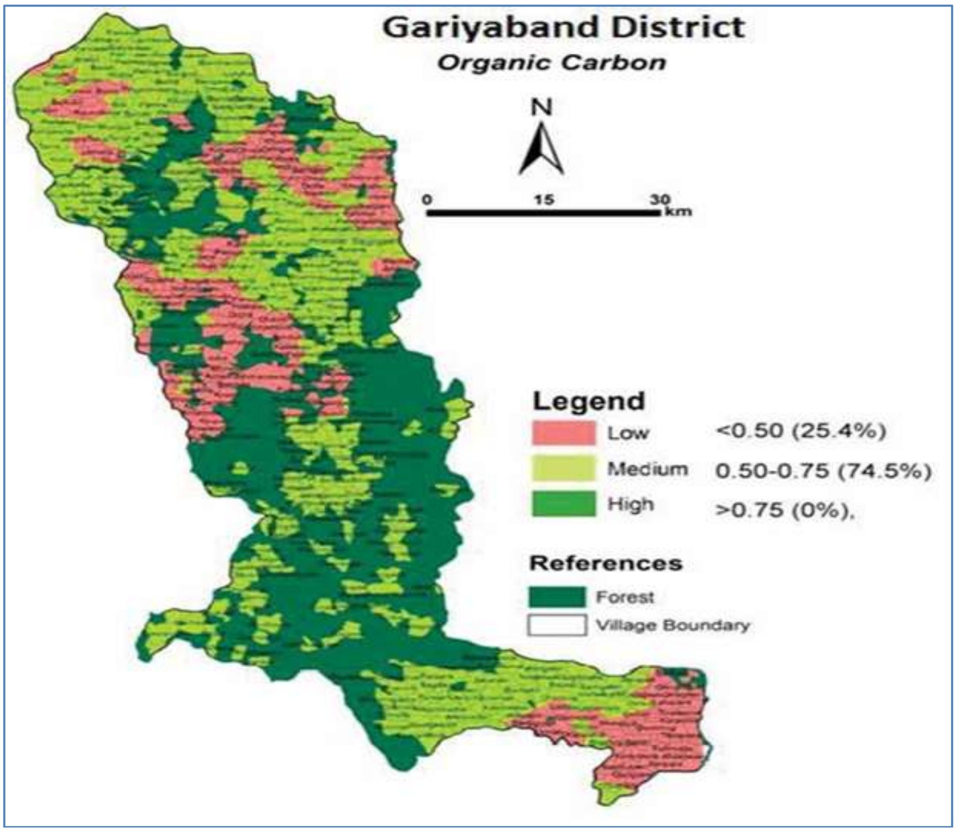

Fig 5: Status of Organic Carban (%) in soils of Gariyaband district

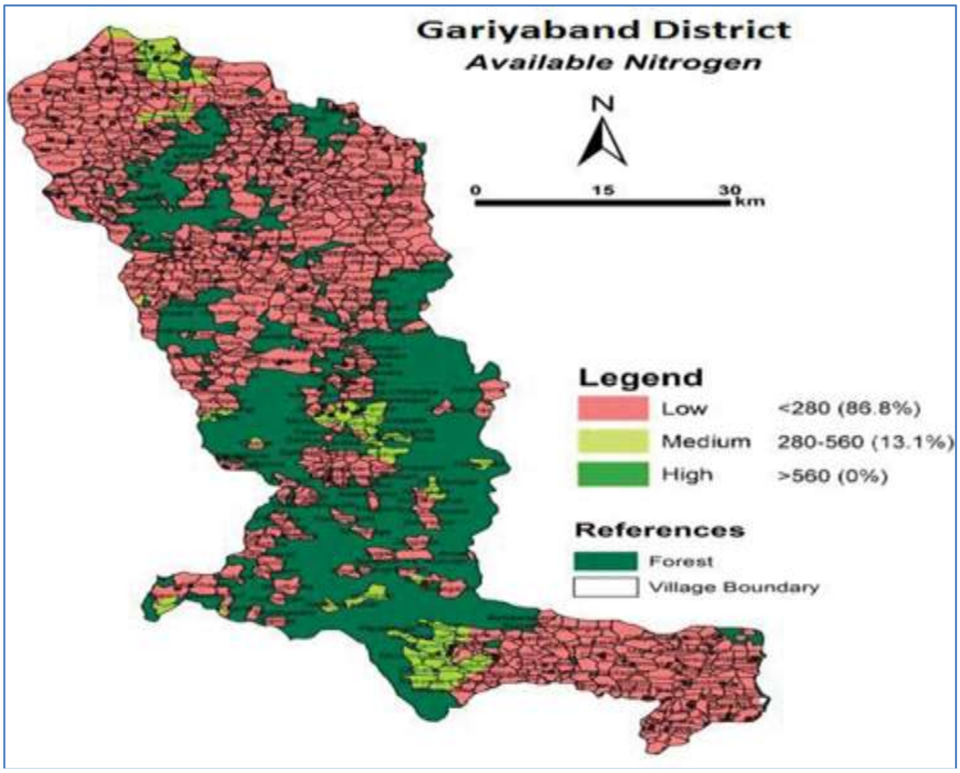

Fig 6: Status of available Nitrogen (kg ha^{-1}) in soils of Gariyaband district

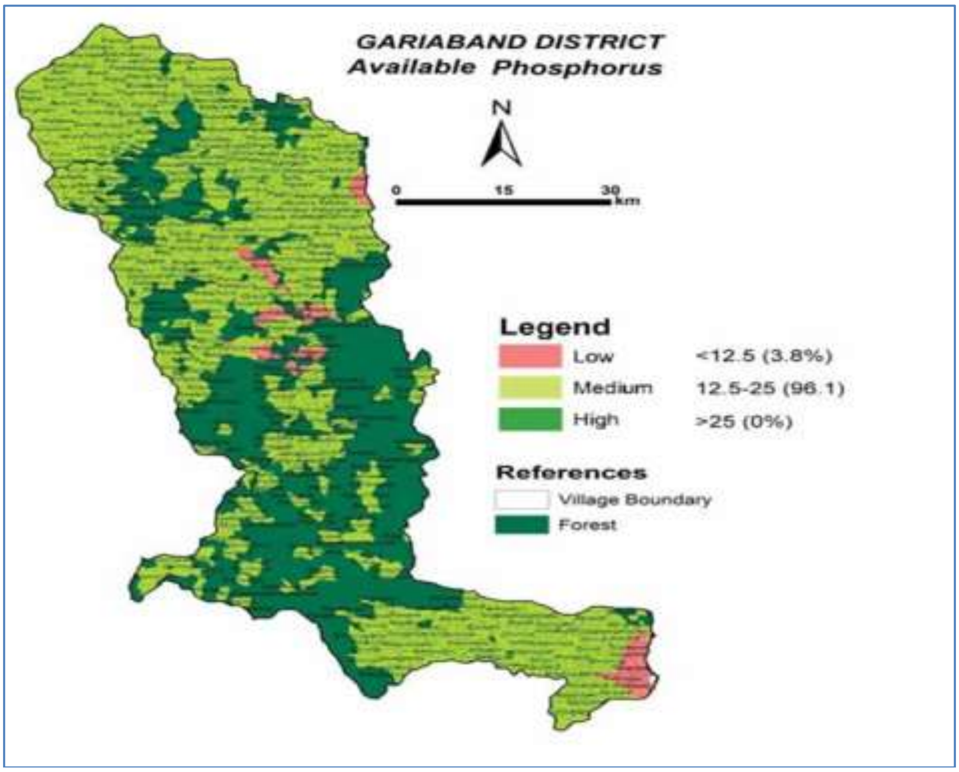

Fig 7: Status of available Phosphorus (kg ha^{-1}) in soils of Gariyaband district

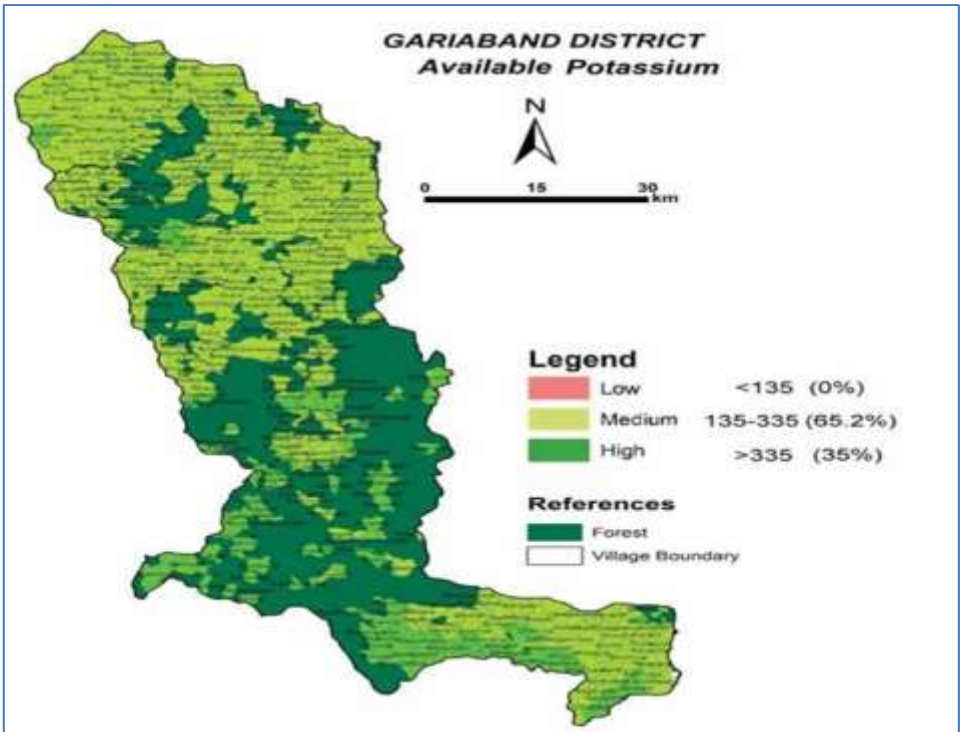

Fig 8: Status of available Potassium (kg ha^{-1}) in soils of Gariyaband district

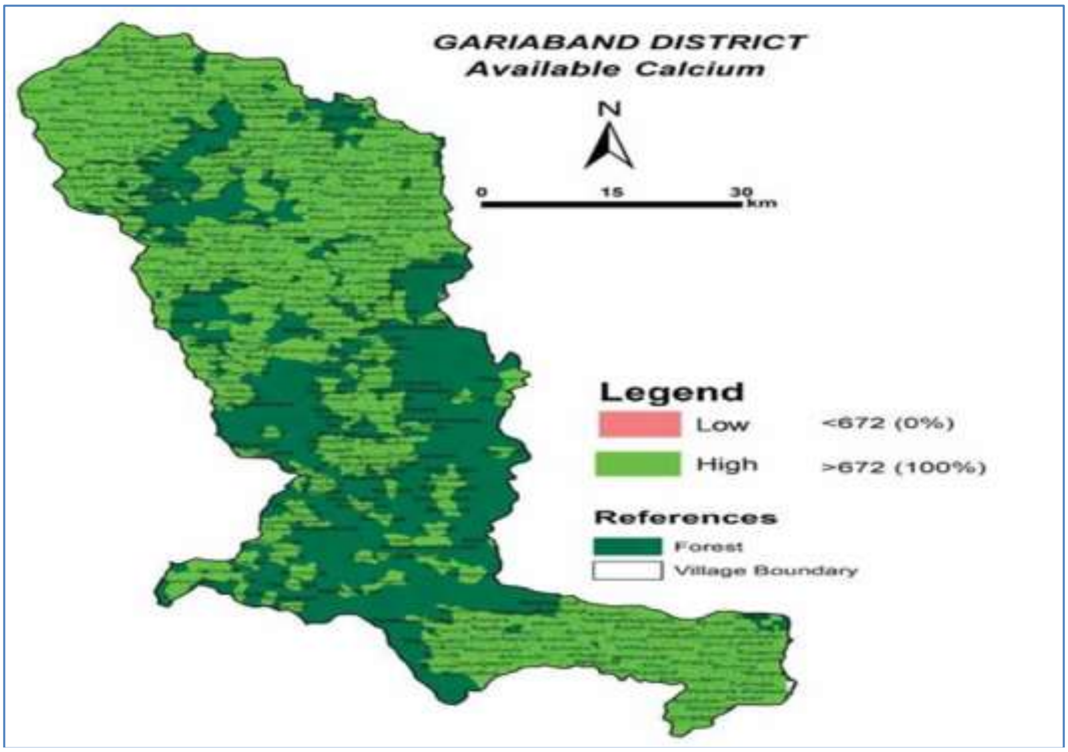

Fig 9: Status of available Calcium (kg ha^{-1}) in soils of Gariyaband district

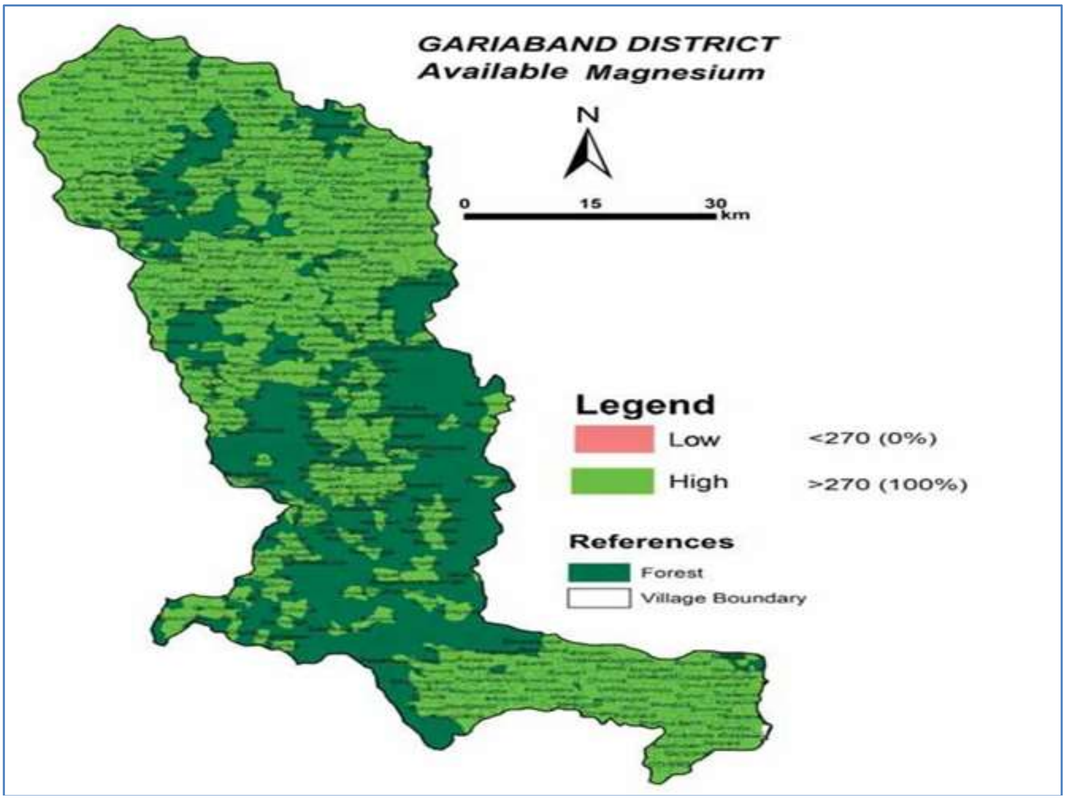

Fig 10: Status of available Magnesium (kg ha-1) in soils of Gariyaband district

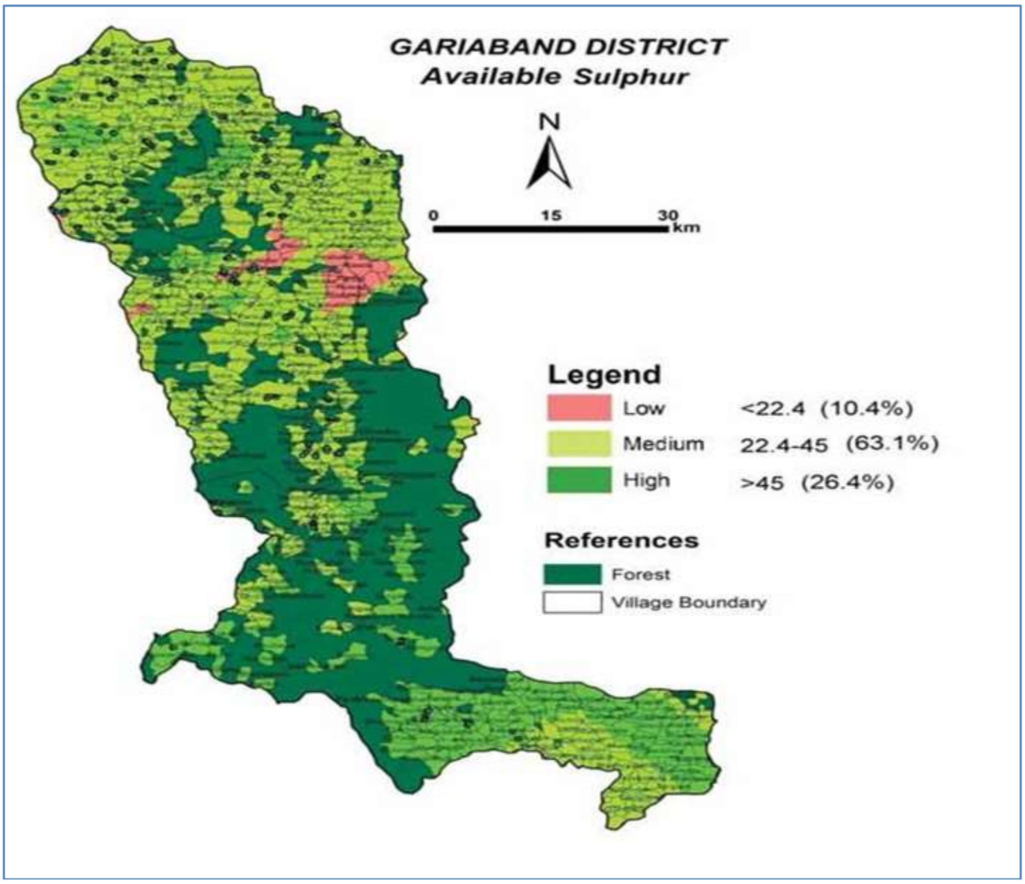

Fig 11: Status of available Sulphur (kg ha^{-1}) in soils of Gariyaband district

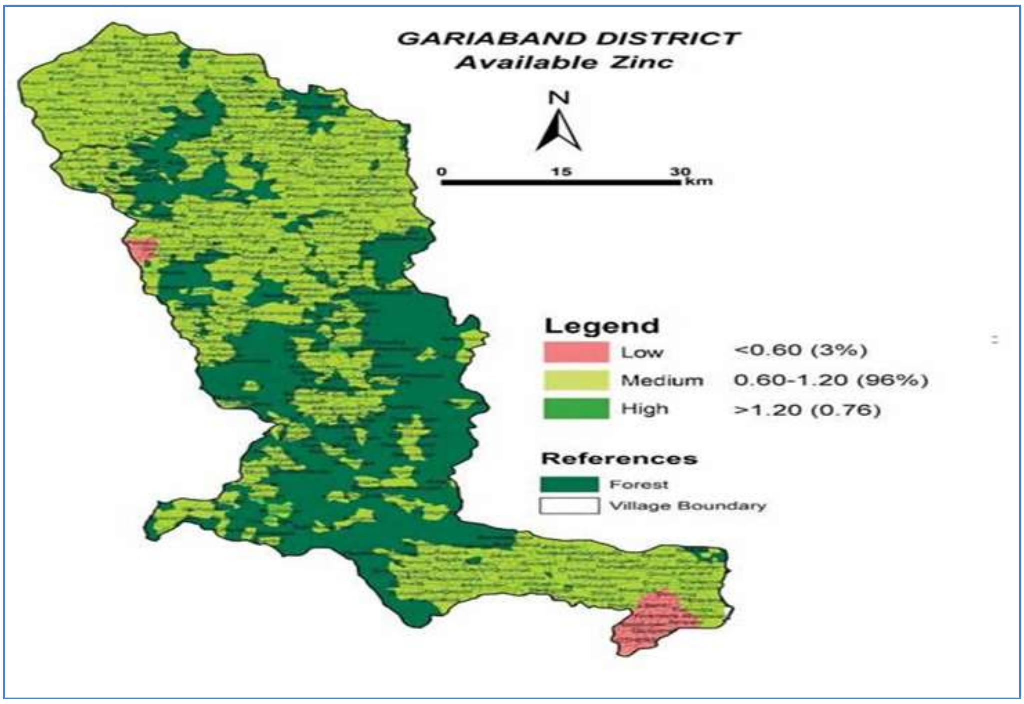

Fig 12: Status of available Zinc (mgkg $^{-1}$) in soils of Gariyaband district

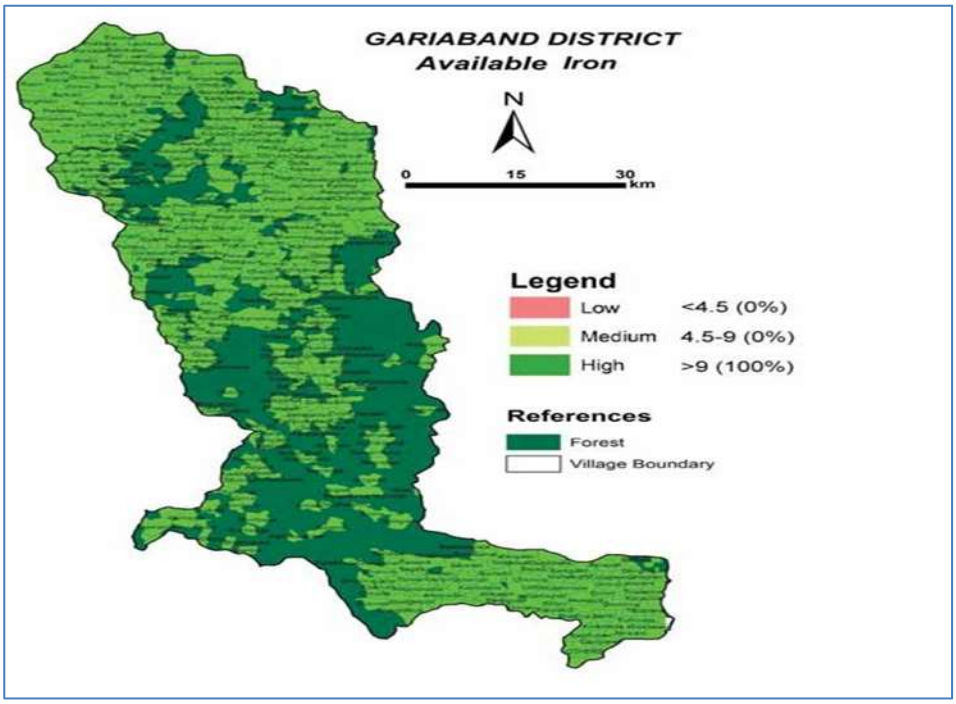

Fig 13: Status of available Iron (mgkg $^{-1}$) in soils of Gariyaband district

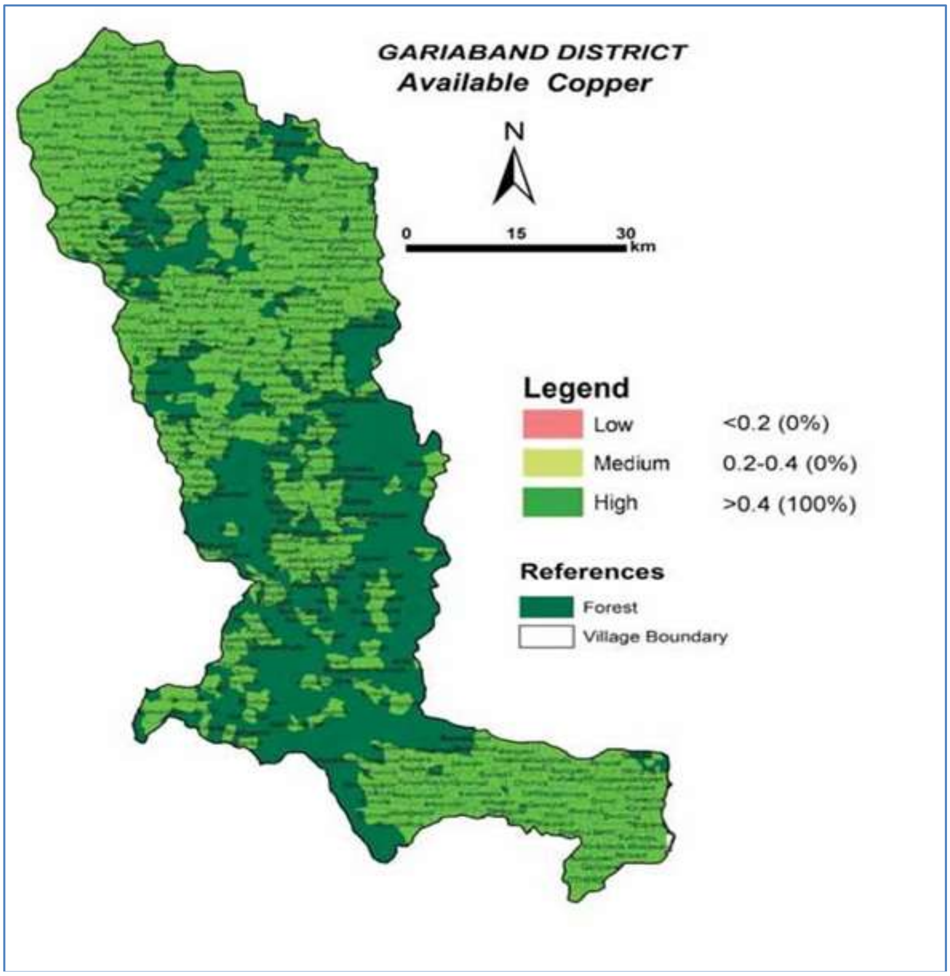

Fig 14: Status of available Copper (mg kg^{-1}) in soils of Gariyaband district

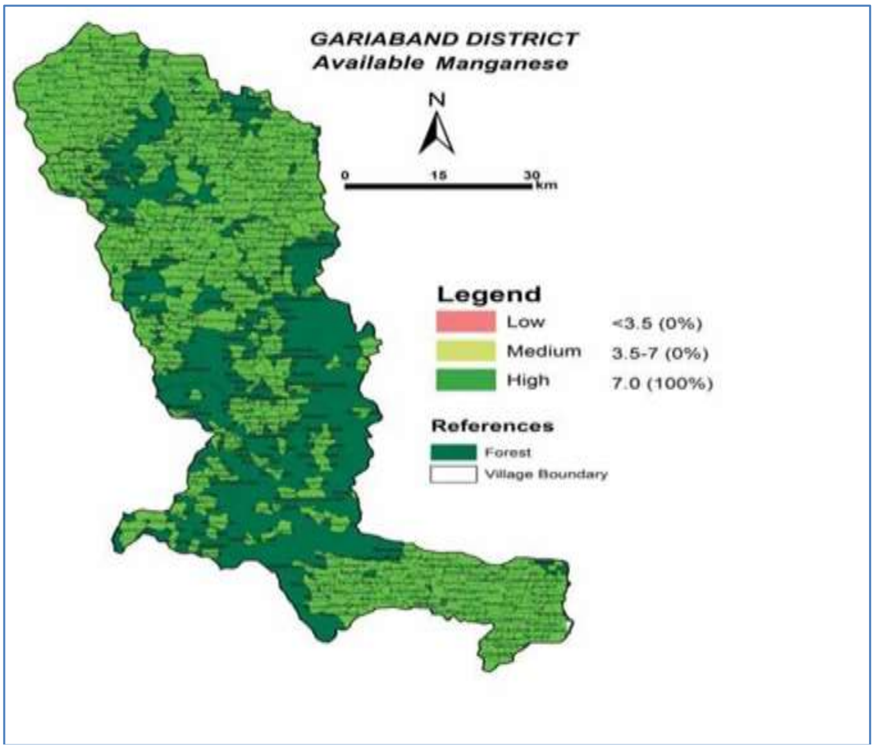

Fig 15: Status of available Manganese (mg kg^{-1}) in soils of Gariyaband district

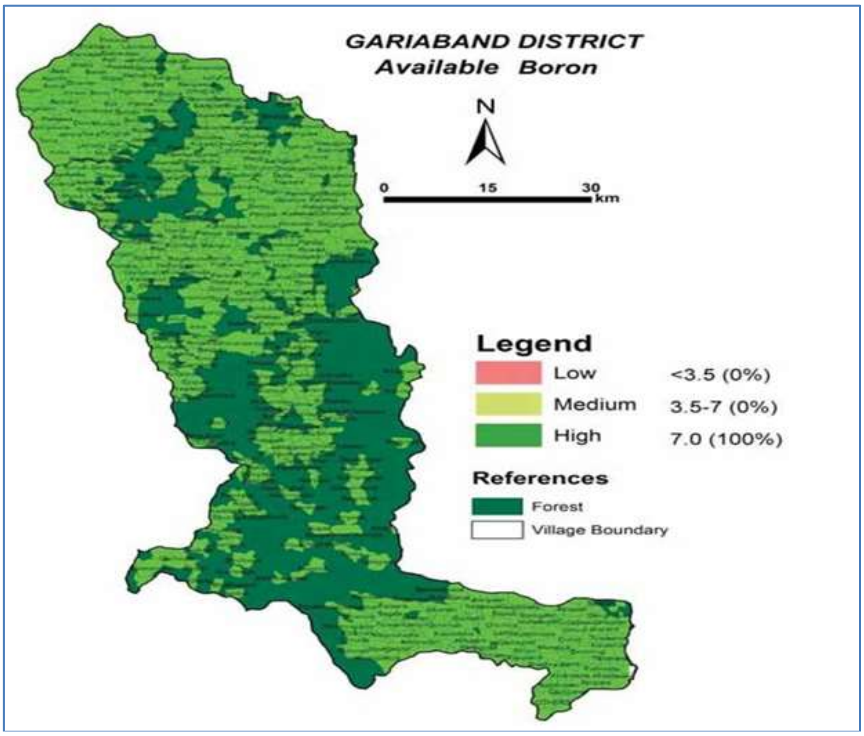

Fig 16: Status of available Boron (mg kg^{-1}) in soils of Gariyaband

Summary and Conclusions

Out of the total geographical area 52.61 and 47.38 % of the area was under moderately acidic and neutral, respectively. In the case of EC, 100 % of the area was under non-saline and no area was reported under slightly saline and saline conditions. The organic carbon status was predominantly medium accounting to (74.52%) of the total area followed by low (25.47%) and no area was found with high OC. In case of available N, about (86.84%) of the total area was predominantly under low category and only (13.15 %) was under medium status and no high category was reported. In case of available P, the status was predominantly under medium representing (96.13%) of the total area followed by low in (3.86 %) of the area. With respect to available K, it was predominantly under medium category representing (65.20%) of the total area followed by low in 34.79 % of the area.

High content of available Ca and Mg were observed in whole area (100%). In case of sulpher, (63.15 %) area of district comes under medium status followed by (26%) area under high categories and only (10.43 %) showed low sulpher status. As far as available micronutrients are concerned, Zn status was found to be sufficient in (96.22) and low level in 3.00 % of the area. In case of available Cu, high content was observed in whole area (100%). With regard to available Fe, predominantly high status was recorded in 99% of the area followed by moderate in (1%). In the case of available Mn also (98%) area was covered with high Fe content followed by 2% under medium category.

It is evident from the preceding results on status of various soil nutrients that six parameters were identified as productivity constraints and needs action plan for its rectification/re-storage for achieving optimum crop production. Based on the soil fertility evaluation and mapping, it was estimated that (18.6 %) of the total cultivable area of the district was found under moderately acid soil that needs lime application for efficient nutrient management. Total 0.270 lakh hectares area of the district was affected with soil acidity. As far as organic carbon content is concern, 0.582 lakh hectares area was identified as low organic C content and needs immediate attention for its improvement. Regarding available N, P, S and Zn status in the soils of the district, more than 70 % area (1.031 lakh ha) with available N, 36% area (0.495 lakh ha) with available P, 30 % (0.436 lakh ha) with available S and 32 % area (0.452 lakh ha) with available Zn were observed deficient and these nutrients are required to be applied for the optimum level of crop production.

Suggestions for future research work

The study undertaken for the Gariyaband district must be extended for other districts of Chhattisgarh which will help farmer's friendly balanced fertilizer application based on soil fertility maps. Based on soil fertility technique, fertility values can be estimated and soil health card can be generated in shortcut way in place of taking huge soil sampling and analyses work in laboratory. Soil fertility maps must be prepared in every third to fourth year to assess the changes occurring in fertility status of the area and soil heath card scheme can be adopted accordingly.

References

1. Ali SM, Malik RN. Spatial distribution of metals in top soils of Islamabad city, Pakistan.Environ Monit Assess 2011;172:1-16.
2. Ramamoorthy B, Narasimham RL, Dinesh RS. Fertilizer application for specific yield targets of Sonora 64. Indian Farming 1967;17:43-44.
3. Tamgadge DB, Gajbhiye KS, Bankar WV. Evaluation of soil suitability for paddy cultivation in Chattisgarh – A parametric approach. J Indian Soc. Soil Sci 2002;50:81-88.
4. Truog E. Fifty years of soil testing. Transactions of Seventh International Congress of Soil Science 1960;3:46-53.
5. Webster R, Oliver MA. Geostatistics for Environmental Scientists. Hoboken, N.J.: John Wiley and Sons Inc 2001.