Original Research Article

Assessment and Mapping of Micronutrient Cation Distribution in Agricultural Research Station Soil: A Geospatial Approach"

ABSTRACT

Aim: The objective was to construct fertility maps of the area, specifically focusing on micronutrient cations. The research aims to provide valuable insights into the spatial distribution of micronutrients, aiding in the development of targeted agricultural practices and informed decision-making.
Study design: soil sampling, soil analysis and soil mapping.
Place and Duration of Study: Agricultural Research Station, Ummedganj-Kota in 2019 and 2020
Methodology: The study involved the collection of 300 soil samples, with precise coordinate's locked using GPS technology. Soil variability maps for soil micronutrient Zn,Fe, Mn and Cu were generated by using Arc GIS 10.5 on the basic of latitude and longitude of sample site by using hand GPS device and analysised sample data.
Results: The available-Zn of the soils ranged from 0.03 to 4.39 mg kg-1 with a mean value 0.61 mg kg-1, the soil falls under low (64.67%) to medium (30.33%) in available Zn. The available-Fe of the soils ranged from 1.09 to 12.54 mg kg-1 with a mean value 4.29 mg kg-1, the soils falls under low (58.00%) and medium (31.67%) categories for available Fe. The available-Mn of the soils ranged from 2.27-22.31 mg kg-1 with a mean value 5.74 mg kg-1, the soils of farm falls under medium (28.33%) to high (69.34%) in available Mn. The available-Cu of the soils ranged from 0.32-2.25 mg kg-1 with a mean value 1.09 mg kg-1, the soil comes under high (57.00%) and very high (30.33%) categories for available Cu.
Conclusion: Spatial variability map it was found that high amount of Zn, Mn, Fe present in the soil of field number 14 and 12A compare to other field. The possible cause behind this may due to adoption of organic farming practices in field number 14 and execution of integrated farming system modules in field number 12A from some year.

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Keywords: GPS, Arc GIS 10.5, organic farming practices and integrated farming system.

1. INTRODUCTION

Soil is a finite, non-renewable natural resource that defines the feasibility of implementing an Agricultural development program (Vedadri and Naidu 2018)[13]. Micronutrient are vital for optimal plant growth and development, despite being required in small quantities. Zinc (Zn), iron (Fe), manganese (Mn), copper (Cu), boron (B), molybdenum (Mo), and nickel (Ni) are essential micronutrients. While discussions on soil fertility often focus on macronutrients like nitrogen, phosphorus, and potassium, the significance of micronutrient should not be underestimated. These micronutrients play critical roles in various physiological and biochemical processes within plants. Ziaeian and Malakouti (2001)[14] found tha Fe, Mn, Zn and Cu fertilization significantly increased grain yield, straw yield, 1000-grain weight, and the number of grains per spikelet. Zinc is essential for enzyme activity and growth hormone synthesis, while iron is crucial for the respiration, photosynthesis and nitrogen fixation processes. Manganese is essential for oxidation and reduction activities, as well as electron transport in photosynthesis. Copper is involved in protein and lignin synthesis. The availability and distribution of micronutrient cations significantly influence plant health and productivity. Inadequate levels can lead to nutrient deficiencies, causing stunted growth, reduced yields, and increased susceptibility to pests and diseases. Conversely, excessive concentrations can lead to toxicity and hinder plant growth.

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Geographical Information System (GIS) is a powerful tool that integrates diverse spatial information, such as agro-climate zones, land use, and soil management. GPS satellites collect data transmitted to ground-based receivers, which is then utilized by GIS software to analyze and utilize the information. By utilizing GPS technology for soil sample collection, soil variability maps can be created, enabling the measurement of nutrient status and guiding efficient fertilizer use. GIS techniques facilitate the generation of site-specific nutrient recommendations, enhancing precision in agricultural practices.

Soil fertility mapping involves the systematic collection and analysis of soil samples to assess geographical representation showing diversity of essential nutrients, pH levels, organic matter content, and other soil properties. This mapping provides valuable information about the fertility status of agricultural fields, aiding in the development of targeted soil management strategies

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2. MATERIAL AND METHOD

2. Materials and Methods

Agricultural Research Station, Ummedganj-Kota is situated in Agro-climatic zone V “Humid South Eastern Plain” which falls in south eastern part of Rajasthan. According to Agro-ecological region map brought out by National Bureau of Soil Survey and Land Use Planning (NBSS & LUP, Nagpur), Kota falls in Agro-ecological region No 06 “Hot Semi-Arid Eco-Region with Shallow and Medium (Dominant) Black Soils” which covered 9.5% of the area of the country. Agricultural Research farm Ummedganj, Kota is located at the 75025’ N latitude 25013’ E longitude and an altitude of 258 m above mean sea level.

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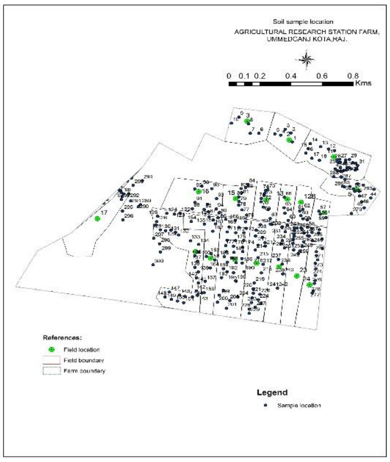
Soil sampling was carried out after harvesting of Rabi crops (in the months of April to May, 2019). Total area of the farm was 107 ha, which was officially marked as farm and mostly under cultivation. Total 300 Geo-referenced surface (0-15 cm) soil samples representing the field were collected following standard methods from 18 blocks/ fields of Agricultural Research Station, Ummedganj-Kota. Soil variability maps for various soil properties were produced using the latitude and longitude, the point shape files showing the location of the observation were generated by using Arc GIS 10.5.



Map1: Sampling points at Agricultural research Station Farm, Ummedganj, Kota

The collected soil samples were dried in shad, cursed and sieved for laboratory analysis. The micronutrients (Fe, Mn, Zn and Cu) were extracted using 0.005M DTPA, 0.01M calcium chloride and 0.1M triethanolamine buffered at pH 7.3 (Lindsay and Noorvell,1978)[8]. DTPA extractant has the ability to chelate Zn, Cu, Fe and Mn in competition with Ca++ and Mg++ and unlike most chelating agent. Took 10 g soil and add 20 ml of DTPA extractant than shake for 2 hrs in mechanical shaker and filter it. Concentration of micronutrients measured by Atomic Absorption Spectrophotometer (AAS) in the filtrate.

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Table.1 Six tier ratings of DTPA extractable micronutrients in soil

S. NO.	Ratings	Fe Mg kg-^{1}	Mn Mg kg-^{1}	Zn Mg kg-^{1}	Cu Mg kg-^{1}
1.	Very low	<2.5	<1	<0.3	<0.1
2.	Low	2.5-4.5	1-2	0.3-0.6	0.1-0.2
3.	Medium	4.5-9	2-4	0.6-1.2	0.2-0.4
4.	Moderately high	9-18	4-8	1.2-1.8	0.4-0.8
5.	High	18-27	8-16	1.8-2.4	0.8-1.2
6.	Very high	>27	>16	>2.4	>1.2
	Critical limits	**10**	**2.0**	**0.6**	**0.2**

Katkar and Patil (2010)[6]

3. Data Analysis and Interpretation

Table 2: Distribution of available Zn and Fe in the soils of Agricultural Research Station, Ummedganj-Kota

Available-Zn (mg kg^{-1})	No. of samples	% Samples	Available-Fe (mg kg^{-1})	No. of samples	% Samples
Very low (<0.3)	1	0.33	Very low (<2.5)	23	7.67
Low (0.3-0.6)	194	64.67	Low (2.5-4.5)	174	58.00
Medium (0.6-1.2)	91	30.33	Moderate (4.5-9)	95	31.67
Moderately high (1.2-1.8)	9	3.00	Moderately high (9-18)	8	2.66
High (1.8-2.4)	4	1.33	High (18-27)	Nil	Nil
Very high (>2.4)	1	0.33	Very high (>27)	Nil	Nil
General statistics					
Range	0.03-4.39		Range	1.09-12.54	
Mean	0.61		Mean	4.29	
Standard deviation	0.38		Standard deviation	1.57	
CV%	61.73		CV%	36.60	

Table 3: Distribution of available Mn and Cu in the soils of Agricultural Research Station, Ummedganj-Kota

Available-Mn (mg kg^{-}	No. of	%	Available-Cu (mg kg^{-}	No. of	%

[1])	samples	Samples	[1])	samples	Samples
Very low (<1)	Nil	Nil	Very low (<0.1)	Nil	Nil
Low (1-2)	Nil	Nil	Low (0.1-0.2)	Nil	Nil
Medium (2-4)	85	28.33	Medium (0.2-0.4)	5	1.67
Moderately high (4-8)	164	54.67	Moderately high (0.4-0.8)	33	11.00
High (8-16)	44	14.67	High (0.8-1.2)	171	57.00
Very high (>16)	7	2.33	Very high(>1.2)	91	30.33
General statistics					
Range	2.27-22.31		Range	0.30-2.25	
Mean	5.74		Mean	1.09	
Standard deviation	3.11		Standard deviation	0.29	
CV%	54.15		CV%	26.88	

4 Spatial interpolation techniques used for fertility mapping

Spatial interpolation is the process of using points with known values to estimate values at other unknown points. This techniques helped to generated full area micronutrient fertility maps through used some point of soil sampling.

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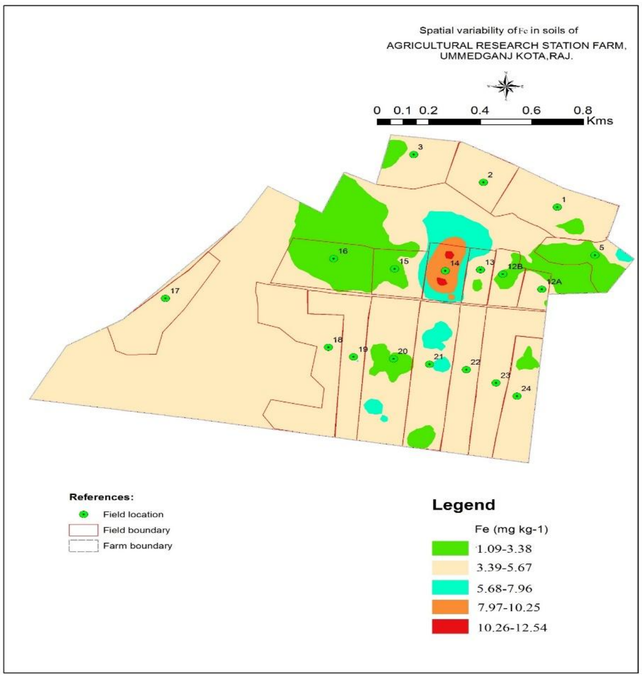
Table 4: Extent of area under different Fe- availability category of the soils of Agricultural Research Station, Ummedganj-Kota

Fe-Availability Category	Available-Fe, mg kg^{-1}	Ranking of the class on the basis of area
I	1.09-3.38 (77)*	II
II	3.39-5.67 (188)	I
III	5.68-7.96 (26)	III
IV	7.97-10.25 (6)	IV
V	10.26-12.54 (3)	V

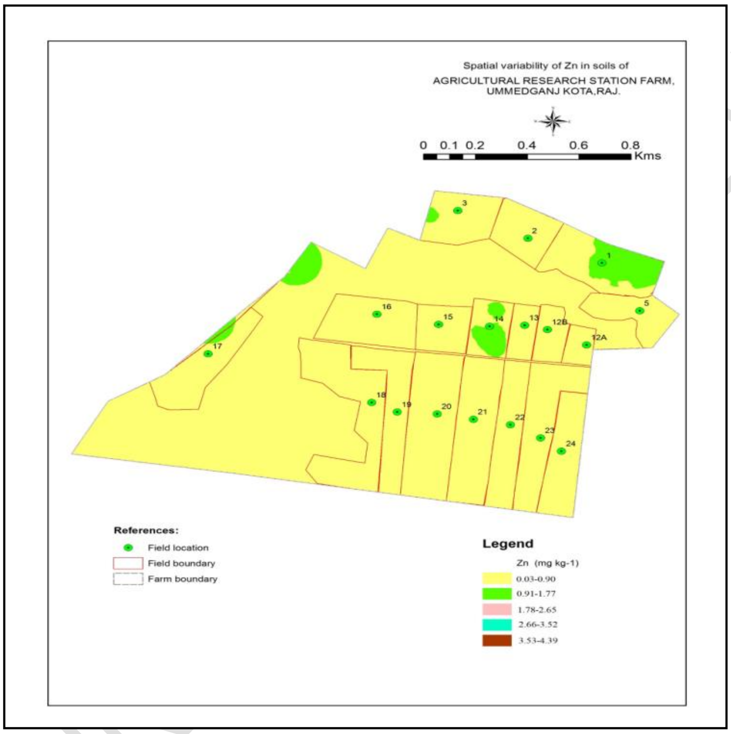


Map 2: Spatial Distribution of available iron in the soils of Agricultural Research Station, Ummedganj-Kota

Table 5: Extent of area under different zinc availability category of the soils of Agricultural Research Station, Ummedganj-Kota

Zn-Availability Category	Available-Zn (mg kg^{-1})	Ranking of the class on the basis of area
I	0.03-0.90 (263)*	I
II	0.91-1.77 (32)	II
III	1.78-2.65 (4)	III
IV	2.66-3.52 (0)	V
V	3.53-4.39 (1)	IV

***** In bracket, number of soil samples under the category.

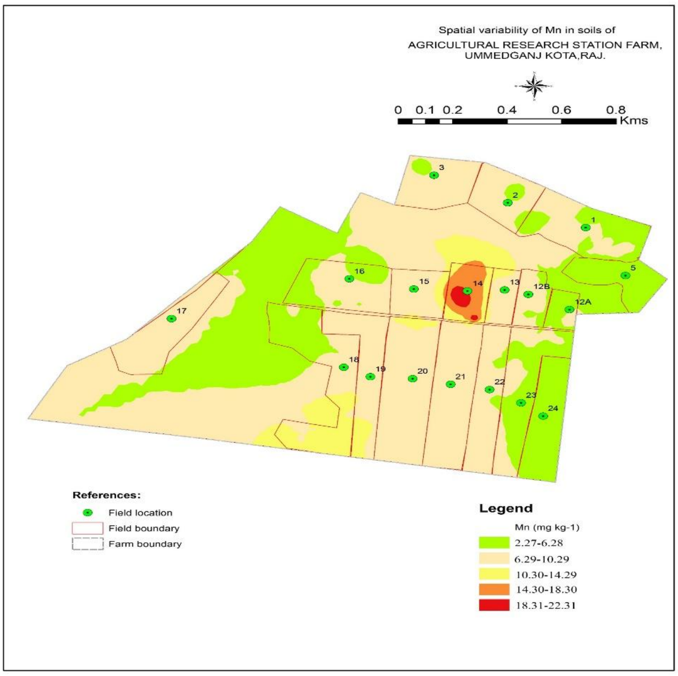


Map 3: Spatial Distribution of available zink in the soils of Agricultural Research Station, Ummedganj-Kota

Table 6: Extent of area under different Mn availability category of the soils of Agricultural Research Station, Ummedganj-Kota

Mn-Availability Category	Available-Mn, mg kg^{-1}	Ranking of the class on the basis of area
I	2.27-6.28 (206)*	I
II	6.29-10.29 (79)	II
III	10.30-14.29 (7)	IV
IV	14.30-18.30 (3)	V
V	18.31-22.31(5)	III

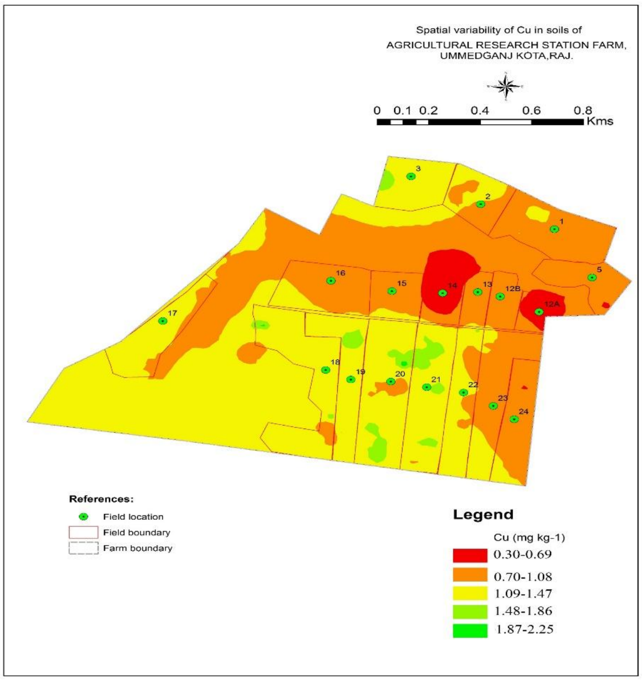
***** In bracket, number of soil samples under the category



Map 4: Spatial Distribution of available manganese in the soils of Agricultural Research Station, Ummedganj-Kota

Table 7: Extent of area under different Cu- availability category of the soils of Agricultural Research Station, Ummedganj-Kota

Cu-Availability Category	Available-Cu, mgkg-^{1}	Ranking of the class on the basis of area
I	0.30-0.69 (21) *	IV
II	0.70-1.08 (135)	I
III	1.09-1.47 (113)	II
IV	1.48-1.86 (29)	III
V	1.87-2.25 (2)	V



Map 5: Spatial Distribution of available copper in the soils of Agricultural Research Station, Ummedganj-Kota

5 Results and Discussion

1. Available Zn

The available-Zn in the soils of ARS ranged from 0.03 to 4.39 mg kg^{-1} with a mean value 0.61 mg kg^{-1}, on the basis of analyzed data, the soils of ARS farm falls under low (64.67%) to medium (30.33%) in available Zn. Zinc deficiency is widespread not only in soils and crops of India (Takkar, 1997)[12] but also in many countries of the world (Cakmak, 2008)[2]. Since, the soils were alkaline and rich in $CaCO_3$, zinc may be precipitated as hydroxides and carbonates under alkaline pH range. Therefore, their solubility and mobility may be decreased resulting in reduced availability. In contrast, Zn extractability from soil is negatively related to phosphate (Yang *et al*., 2011)[14] and calcium carbonate content in soil (Iratkar *et al*., 2014)[5]. Therefore, low plant availability of Zn can be expected in calcareous soils. On the basis of soil analysis data, the field number 3 and 14 (1.20 and 1.07mg kg^{-1}) were have higher amount of Zn compare to other fields. The results are in close agreement with the findings of Rajendiran*et al*., (2018)[10] in the Alirajpur district of Madhya Pradesh, Kumar *et al*., (2015)[7] in the Theni district of Tamil Nadu, Amara *et al*, (2017)[1] of the soils of Bogur micro watershed in Karnataka state of India.

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2. Available Fe

The available-Fe in the soils of ARS ranged from 1.09 to 12.54 mg kg^{-1} with a mean value 4.29 mg kg^{-1}. The soils of ARS farm falls under low (58.00%) and medium (31.67%) categories in available Fe. Iron deficiency can be explained by high soil pH (7.7) and little SOC (Foroughifar*et al*. 2013)[4], which also indicated by the negative correlation between Fe and pH and a positive correlation between Fe and SOC. Low Fe content may be due to precipitation of Fe^{2+} by $CaCO_3$ and decrease the availability. On the basis of soil analysis data that field number 14 (10.08 mg kg^{-1}) have contains higher amount of available Fe compare to other fields, because continuous organic farming practices performed in field number 14 and integrated farming system modules executed in field number 12A from some years. The results are in close agreement with the findings of Amara *et al*., (2017) [1] of the soils of Bogur micro watershed in Karnataka state of India, Madhu *et al*., (2017) [9] in the soils of JamunaPaar regions of Allahabad District, Uttar Pradesh.

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3. Available Mn

The available-Mn in the soils of ARS ranged from 2.27-22.31 mg kg^{-1} with a mean value 5.74 mg kg^{-1}, the soils of ARS farm falls under medium (28.33%) to high (69.34%) in available Mn. Manganese deficiency usually does not occur in black soils because a sizeable portion of Mn is bound with manganese oxide which may be readily available (Singh, 1988)[11].On the basis of soil analysis data the field number 14 (10.08 mg kg^{-1}) have contains higher amount of available Mn compare to other fields because organic farming practices applied in this field from some years. The results are in close agreement with the findings of Amara *et al*., (2017)[1] in the soils of Bogur micro watershed in Karnataka state of India, Dash *et al*., (2018)[3] RRTTS and KVK farm, Dhenkanal located in the mid-central table land Agro climatic zone of Odisha, India.

4. Available Cu

The available-Cu in the soils of ARS ranged from 0.30-2.25 mg kg^{-1} with a mean value 1.09 mg kg^{-1}, the soils of ARS farm falls under high (57.00%) and very high (30.33%) categories in available Cu. Reason behind this, sufficient amount of Cu content in soils due to low availability of organic carbon, because copper formed chelates and has negative correlation with the OC. According to soil analytical data and spatial variability map the soils of field number 19 was found highest in amount of Cu content (1.48 mg kg^{-1}) at ARS, Kota. The results are in close agreement with the findings of Amara *et al*., (2017)[1] of the soil of Bogur micro watershed in Karnataka state of India, Madhu *et al*., (2017)[9] in the soils of JamunaPaar region of Allahabad District, Uttar Pradesh.

6. Conclusion

It can be concluded from above result that available-Zn, Fe, Mn and Cu ranged from 0.03 to 4.39mg kg^{-1},1.09 to 12.54mg kg^{-1},2.27-22.31mg kg^{-1} and 0.30-2.25mg kg^{-1} with mean value 0.61mg kg^{-1}, 4.29mg kg^{-1},5.74mg kg^{-1} and 1.09mg kg^{-1}, respectively. Spatial variability map it was found that high amount of Zn, Mn, Fe present in the soil of field number 14 and 12A compare to other field. The possible cause behind this may due to adoption of organic farming practices in field number 14 and execution of integrated farming system modules in field number 12A from some year. Cu was highest amount evaluated in the soils of field number 19. Soil fertility index mean value was observed for Zn-1.21, Fe-1.15, Mn-1.96 and Cu-2.58, as resulted, soil fertility class for Zn and Fe were low, medium for Mn and high fertility class for Cu. This data also very useful for providing a base for making sounds fertilizers recommendations for various crops and crop planning in near future. Spatial variability analysis of nutrient is one of key factor precision agriculture management.

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