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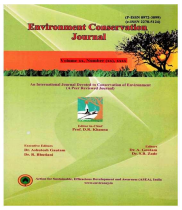

Spatial variability map of micronutrients in vegetable growing area of Varanasi

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ABSTRACT

Soil pH and the availability of essential micronutrients is a deciding factor for vegetable production. Major nutrients i.e. nitrogen, phosphorus, potassium, micronutrients are critical elements in enhancing vegetable growth and productivity. The present study focused on the micronutrient status of a vegetable growing area i.e. Shanshahpur village of Varanasi, Uttar Pradesh, India. Spatial variability maps were prepared from 50 samples collected from individual vegetable intercropping system from farmer's field for all the micronutrient element i.e. Fe, Mn, Zn & Cu respectively. Most of the soils of the vegetable growing area of Shanshahpur were alkaline (7.99-8.72) in nature and lies within a safe range of electrical conductivity (<0.20 dSm^{-1}). However, a medium range of soil organic carbon (0.50-0.75%) status was observed throughout the area. According to the variability map for micronutrient status there was a medium to high status for available Cu (0.81 $mgkg^{-1}$) but in contrast available Fe and Zn content of the vegetable growing lies in low status category(2.00-13.15$mgkg^{-1}$ and 0.02-2.26 $mgkg^{-1}$ respectively). Available Mn status was seen reduced with increased alkalinity (9.08-0.74 $mgkg^{-1}$). But most of the micronutrients were deficient for vegetable production because maximum number of soil samples lies in alkaline category which throws a scope towards amelioration of the vegetable growing soils for reducing its pH.

Introduction

The micronutrients play important role in Indian agriculture towards sustainable crop production. Thus, the importance of micronutrients need to be viewed in food systems context, as their inclusion in balanced fertilization schedule would optimize micronutrient supply and availability in the entire food consumption cycle (James and Henry, 2020). Indian soils are generally poor in fertility especially in micronutrients as these have consistently been mined away from their finite soil source due to continuous cultivation for a very long time without addition of micronutrient fertilizer resulting in emerging micronutrient deficiency (Hotz and Gibson, 2007). In addition, green revolution led-increased demand of micronutrients by the high yielding crop cultivars (especially rice and wheat) as well as adoption of intensive cropping practices, use of high-analysis fertilizers with low micronutrient content, decreased use of organic manures and crop residues, growing of crops in soils with low micronutrient reserves. Besides, other natural and anthropogenic factors are adversely affecting phyto-availability of micronutrients aggravated the situation. Geostatistics and geographic information system (GIS) provide powerful tools for analysing spatial variability and visualizing spatial classification, as well as other spatial algebraic functions (Hedge *et al.,* 2019). In the last two decades, these techniques have been applied widely in soil science to explore

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spatial variability of physical and chemical properties of soils under grain crops and pasture in developed countries (Blackmore *et al.,* 1998). Site specific nutrient management (SSNM) was developed for large-scale agriculture with high levels of mechanization. The objective of this study is to investigate spatial variability of micronutrients in vegetable growing areas of Varanasi.

Material and Methods

Experimental Site details

Fifty soil samples are collected from vegetable growing fields using hand held GPS 1:50000 scale. Soils are collected from 25.08° to 25.23° N latitude and 82.50° to 83.03° E longitude having altitude of 80.71 meters above mean sea level (MSL).

Evaluation of Soil fertility status

The soil samples are analyzed for pH by pH meter (Jacksons 1978), EC content by EC meter (Jacksons 1978), and organic carbon by Wet oxidation method using Walkley and Black (1934),

Estimation of Micronutrients of the sampled soils

The available Fe, Mn, Cu and Zn of the soil sample were determined with 0.005M DTPA (Diethylene Triamine Penta Acetic Acid) using Atomic Absorption Spectrophotometer using (Lindsay and Norvell, 1978).

Generation of Spatial Variability Map

The spatial variability map of micronutrients was created by descriptive statistics &geostatistical methods as proposed by (Li *et al.,* 2021).

Results and Discussion

Soil fertility status

The pH in soils of Shanshahpur village generally ranged from slightly acidic to alkaline (6.03-8.72). The lowest pH (6.03) value was obtained in S_{19}. The maximum pH (8.72) value was observed inS_{13} i.e. pumpkin field (Table 1). The mean value of pH was 7.99. Most of the samples were slightly alkaline in pH (90%), few were acidic to neutral i.e. 8% and 2 % respectively. Similar result was observed by Singh *et al.*(2016) in the soil of Sevapuri block of Varanasi of Uttar Pradesh. The map indicates that most of the vegetable growing areas were in neutral to alkaline pH. The electrical conductivity in soil of Shanshahpur village were in normal range, with a mean of 0.20 dSm^{-1}, the lowest value being 0.11 dSm^{-1}in S_5, S_9 & S_{50} and highest EC value being 0.52 dSm^{-1} in S_2 (Table 1).Similar results were observed by Chaurasia *et al.* (2013) in the district of Varanasi of Uttar Pradesh. Their above map shows that most of the areas were in low to medium category of EC & ranged from 0.11-0.52 dSm^{-1} and a small portion were in high category.

The maximum and minimum percent of organic carbon content in soils of Shanshahpur village of Varanasi were 0.49% and 0.92% respectively (Table 1). However, the minimum percent of organic carbon were found from pointed gourd field. Most of the samples (86%) were in medium range in terms of organic carbon status followed by high status (10%) and low status (4%). Similar result was observed by Singh *et al*. (2016) in Shikhar block of Mirzapur district of Uttar Pradesh.

Micronutrients status of the sampled soils according to the Variability maps

The available Cu content ranges from 0.22 to 2.46 $mgkg^{-1}$of soil (Table 2). Maximum soil samples were in high category (92%) with mean value 0.81 $mgkg^{-1}$. The similar content of available Cu was also reported by Sahoo *et al*. (1989). However, Panwar and Totawat (2004) reported the range of Cu from 0.27 to 1.04 $mgkg^{-1}$ of soil. The variability map shows (Figure 1) that the available Cu were in medium to high category and a small portion were in low category. The available Mn content in soil ranges from 0.74 to 9.08 $mgkg^{-1}$. (Table 2).However, maximum soil samples were in low category (66%).The similar findings were reported by Panwar and Totawat (2004).The variability map shows (Figure 2) that the soil Mn content in low category. Further, the availability of manganese decreased in alkaline soil.

The available Fe content ranges from 2.00 to 13.15 $mgkg^{-1}$ of soil (Table 2). Maximum soil samples were in low category (92%).Patel *et al*. (1995) also reported the same results in command areas of Gujarat. The available iron content in the vegetable growing areas were in low category as shown by the variability map (Figure 3). Further, the available Zn in soil content in soil ranged from 0.02 to 2.26 $mgkg^{-1}$. (Table 2). Maximum soil samples were in low category (88%). Singh *et al*. (1989) was also reported similar result in plain areas of Haryana. The low content of available Zn in surface horizon was also reported by Singh and Tripathi (1983), Vijay Kumar *et al*. (1996), Sen *et al*. (1997) and

Table 1: pH, EC(dSm^{-1}) and organic carbon(%) content in soils of Shanshahpur village.

SN	pH	EC (dSm^{-1})	OC (%)
S_1	6.10	0.34	0.53
S_2	7.43	0.52	0.49
S_3	7.74	0.15	0.57
S_4	7.95	0.13	0.65
S_5	8.40	0.11	0.49
S_6	8.43	0.16	0.69
S_7	8.46	0.17	0.61
S_8	8.07	0.16	0.69
S_9	8.23	0.11	0.67
S_{10}	8.60	0.17	0.61
S_{11}	8.68	0.17	0.71
S_{12}	8.26	0.16	0.74
S_{13}	8.72	0.15	0.73
S_{14}	7.98	0.14	0.60
S_{15}	8.11	0.15	0.64
S_{16}	7.31	0.15	0.63
S_{17}	7.81	0.21	0.70
S_{18}	6.31	0.26	0.63
S_{19}	6.03	0.39	0.55
S_{20}	7.88	0.19	0.68
S_{21}	7.48	0.17	0.61
S_{22}	8.23	0.16	0.54
S_{23}	8.12	0.27	0.68
S_{24}	8.20	0.20	0.76
S_{25}	8.15	0.20	0.73
S_{26}	8.10	0.23	0.56
S_{27}	7.95	0.22	0.75
S_{28}	8.03	0.20	0.67
S_{29}	7.95	0.22	0.78
S_{30}	8.25	0.22	0.68
S_{31}	8.32	0.19	0.67
S_{32}	8.63	0.20	0.64
S_{33}	8.70	0.24	0.68
S_{34}	7.98	0.17	0.65
S_{35}	8.47	0.26	0.75
S_{36}	8.52	0.23	0.79
S_{37}	8.20	0.23	0.56
S_{38}	8.14	0.19	0.69
S_{39}	8.30	0.18	0.61
S_{40}	8.35	0.21	0.64
S_{41}	8.37	0.18	0.57
S_{42}	8.25	0.17	0.73
S_{43}	8.26	0.19	0.60
S_{44}	7.55	0.15	0.70
S_{45}	8.18	0.16	0.67
S_{46}	8.33	0.23	0.92
S_{47}	7.95	0.19	0.64
S_{48}	7.62	0.19	0.68
S_{49}	7.98	0.21	0.86
S_{50}	6.41	0.11	0.87
Range	6.03-8.72	0.11-0.52	0.49-0.92
Mean	7.99	0.20	0.67
S.D.	0.62	0.07	0.09
C.V. (%)	7.75	35.05	13.43

Table 2: Available DTPA extractable micronutrients (mgKg^{-1}) in soils of Shanshahpur village.

Sample no.	Available Cu (mgKg^{-1})	Available Mn (mgKg^{-1})	Available Fe (mgKg^{-1})	Available Zn (mgKg^{-1})
S_1	1.14	2.24	3.05	0.25
S_2	1.17	2.28	2.93	0.34
S_3	2.46	3.76	2.66	0.30
S_4	1.79	9.08	2.54	0.60
S_5	0.67	0.88	3.56	0.15
S_6	1.28	1.24	2.41	0.16
S_7	0.82	0.83	3.77	0.15
S_8	1.02	2.90	2.06	0.20
S_9	0.79	1.15	2.00	0.68
S_{10}	0.94	0.78	2.69	0.16
S_{11}	0.67	0.74	2.39	0.23
S_{12}	0.80	1.61	2.28	0.43
S_{13}	0.51	0.80	3.83	0.18
S_{14}	1.03	1.39	2.14	0.13
S_{15}	0.48	0.74	2.96	0.12
S_{16}	0.85	1.99	3.46	1.41
S_{17}	0.92	1.77	2.57	0.32
S_{18}	0.34	1.79	12.25	0.40
S_{19}	0.24	2.67	3.75	0.21
S_{20}	0.66	1.60	2.87	0.14
S_{21}	0.22	2.20	3.58	0.10
S_{22}	0.02	0.90	3.73	0.12
S_{23}	0.46	2.06	2.25	0.25
S_{24}	0.68	1.45	2.13	0.47
S_{25}	0.56	1.52	2.84	0.46
S_{26}	0.69	1.29	7.26	0.60
S_{27}	0.58	3.33	3.35	0.67
S_{28}	0.75	1.38	2.67	0.33
S_{29}	0.68	1.98	2.20	0.56
S_{30}	0.74	1.53	3.33	0.26
S_{31}	0.73	1.07	2.94	0.14
S_{32}	0.77	1.15	2.52	0.17
S_{33}	0.90	1.24	3.76	0.17
S_{34}	0.70	2.26	4.24	0.14
S_{35}	1.94	1.09	3.49	2.26
S_{36}	1.11	0.75	3.51	0.12
S_{37}	0.42	1.01	2.66	0.11
S_{38}	0.84	0.94	2.34	0.14
S_{39}	0.67	2.38	3.22	0.30
S_{40}	0.69	1.79	2.48	0.27
S_{41}	0.78	2.97	2.28	0.09
S_{42}	0.81	3.39	3.86	0.18
S_{43}	0.52	2.69	2.40	0.03
S_{44}	0.75	2.01	2.34	0.02
S_{45}	0.86	1.07	2.93	0.05
S_{46}	1.14	0.78	2.69	0.38
S_{47}	0.90	1.10	13.15	0.08
S_{48}	0.77	2.56	2.86	0.06
S_{49}	0.8	1.84	2.68	0.22
S_{50}	0.65	3.8	4.84	0.09
Range	0.22-2.46	0.74-9.08	2.00-13.15	0.02-2.26
Mean	0.81	1.91	3.39	0.31
S.D.	0.41	1.32	2.10	0.37
C.V. (%)	50.61	69.10	61.94	119.35

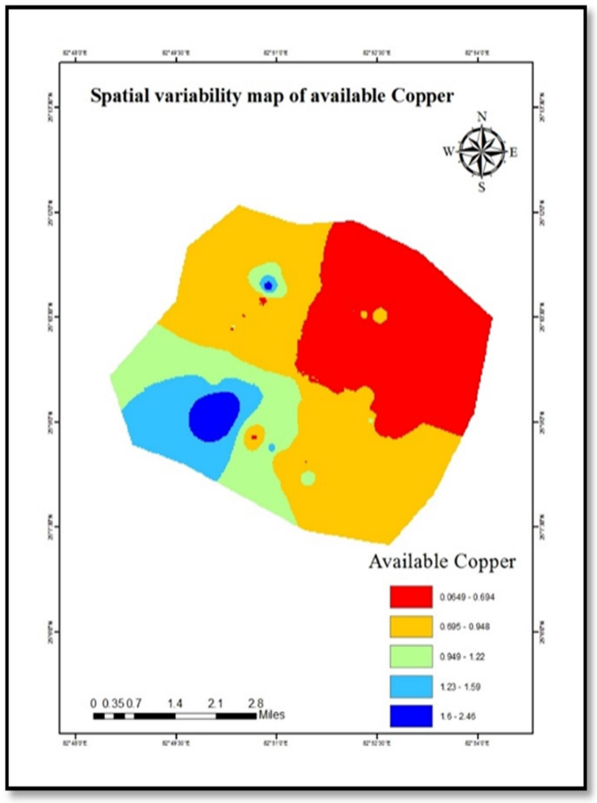

Figure 1: Spatial variability map for available Copper (Cu).

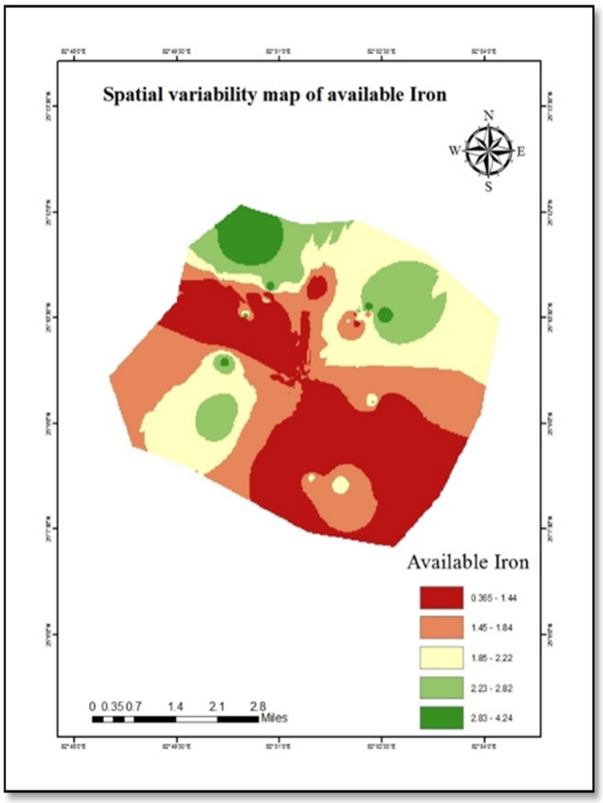

Figure 3: Spatial variability map for available Iron (Fe).

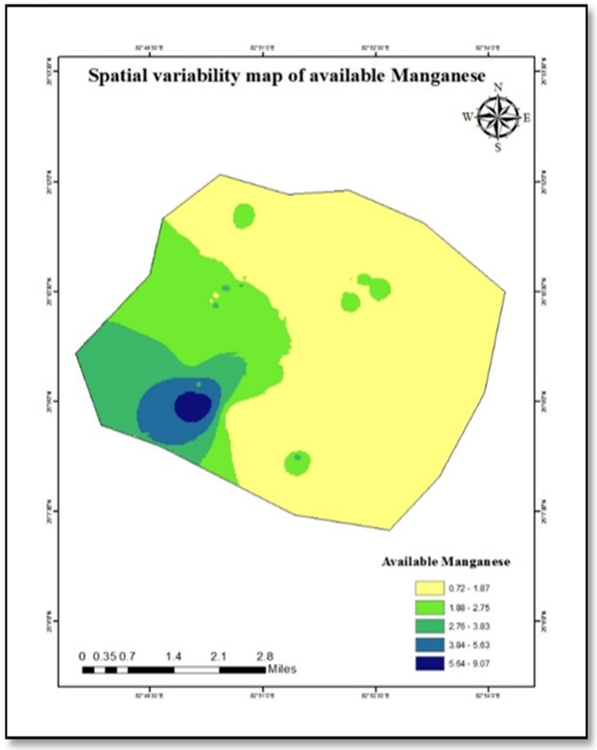

Figure 2:Spatial variability map for available Manganese (Mn).

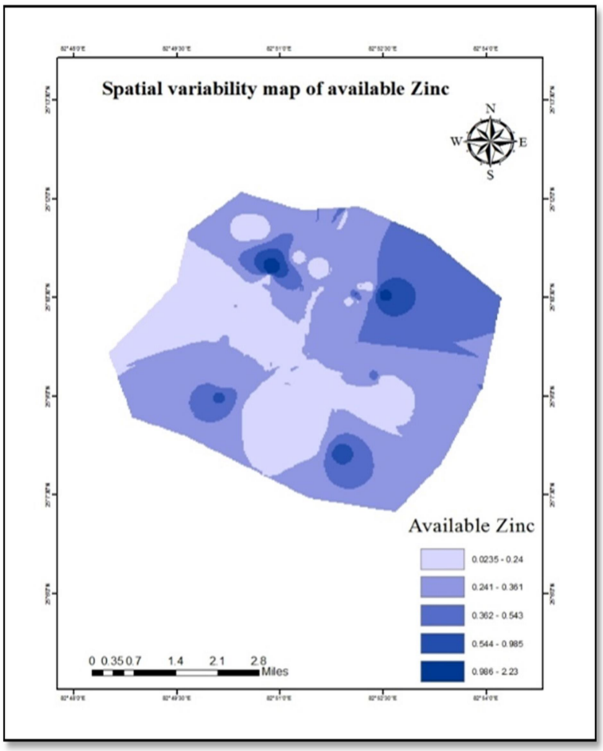

Figure 4: Spatial variability map for available Zinc (Zn).

Sharma *et al*. (2000). According to the variability map (Figure 4) most of the soil samples were Zn deficient. But the low available Zn in surface layer was due to complexing with organic matter.

Conclusion

It is observed that most of the soils of the vegetable growing area of Shanshahpur were alkaline in nature and lied within a safe range of electrical conductivity. However, a medium range of soil organic carbon status was observed throughout the area. According to the variability map for micronutrient status there was a medium to high status for available Cu but in contrast available Fe and Zn content of the vegetable growing lies in low status category. Further, the available Mn status was seen to be reduced with increased the alkalinity.However, most of the micronutrients were deficient for vegetable production as most of the soil samples lies in alkaline category which throws a scope towards amelioration of the vegetable growing soils for reducing its pH.

Conflict of interest

The authors declare that they have no conflict of interest.

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