International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 2312-2318

Received: 20-07-2019
Accepted: 22-08-2019

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Delineation and GPS-GIS based mapping of available macro and micronutrients of soils of Lakhani block of Bhandara, Maharashtra

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Abstract
The present experiment for assessing and mapping of available macro and micronutrients status was conducted in 101 villages of Lakhani block of Bhandara district in Maharashtra state of India, located in north deccan Maharashtra lower plateau in '*Wainganga'* sub-basin of '*Godawari'* basin, during the pre-monsoon season of 2015-2018. The collected and processed composite soil samples were analyzed for some physico-chemical properties, available macro and micronutrient status. The results showed that pH, EC, OC, N, K, P, S, Zn, Fe, Cu, Mn and B were ranging from 6.00-7.8, 0.1-1.9 dSm^{-1}, 0.27-0.78%, 180.7-513.9 kg ha^{-1}, 9.7-132.0 kg ha^{-1}, 169.1-803.9 kg ha^{-1}, 0.1-63.1 kg ha^{-1}, 0.2-1.7 mg kg^{-1}, 0.4-24.2 mg kg^{-1}, 0.6-4.4 mg kg^{-1}, 2.1-19.3 mg kg^{-1} and 0.1-2.3 mg kg^{-1} respectively. The nutrient index of available nitrogen, phosphorus, potassium and sulphur was 1.4, 2.4, 2.9 and 1.6 respectively. The nutrient index values for available Zn, Fe, Cu, Mn and B were 1.1, 1.8, 3.0, 2.9 and 1.0 respectively.

Keywords: Soil macro and micronutrients, mapping, Lakhani block (Bhandara), GPS, GIS

Introduction
In 1960's the green revolution has just pushed the production in such way that, intensive cultivation of high yielding and hybrid varieties has declined the uses of organic manures as well as crop residual recycling which has resulted to wide spread deficiencies in soil nutrients (Santhi *et al.,* 2018) [12]. Now a days the key factor for efficient fertilizer management is appropriate supply of plant nutrients in balanced manner. Specific nutrient supply gives the high production as well as it maintains the soil health. The presence of macro and micronutrients determines the soil fertility as it is the inherent ability of soil to supply nutrients to plants (Kumar *et al.,* 2017) [9]. The study on soil fertility status of intensively cultivated soils should be undertaken, which are majorly deficient in available macro and micro nutrients (Dongarwar *et al.,* 2015) [3]. The remote sensing and geographic information system techniques are rapid, reliable, cost effective as well as it provide quick spatial information of earth surface (Kashiwar *et al.,* 2018) [8]. Soil information without geospatial coordinates is not useful for site specific recommendations and subsequent monitoring. Whereas the use of GPS and GIS will be very helpful for fertilizer recommendation and it is easy to access the status of soil fertility spatially in future studies (Kashiwar *et al.,* 2018) [8].

Materials and Methods
The experiment was conducted at Lakhani block of Bhandara district in Maharashtra, India which is located in north deccan Maharashtra lower plateau in '*Wainganga'* sub-basin of '*Godawari'* basin, and lies between 21.0736° N, 79.8297° E (Figure 1). The study area falls under hot moist sub humid region with moderate winter and severe summer as well distributed rainfall is received from southwest monsoon during June to September. The normal annual rainfall ranges from 1250 to 1500 mm. The georeferenced surface soil samples (0-15 cm) were collected from each 101 villages of Lakhani block with the help of Khurpi and Garmin GPSMAP 78S Marine GPS Navigator device was used for recording geo coordinates. The collected soil sample was mixed thoroughly and composite samples were taken for laboratory analysis. The estimation of pH was done by glass electrode pH meter (Jackson, 1973) [7], electrical conductivity by electrical conductivity meter (Jackson, 1973) [7], organic carbon by

wet oxidation method (Walkley and Black, 1934) [14], nitrogen by alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [13], phosphorus by Bray's method (Bray and Kurtz, 1945) [1] and Olsen's method (Olsen, 1954) [11], potassium by Ammonium Acetate method (Hanway and Heidel, 1952) [6] and sulphur by calcium chloride method (Chesnin and Yien, 1951) [2]. The micronutrients like zinc, iron, copper and manganese was estimated using DTPA solution (Lindsay and Norvell, 1978) [10]. The boron was estimated using Azomethine□H method (Wolf, 1974) [15]. All the thematic maps were generated using ArcGIS 10.4.1 by kriging interpolation technique in ArcGIS toolbox.

Results and Discussion

Physico-chemical properties of soils of Lakhani block

The soil pH of block was ranging from 6.0 to 7.8, with a mean of 7.1. Navra village was recorded with least pH (6.0) and Maregaon was high in soil pH (7.8). The soils of 18 villages (17.8%) was found acidic in nature, 55 villages (54.5%) were in neutral range and soils of 28 villages (27.7%) was alkaline in nature (Table 1). The electrical conductivity (EC) was ranged between 0.1-1.9 dSm^{-1}, with a mean of 0.30 dSm^{-1}. The soil of Machalna village was normal in EC (0.1 dSm^{-1}) whereas soil of Badrazari village was saline in nature (1.9 dSm^{-1}). Out of total samples, majority (99.0%) of soil samples were in normal range, whereas only 1.0% samples were in slightly saline range. The oxidizable organic carbon content was ranged between 0.27-0.78%, with a mean value of 0.41%. Soils of Pohara village was low in OC (0.27%) whereas Khunari village has highest content of OC (0.78%) in lakhani block (Table 1). Out of total samples, 85.1% of soil samples were in low OC range, 13.9% samples were in moderate OC range and 1.0% of sample were high in organic carbon content. The thematic soil maps of pH, EC and OC are presented in Figure 2, Figure 3 and Figure 4.

Table 1: Status of physico-chemical properties of Lakhani block of Bhandara district

Particulars/Soil properties	Range	Mean	SD	CV
pH	6.0-7.8	7.1	0.5	0.1
EC	0.1-1.9	0.3	0.2	0.6
OC	0.27-0.78	0.41	0.1	0.3

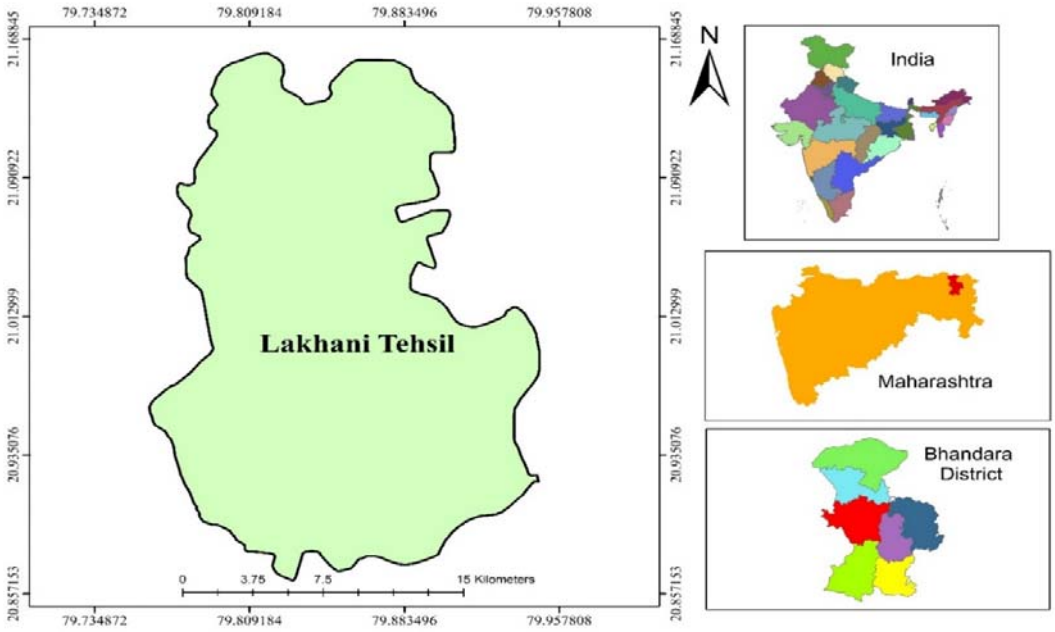

Fig 1: Location map of Lakhani block of Bhandara district, Maharashtra

Macro-nutrient status in soils of Lakhani block

Available nitrogen status

Available nitrogen content was ranged between 180.7-513.9 kg ha^{-1} with a mean of 291.8 kg ha^{-1}. Soils of Lakhani villages was recorded with low nitrogen content (180.7 kg ha^{-1}) whereas, soils of Kharashi village has highest nitrogen content (513.9 kg ha^{-1}). The NIV for available N of 101 soil samples of Lakhani block was 1.4 (Table 2 and Fig 5). Similar results were also observed by Dongarwar *et al.* (2015) [3], (2018a) [4], (2018b) [5] and Kashiwar *et al.* (2018) [8]. Out of total 101 soil samples 59.4% were low, 40.6% were medium and 0.0% were high in nitrogen content.

Available phosphorous status

Soil available P content was ranged between 9.7-132.0 kg ha^{-1} with a mean of 31.4 kg ha^{-1}. Soil of Chichtola villages was recorded with low phosphorous content (9.7 kg ha^{-1}) whereas, soils of Kanhalgaon village has highest phosphorous content (132.0 kg ha^{-1}). The NIV for available P the 101 soil samples of Lakhani block was 2.4 (Table 2 and Fig 6). Similar results were also observed by Dongarwar *et al.* (2015) [3], (2018a) [4], (2018b) [5] and Kashiwar *et al.* (2018) [8]. From 101 soil samples, 5.9% were low, 48.5% were medium and 45.5% were high in phosphorus content.

Available potassium status

Soil available potassium content was ranged between 169.1-803.9 kg ha^{-1} with a mean of 402.7 kg ha^{-1}. Soil of Chichtola villages was recorded with low potassium content (169.1 kg ha^{-1}) whereas, soils of Kanhalgaon village has highest potassium content (803.9 kg ha^{-1}). The NIV for available potassium of the 101 soil samples of Lakhani block was 2.9 (Table 2 and Fig 7). Similar results were also observed by Dongarwar *et al.* (2015) [3], (2018a) [4], (2018b) [5] and Kashiwar *et al.* (2018) [8]. From 101 soil samples, it was recorded that none was low, 9.9% were medium and 90.1% were high in potassium content.

Table 2: Status of available Macro-nutrient in Soils of Lakhani block of Bhandara district

Particulars/Soil properties	Range	Mean	SD	CV	NIV
Available N	180.7-513.9	291.8	76.3	0.3	1.4
Available P	9.7-132.0	31.4	18.1	0.6	2.4
Available K	169.1-803.9	402.7	121.3	0.3	2.9
Available S	0.1-63.1	14.3	15.3	1.1	1.6

Available sulphur status

Available sulphur content was ranged between 0.1-63.1 kg ha^{-1} with a mean of 14.3 kg ha^{-1}. Soil of Garada villages was recorded with low sulphur content (0.1 kg ha^{-1}) whereas, soils of Palasgaon village has highest sulphur content (14.3 kg ha^{-1}). The NIV of available sulphur for the 101 soil samples of Lakhani block was 1.6 (Table 2 and Fig 8). Similar results were also observed by Dongarwar *et al.* (2015) [3], (2018a) [4], (2018b) [5] and Kashiwar *et al.* (2018) [8]. Of the total 101 samples, 57.4% samples were low, 23.8% were medium and 18.8% were high in available sulphur content.

Micro-nutrient status in soils of Lakhani block

Available zinc status

The average zinc content was 0.5 Zn mg kg^{-1} and was ranged between 0.2 to 1.7 mg kg^{-1}. Soil of Chichtola villages was recorded with low zinc content (0.2 mg kg^{-1}) whereas, soils of Gondi village has highest zinc content (1.7 mg kg^{-1}). The NIV for available DTPA extractable zinc for the 101 soil samples of Lakhani block was 1.1 (Table 3 and Fig 9). Similar results were also observed by Dongarwar *et al.* (2015) [3], (2018a) [4], (2018b) [5] and Kashiwar *et al.* (2018) [8]. Of the total samples analyzed, 85.1% samples were deficient, 14.9% were marginal and 0.0% high in available zinc content.

Available iron status

Available iron content of the study area was ranged between 0.4-24.2 mg kg^{-1} with a mean of 7.6 mg kg^{-1}. Soils of Salebhata village was recorded with low iron content (0.4 mg kg^{-1}) whereas, soils of Palasgaon village has highest iron content (24.2 mg kg^{-1}). The NIV for available Fe for the 101 soil samples of Lakhani block was 1.8 (Table 3 and Fig 10). Similar results were also observed by Dongarwar *et al.* (2015) [3], (2018a) [4], (2018b) [5] and Kashiwar *et al.* (2018) [8]. Out of total samples, 32.7% samples were deficient, 58.4% were marginal and 8.9% were high in available iron content.

Available copper status

Available copper content of the experimental area was ranged between 0.6-4.4 mg kg^{-1} with a mean of 1.5 mg kg^{-1}. Data showed that soils of Chichtola village was recorded with low copper content (0.6 mg kg^{-1}) whereas, soils of Palasgaon village has highest copper content (4.4 mg kg^{-1}). The NIV of available Cu for the 101 soil samples of Lakhani block was 3.0 (Table 3 and Fig 11). Similar results were also observed by Dongarwar *et al.* (2015) [3], (2018a) [4], (2018b) [5] and Kashiwar *et al.* (2018) [8]. Of the whole samples analyzed, none was deficient in available Cu but 3.0% were marginal and 97.0% were high in copper content.

Table 3: Status of available Micro-nutrient in Soils of Lakhani block of Bhandara district

Particulars/Soil properties	Range	Mean	SD	CV	NIV
Available Zn	0.2-1.7	0.5	0.3	0.6	1.1
Available Fe	0.4-24.2	7.6	5.6	0.7	1.8
Available Cu	0.6-4.4	1.5	0.8	0.5	3.0
Available Mn	2.1-19.3	10.7	4.4	0.4	2.9
Available B	0.1-2.3	0.6	0.6	0.9	1.0

Available manganese status

Soil available manganese content was ranged between 2.1-19.3 mg kg^{-1} with a mean of 10.7 mg kg^{-1}. Soils of Rampuri village was recorded with low Mn content (2.1 mg kg^{-1}) whereas, soils of Gadegaon village has highest Mn content (19.3 mg kg^{-1}). The NIV of DTPA extractable available Mn for the 101 soil samples of Lakhani block was 2.9 (Table 3 and Fig 12). Similar results were also observed by Dongarwar *et al.* (2015) [3], (2018a) [4], (2018b) [5] and Kashiwar *et al.* (2018) [8]. Out of total assessed samples 6.9% were marginal and 93.1% high in Mn content. However, none of the samples were deficient in available Mn.

Available boron status

Available boron content of the study area was ranged between 0.1-2.3 mg kg^{-1} with a mean of 0.6 mg kg^{-1}. Soils of Nimgaon village was recorded with low boron content (0.1 mg kg^{-1}) whereas, soils of Kesalwada village has highest boron content (2.3 mg kg^{-1}). The NIV of available B for the 101 soil samples of Lakhani block was 1.0 (Table 3 and Fig 13). Similar results were also observed by Dongarwar *et al.* (2015) [3], (2018a) [4], (2018b) [5] and Kashiwar *et al.* (2018) [8]. It was found that all (100%) soil samples were deficient in boron content.

Conclusion

The study revealed that the soils of 55 and 28 villages of Lakhani block of Bhandara, Maharashtra were neutral and alkaline in nature respectively. The soils of study area were mostly non-saline and organic carbon content of 85.1% soil samples was low. Available nitrogen was deficient in soils of majority of the study area but the availability of phosphorus and potassium was moderate and high respectively. Micronutrients like Zn, Fe, B were deficient, whereas Cu and Mn were sufficiently available in the study area.

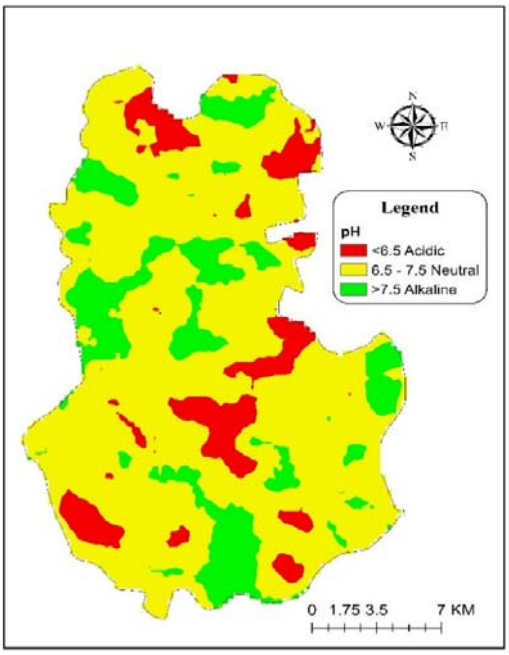

Fig. 2: Thematic map of soil pH

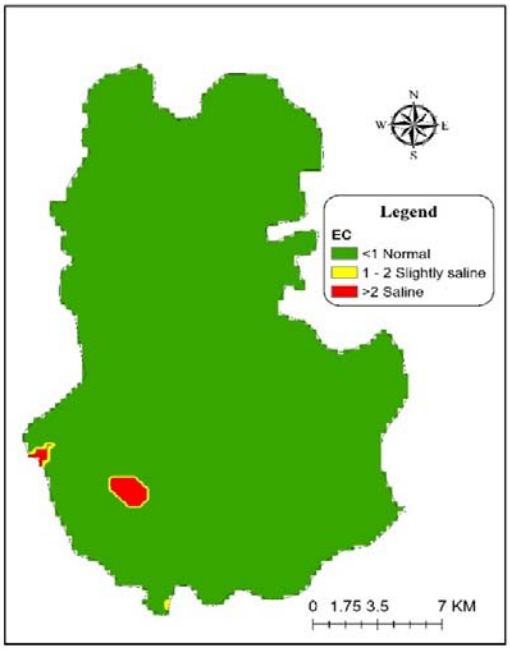

Fig. 3: Thematic map of soil EC

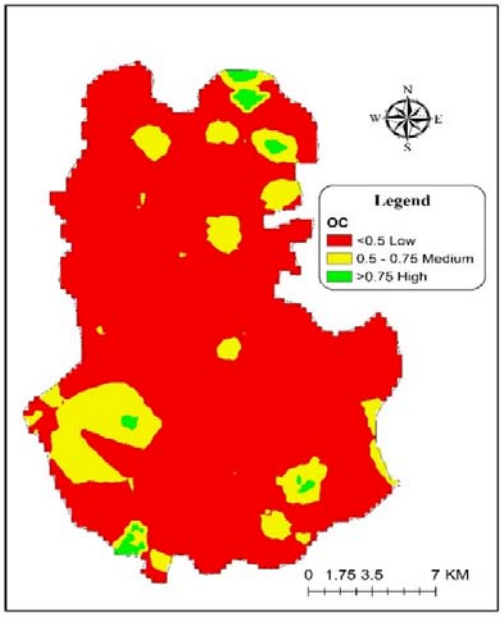

Fig. 4: Thematic map of soil OC

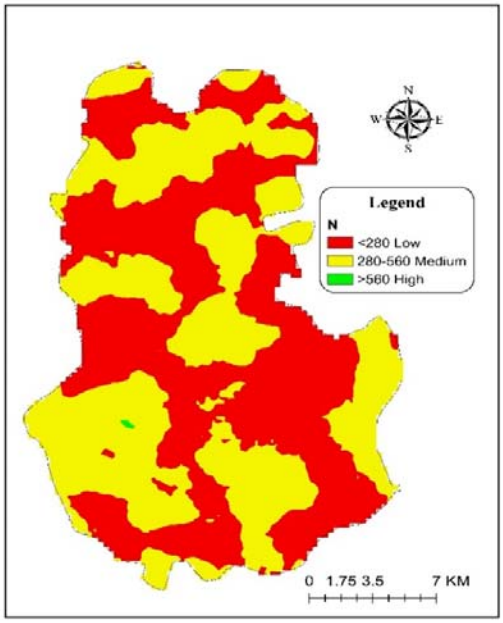

Fig. 5: Thematic map of soil available N

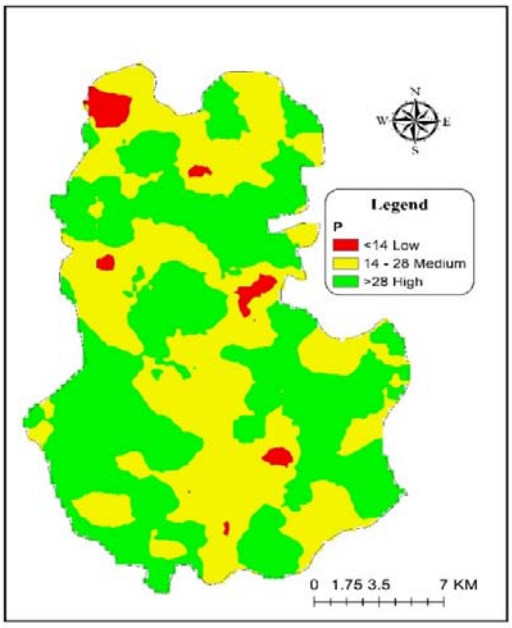

Fig. 6: Thematic map of soil available P

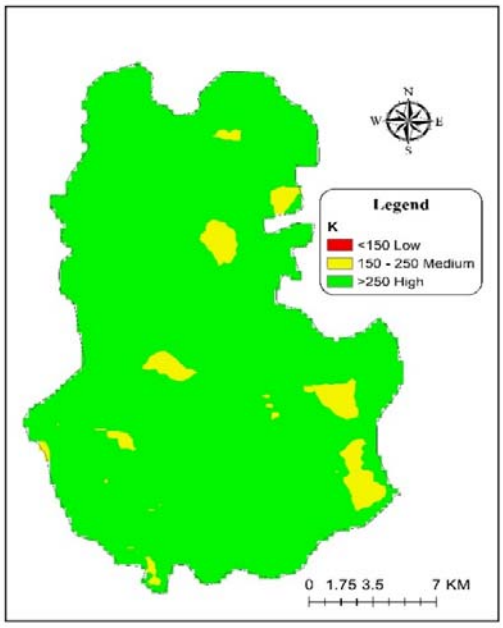

Fig. 7: Thematic map of soil available K

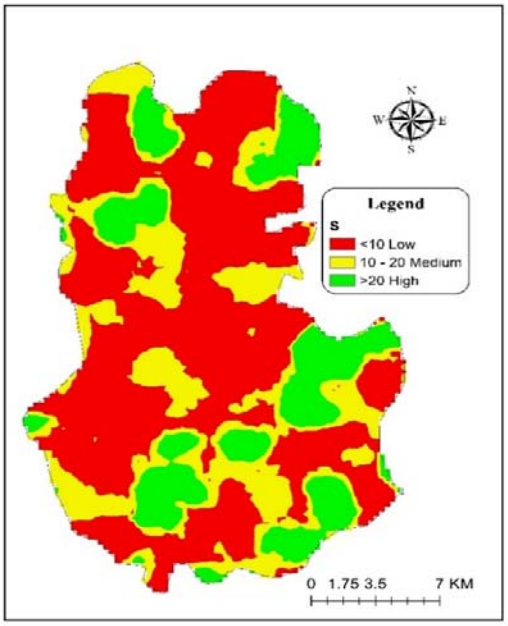

Fig. 8: Thematic map of soil available S

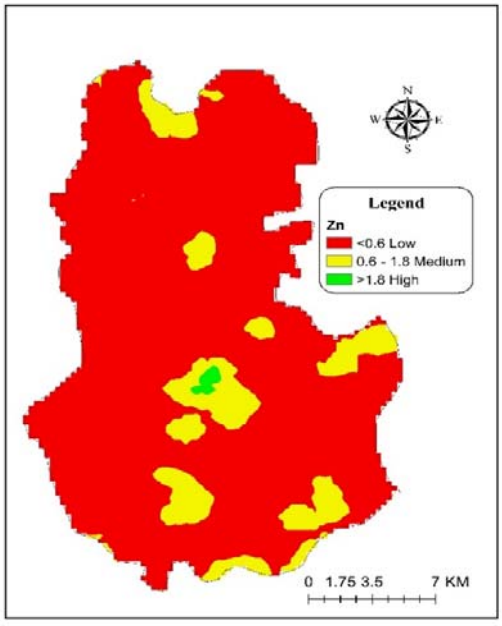

Fig. 9: Thematic map of soil available Zn

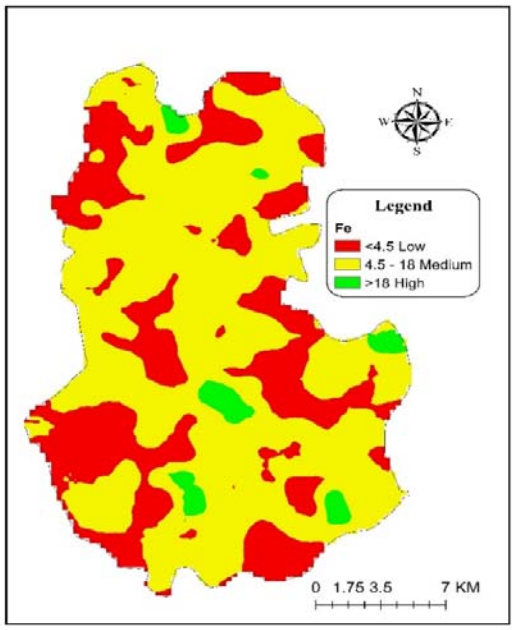

Fig. 10: Thematic map of soil available Fe

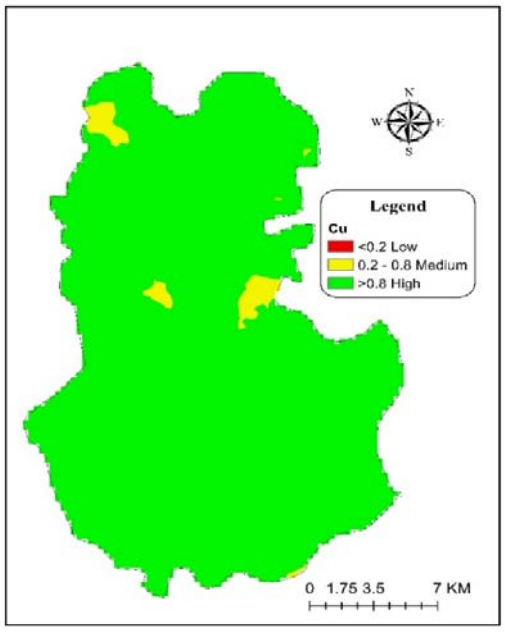

Fig. 11: Thematic map of soil available Cu

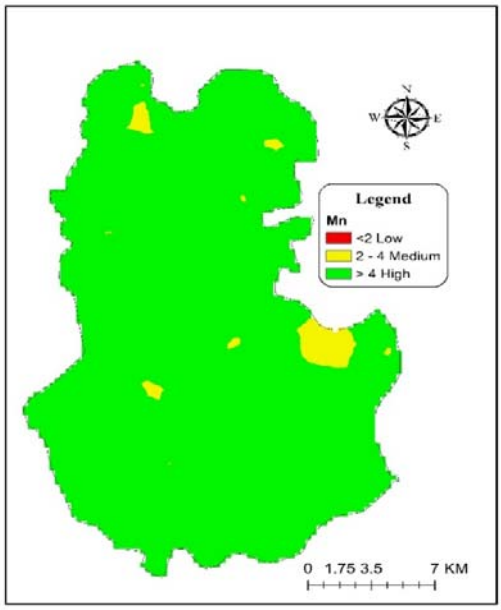

Fig. 12: Thematic map of soil available Mn

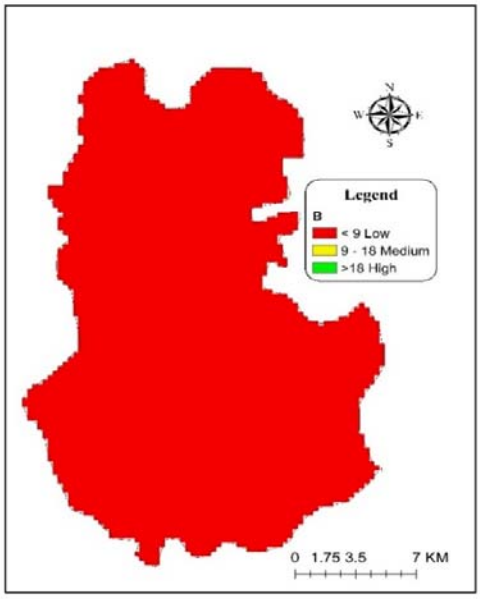

Fig. 13: Thematic map of soil available B

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