SPATIAL DISTRIBUTION OF SOME SOIL NUTRIENTS IN KABBA COLLEGE OF AGRICULTURE, KOGI STATE, NIGERIA.

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ABSTRACT
The management of soil nutrients for optimum productivity requires the understanding of their levels and distribution. This study evaluates the distribution of some macro and micro-nutrients in the soil of a teaching and research farm. Sixty soil samples were collected at the depth of 0-30cm and analyzed for nitrogen (N), phosphorus (P), potassium (K), total iron (Fe), total zinc (Zn), total copper Cu, and total manganese (Mn). Mean, standard deviation and coefficient of variation were used to evaluate the level and variability of the nutrients. N (0.080 to 0.170%) were below the critical level while P and K levels (5.44 to 4.320ppm and 0.210 to 0.480 cmol/kg respectively) were moderate, there variation (CV = 24.11%, 30.10%, and 22.19% respectively) were moderate across the landscape. Fe has means of 3.6355mg/kg, minimum value of 2.100 mg/kg, maximum value of 5.67 mg/kg; they are rated moderate. Cu has mean value of 0.885mg/kg and maximum value of 7.510 mg/kg; they are rated low. Zn has a mean value of 22.409mg/kg, minimum value of 16.380mg/kg and maximum value of 29.750mg/kg; the values are considered to be low. Mn has mean value of 268.33mg/kg, minimum value 210.000mg/kg and maximum value is 415.000mg/kg; the values are rated high. The distributions of the nutrients are influenced by cultivation, cropping pattern crop type, leaching and erosion. Compound fertilizers containing micro nutrients should be used for crops in the location, fertilization with different ratios of NPK. should be done for different portion of the land with reference to their distribution.
Key words: distribution, evaluation, nutrients, spatial

1.0 INTRODUCTION

Soil is made up of micro and macro- nutrients. Nitrogen (N), phosphorus (P), and potassium (K) are important macronutrients which can limit or co-limit plant growth(Li, 2016; Tripler, 2006). Human activities, such as fertilization, reclamation, and weeding, have greatly affected the biogeochemical cycling of N, P, and K, thereby altering the pattern, magnitude, and extent of nutrient limitation on land (Marklein, 2012). Effective, efficient, and site-specific management and estimation of soil N, P, and K have attracted great interests for scientists looking to improve nutrient input efficiency, thus increasing stand productivity and reducing environmental risks (Du, 2016).

Seven plant nutrients, namely, boron (B), chloride (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn), required by plants in very small quantities, are known (Rashid and Ryan, 2004). Although they are required in minute quantity but have some agronomic importance as macro- nutrients does. The seven (7) micronutrient are sufficient in most soil to meet crops needs. However, some sandy soils and other low organic matter soil are naturally deficient in micronutrient and high pH soils may make some micronutrients less available and therefore deficient. In crop production the micronutrients most often supplied by fertilization include zinc, manganese, boron, and iron. Frageria *et al*., (2002) in their review of micronutrient in crop production, maintained that micronutrient deficiencies in crop plant are widespread worldwide.

Due to various climatic conditions, parent materials, topography, vegetation types, soil texture, and land use, soils are characterized by a highly spatial and temporal variability (Ross, 1999). This has made the accurate estimation of spatial nutrient content difficult. However, rational soil management requires a deep understanding of the spatial variability of soil nutrients (Lui, 2013). Areas of particular concern, such as nutrient deficiency, can be identified.According to Dar (2004), there is need for monitoring the nutrient status through analysis of soils and the plant tissues in farmers' fields. This is as a results of the fact that land users are unaware of hidden hunger and there is an urgent need to ensure that they know the nutrient status of their soil to ensure optimum production (Gebeyaw, 2015).

Therefore, it is necessary to investigate the status and level of soil nutrients in order to improve the understanding of their spatial distribution to guide in the development of sustainable management practices for optimum nutrient use by crops towards farm productivity, food security and environmental protection.

The objective of the study was to evaluate thedistribution of nitrogen, phosphorus, potassium, iron, copper, zinc and manganese in the Teaching and Research farm of Kabba College of Agriculture in Kogi State Nigeria.

2.0 MATERIALS AND METHOD

2.1 Description of the study area

The study was carried out at the Teaching and Research farm of Kabba College of Agriculture on latitudes 7.85467° and 7.85728^{0}and longitudes 006.08022^{0}and 006.07564^0. The area is within the southern Guinea Savanna agro-ecological zone of Nigeria with rainfall that spans the month of April/early May to November. The average annual rainfall is 1,329mm (Weatherbase, 2019).

The main annual temperature of the area is 30^{0}C, mean annual relative humidity is 67% (Weatherbase, 2019).

The area is used for commercial, teaching and research farming; cultivated with cassava, maize, sorghum, yam, pasture crop, moringa, sweet potato, roselle, cowpea, pigeon pea, walnut while some part was under fallow. The use of fertilizer and lime is a common practice in the area.

2.2 Soil sampling

The field was marked out using digital mapping methods. Longitude and latitude were recorded at the boundaries of the field with GPS device and map was produced using the Arc GIS software.

The conventional method of soil survey including the free survey procedure was adopted to sample the soils. Sampling points were identified based on physiographic positions, vegetation, colour and texture variation and crop system. The sampling points were geo-referenced and soil samples collected within 0-30cm soil depth.

2.3 Laboratory analysis

Soil samples collected from the various point were air dried in the laboratory, crushed with porcelain pestle and mortar and sieved to remove material greater than 2mm (gravel) percentage gravel to total soil were calculated and less than 2mm materials was used to carry out laboratory analysis for nitrogen, phosphorus and potassium following the procedures suggested by IITA, (1979).

Total nitrogen was determined using macro-Kjedhal method (Black, 1965) involving the complete digestion of sample in hot concentrated acid, and in the presence of an appropriate metal ion catalyst (Ibitoye, 2015).

Available phosphorus was determined using the Bray P^{-1} extraction method of Bray and Kurtz (1945). The phosphorus was determined using spectrophotometer (Ibitoye, 2015).

Exchangeable potassiumwas extracted with 1MNH$_4$OA$_C$ and determined with a flame photometer (Ibitoye, 2015).

Analysis was carried out for available micronutrients Iron (Fe), Copper (Cu), Zinc (Zn) and Manganese (Mn).

The micronutrients were extracted with DTPA as described by Sahlemedhin and Taye (2000) and measured with atomic absorption spectrophotometer (Ibitoye, 2005).

2.4 Data analysis

The spatial distribution of the nutrientswas expressed with maps using the Arc GIS software.

Mean and standard deviation was used to illustrate the levels of the nutrients.

The coefficient of variation (CV) was used to describe the degree of variation of the soil properties. The classification of degree of soil variability of Wilding and Drees (1978) as adopted by Babalola and Fasina (2007) was used (Table 1)

Table 1: Classification of degree of variation.

Range of CV values	Degree of variation
Least variable	<15 %
Moderately variable	15-35 %
Extremely variable	>35 %

3.0 RESULTS AND DISCUSSION

3.1 Descriptive statistics and coefficient of variation

The summary of statistics of the nutrients are presented in Table 2.

Total N has minimum value of 0.080% and maximum value of 0.170% with means of 0.112%. The values are below the critical value of 0.200% where response is unlikely and fertilizer application may not be necessary (FFD, 2002). Similar lower values had been reported by Onyekwere *et al*. (2001), Noma *et al*. (2011), Babalola (2007), Babalola *et al*., (2011), Babalola (2018) for soils of the savannah zone of Nigeria. It was attributed to take up by crops, crop residue removal and sandy texture of soil.

Available P has minimum value of 5.440ppm, maximum value of 4.320ppm and means of 9.152ppm FMANR (1990) suggested the critical level value of 8.5ppm for available phosphorus in Nigeria. The mean value and maximum value are above the critical level while the minimum value is below. Fertilizer use, organic matter and parent materials have been reported to influence the level of available phosphorus in soils (Babalola, 2018). Exchangeable K has minimum value of 0.210 cmol/kg, maximum value of 0.480 cmol/kg, and mean of 0.338 cmol/kg. The minimum value is low while the maximum and mean are moderate according to the rating of FAO (2004). Leaching, plants up take and parent materials have been reported to contribute to exchangeable potassium levels in soil (Maniyunda, 2012; Babalola, 2018).

The total iron (Fe) has a mean of 3.635% minimum value of 2.100% and maximum value of 5.670%. These values are rated moderate (Soil Survey Division Staff, 1993) and similar to values reported for Nigeria savannah soils by Agbenin and Tissen

(1995), Raji *et al*. (2000), Maniyunda 2012. It was attributed to Fe occurrences in tropical soils as clay or coatings on clay surfaces (Babalola, 2018) and the presence of minerals like feldspar, magnetite, hematite and limonite in alfisols (Vijayakumar *et al*., 2003).

The total copper (Cu) has a mean value of 0.885mg kg^{-1}, minimum value of 0.309mg kg^{-1} and maximum value of 7.510mg kg^{-1}. the values are rated low (Shaato *et al* 2002), but within the range reported for different soils of West African savannah (Barghouthi *et al* 2012; Shaato *et al*, 2002).

The total Zinc (Zn) mean value is 22.409mg kg^{-1}, minimum value of 16.380mg kg^{-1} maximum value of 29.750mg kg^{-1}. the values are rated low (Shaato *et al*., 2012). Although total Zn content are considered as poor indicator of Zinc supplying capacity of soils for long term management of cropping system (Dasappagol *et al*., 2017) however, there may be likely hood of deficiency of zinc, in that deficiency is common in the arid and semi—arid regions of the world (Shivaprasad *et al*., 1996; Dasappagol *et al*., 2017).

The mean value of total manganese is 268.33mg kg^{-1}, minimum value is 210.000mg kg^{-1}, and maximum value is 415.000mg kg^{-1}. The values are rated high and similar to the reports of Yaro (2005), Maniyunda (2012) and Babalola (2018) for Nigerian savannah soils.

Table 2: Summary of statistics of soil N, P and K in the study area

Soil properties	Mean	Min	Max	SD	%CV
Total N (%)	0.112	0.080	0.170	0.027	24.11
Available P (ppm)	9.152	5.440	14.320	2.755	30.10
Exchangeable K (cmol/kg)	0.338	0.210	0.480	0.075	22.19
Fe (%)	3.635	2.100	5.670	1.055	29.02
Cu (mg kg^{-1})	0.885	0.309	7.510	0.285	32.20
Zn (mg kg^{-1})	22.409	16.380	29.750	4.559	20.35
Mn (mg kg^{-1})	268.333	210.000	415.000	72.912	27.17

N- nitrogen, P- phosphorus, K- potassium, Min- minimum, Max- maximum, SD- standard deviation, CV- coefficient of variation.

The coefficient of variation values (CV) of N, P, K, total Fe, Cu, Zn, and Mn are 24.11, 30.10, 22.19, 29.02, 32.20, 20.35 and 27.17% respectively. According to the classification of Wilding and Dress (1978) as adopted by Babalola and Fasina, (2006), these properties are moderately variable across the landscape of the study location. The order of variation is as follows: Cu>P>Fe>Mn>N>K>Zn. The variability of N, P and K across landscape had been attributed to different cultivation practices, addition of fertilizer, bush burning activities, erosion (wash) and deposition. (Alboni 2001; Zebarth *et al*., 2002, Fasina, 2003; Babalola and Fasina 2007). While that of macronutrients was attributed to the influence of leaching, rate of organic matter accumulation and decomposition and plant uptake (Sharma *et al*., 2003); Yaro, 2005; Babalola, 2018).

3.2 Spatial distribution of nutrients

The spatial distribution patterns of the nutrients are presented in Figs 1 to 7.

N and P appeared to have similar pattern of distribution. The highest values are at the portion of the land cultivated with pigeon pea, cowpea, experimental site and fallow. The highest value range is 0.14- 0.17% for N followed by 0.12 – 0.14%. P has the highest range of 11.91 – 14.32ppm followed by 10.04 – 11.91ppm.

The distribution of K was higher in the portion of the land under pigeon pea, fallow and cassava with value range of 0.37 – 0.42cmol/kg and 0.32 – 0.37cmol/kg. There are lower values in the portion under intensive cultivation.

Positive correlation had been reported between available potassium, total nitrogen and organic carbon and was attributed to the occurrence of N and P in organic form in soil (Babalola, 2018). Similar view was expressed by Matsumo and Ae, (2004), Brady and Weil, (2005) and Kharal *et al*., (2018).

The distribution of N and P could have been influenced by the cultivation of legumes crops, accumulation and decomposition of litter fall on the soil surface and subsequent nutrient release. (Uma *et al*., 2011; Bhalane *et al*., 2013).

The distribution of K might have been influenced by cultivation, this implies that high leaching and erosion losses of the nutrient might have occurred since the cultivated area are exposed to rainfall, flow and water movement. Also some of the K might have been removed from the soil as a result of harvest and poor residue management (Khara *et al*., (2018).

Total iron has highest value range of 4.78 to 5.67% in portions close to the Inselberg. The larger portion of the land area has total Fe value of 3.41 to 4.04%.

Total copper range of 0.62- 1.94mg kg^{-1} and zinc of 20.62 to 25.51mg kg^{-1} are present in the larger portion of the land area most especially, the area under intensive cultivation with cassava, yam, maize, pasture grasses and sorghum.This established that there has been loss of these micro nutrients to leaching and crop removal (Fagbami *et al*., 1985) therefore, deficiency may occur. Positive relationship between Cu and Zn has been reported (Shaato *et al*., 2012) this implies that their accumulations are influenced by similar factors.

Highest range of total Mn values (243.14- 415 mg kg^{-1}) were observed in the portions of the landscape under fallow and the part cultivated with pigeon pea. This could have been as a result of accumulation of organic matter from plant residues. Sharma *et al*. (2000), Yaro (2005) and Babalola (2018) reported significant correlation between Mn and organic matter.

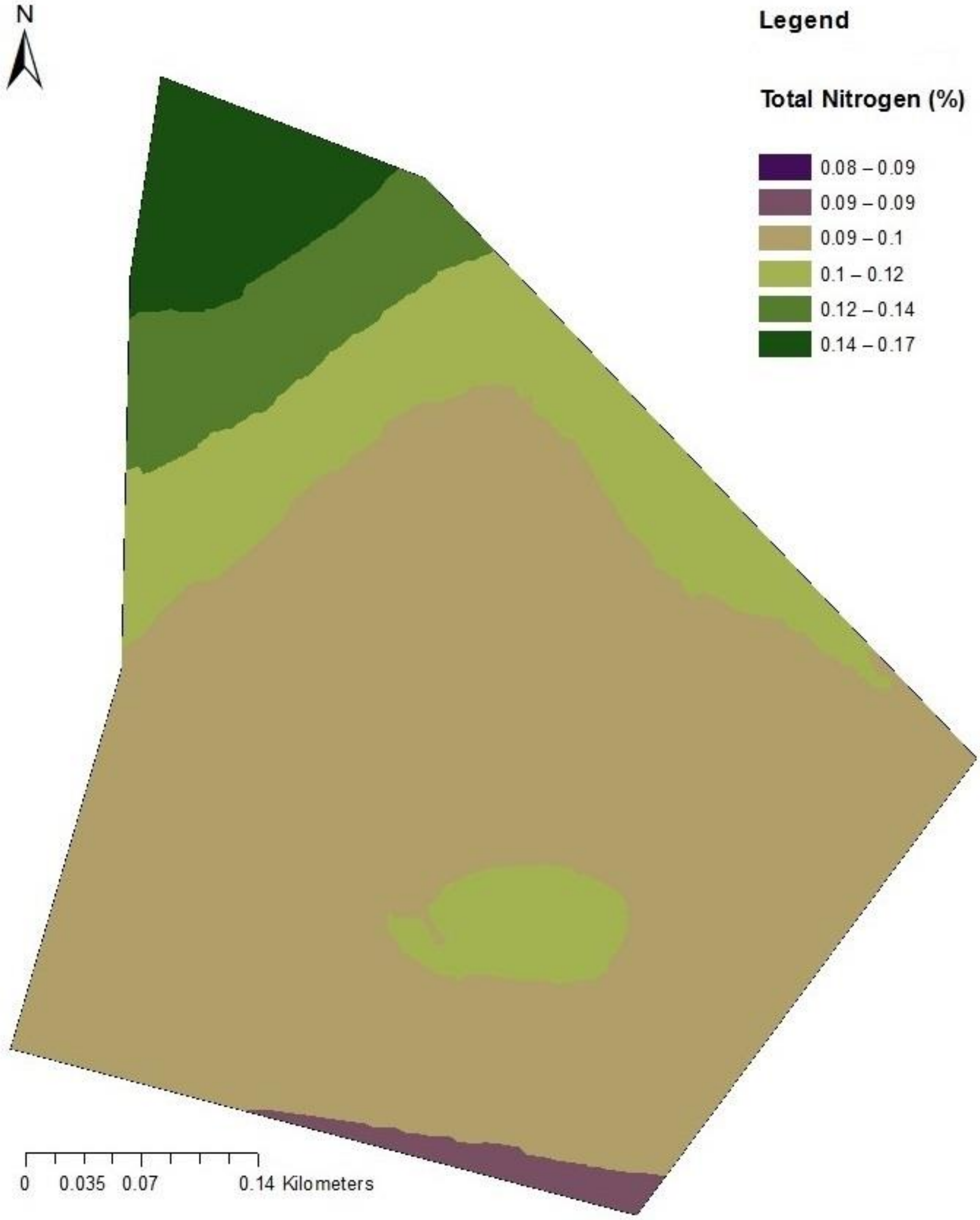

Figure 1: Spatial distribution of total nitrogen

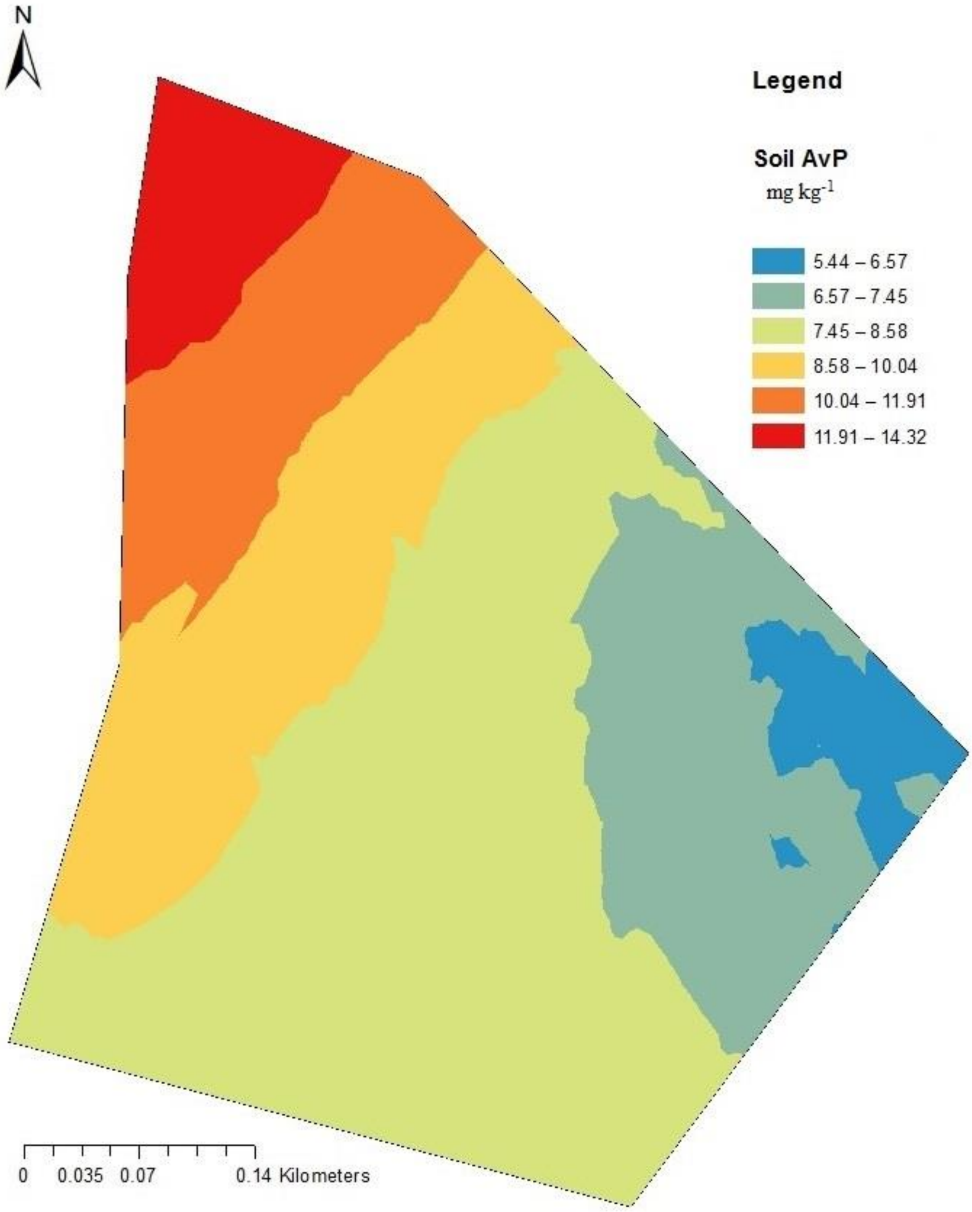

Figure 2: Spatial distribution of available phosphorus

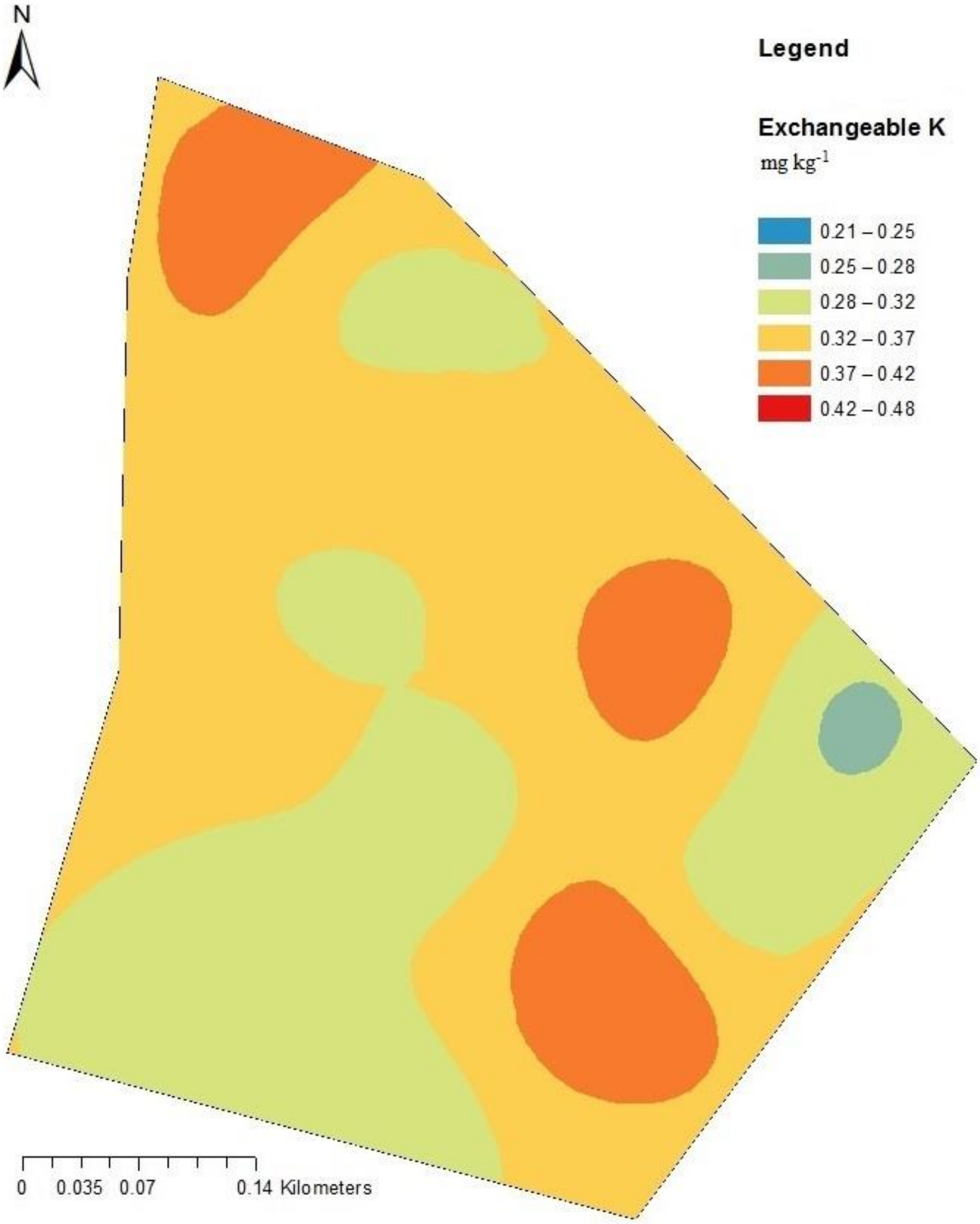

Figure 3: Spatial distribution of exchangeable potassium

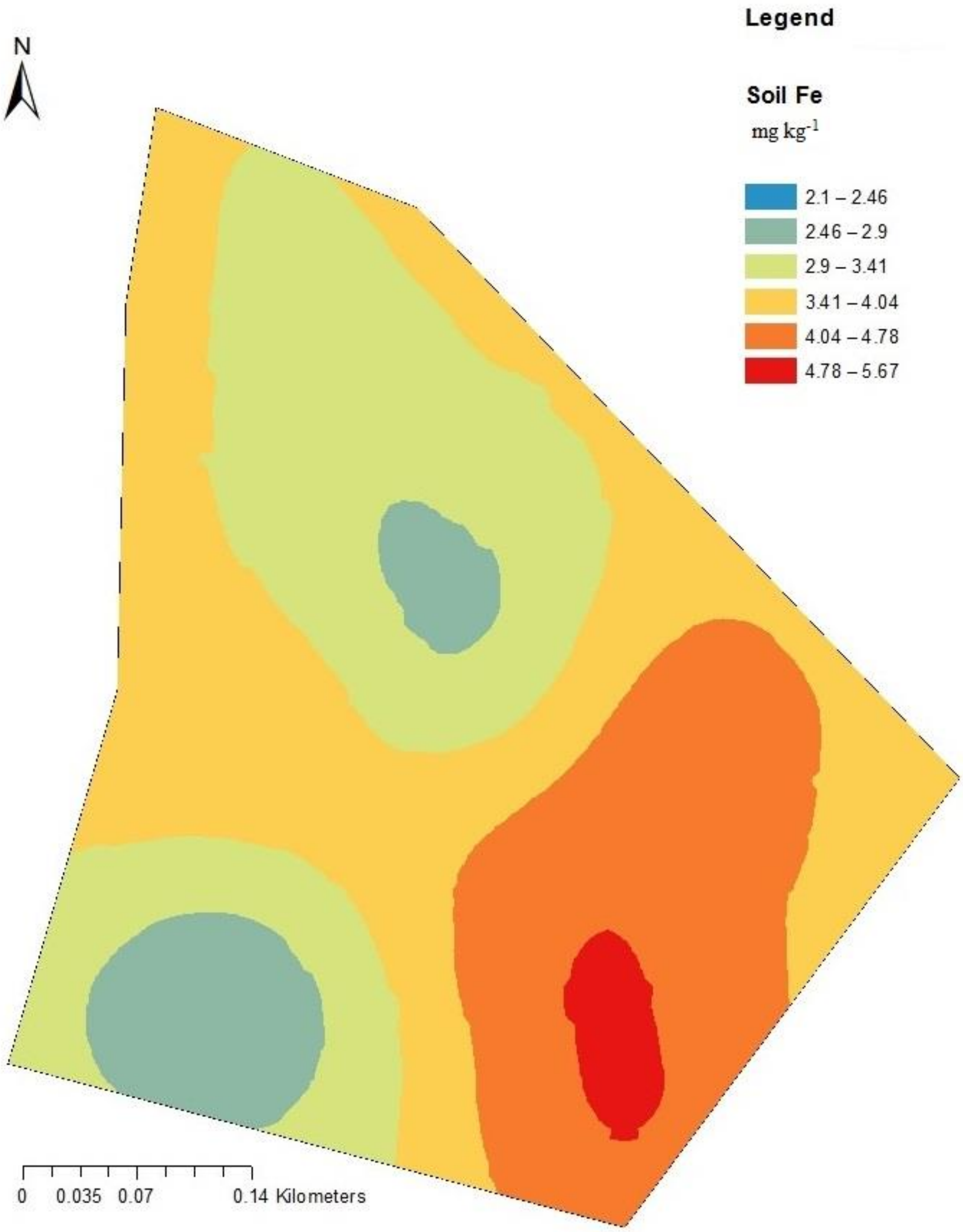

Figure 4: Spatial distribution of soil Iron (Fe)

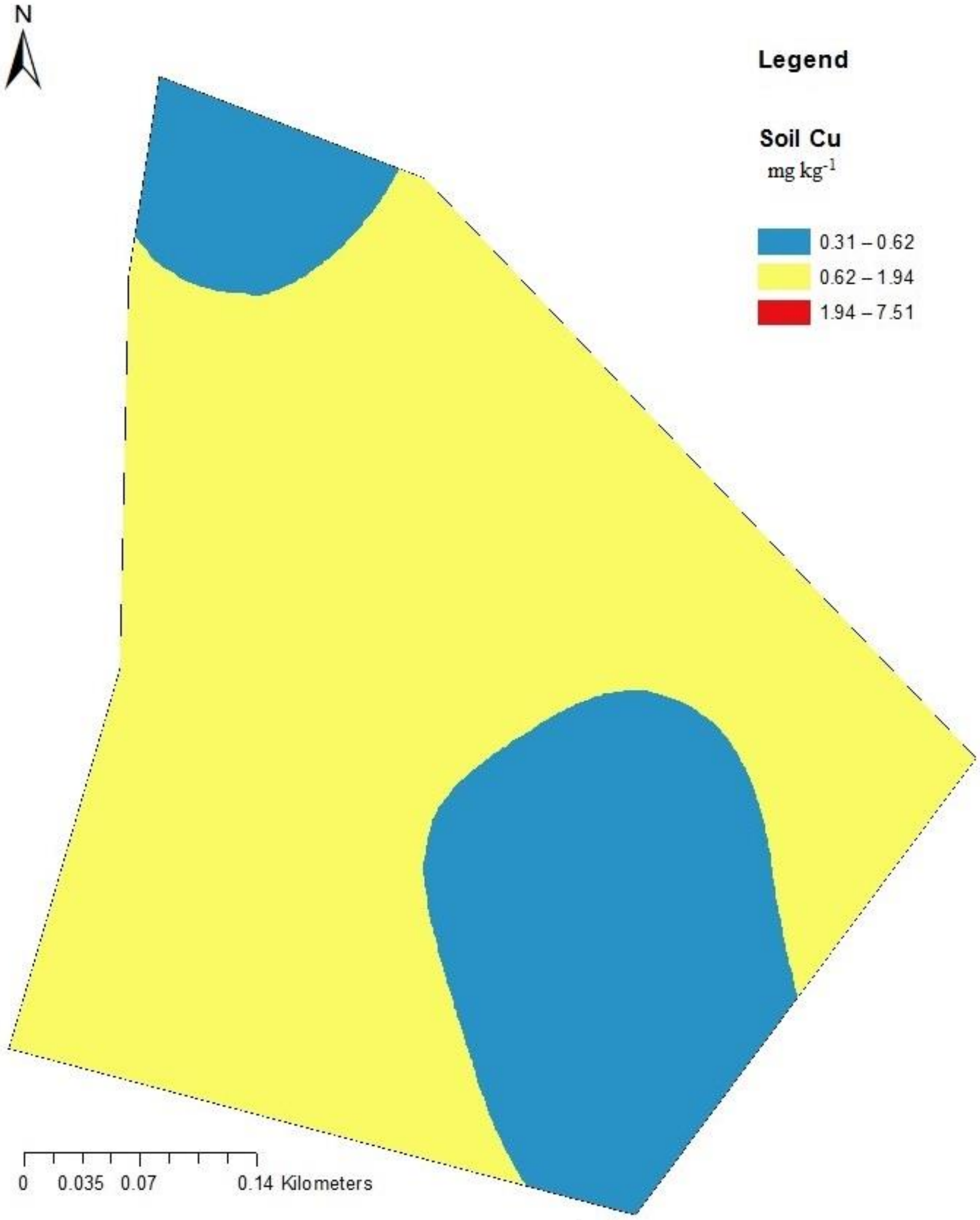

Figure 5: Spatial distribution of soil copper (Cu)

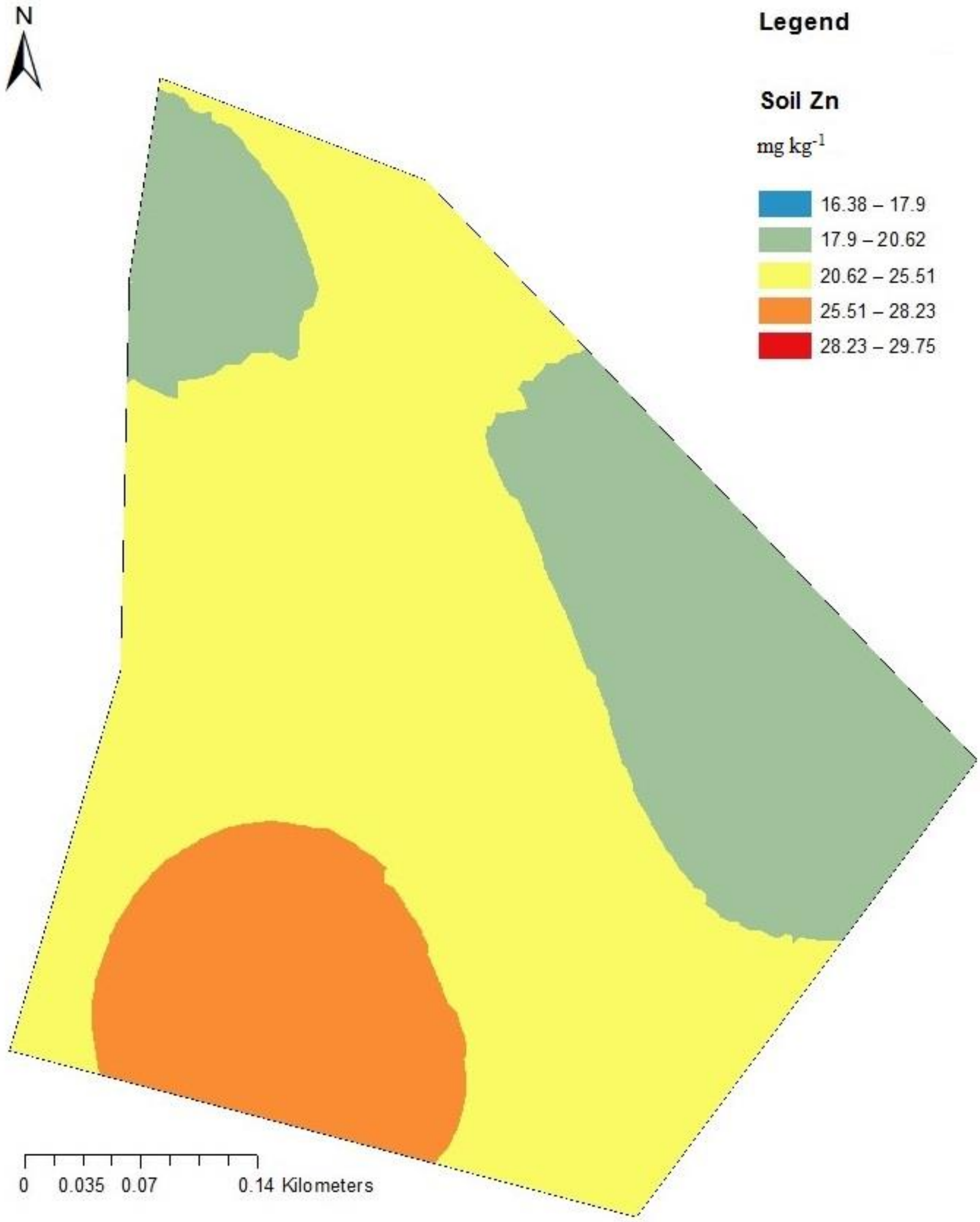

Figure 6: Spatial distribution of soil zinc (Zn)

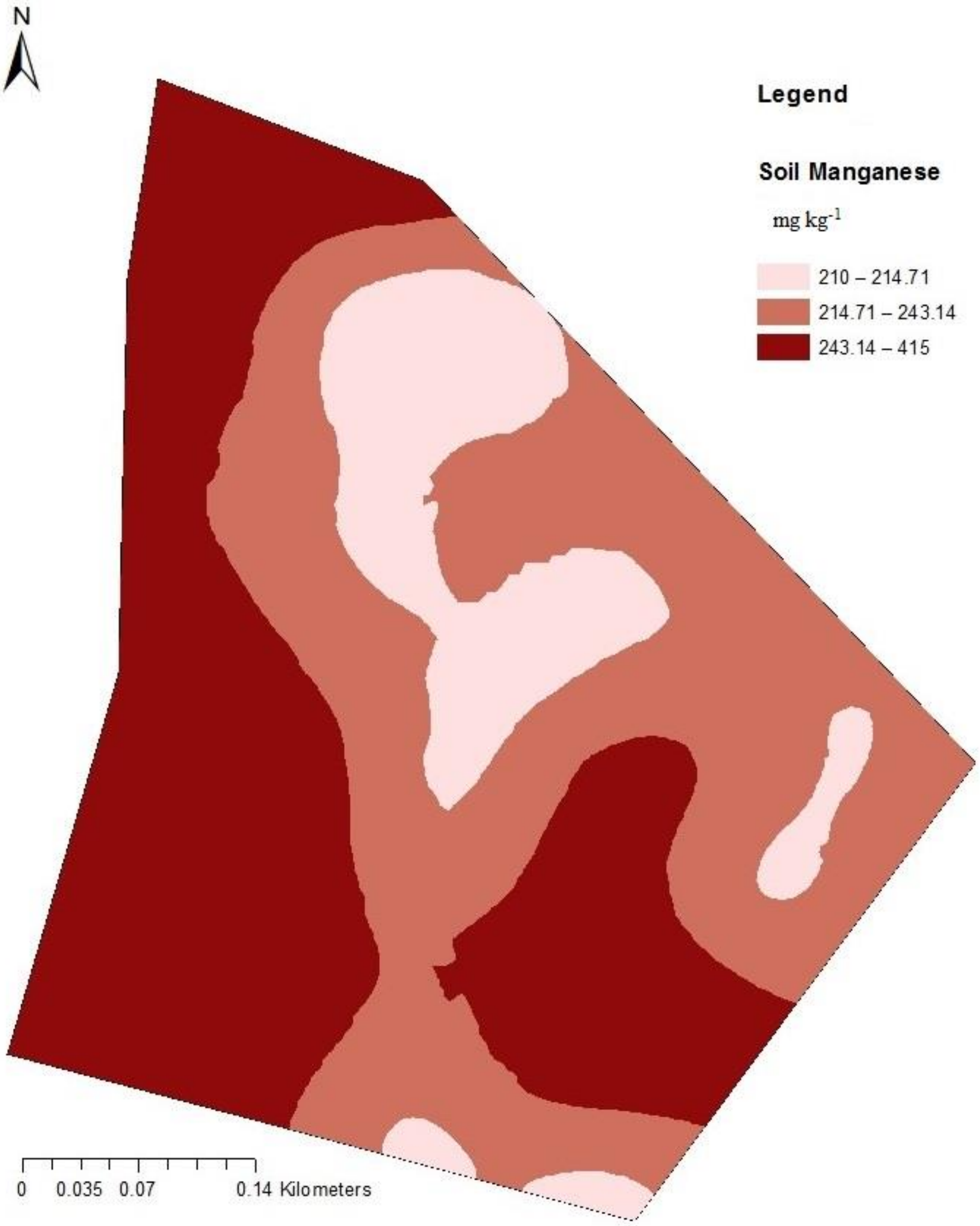

Figure 7: Spatial distribution of soil manganese

4.0 CONCLUSION

The nitrogen contents are below the critical level, phosphorus and potassium levels are moderate, total Iron (Fe) level is moderate, total copper (Cu) and Zinc (Zn)are low while total manganese (Mn) is high. There is likely hood of deficiency of Znand Cu in soil of the study area.Variability of the nutrients across the landscape is moderate.The area under intensive cultivation had lower value of Zn, Cu, and Mn. Leaching and crop uptake/ removal are suspected to have contriubuted to their level.

5.0 RECOMMENDATIONS

1. Compound fertilizers containing micro nutrients should be used for crops in the location
2. Fertilization with different ratios of N:P:K. should be done for different portion of the land with reference to their distribution.
3. Practices such as green manuring and post-harvest crop residue management involving incorporation of crop residue into the soil should be adopted.

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