Assessment of Cationic Micronutrient status for Efficient Farm Management in an Experimental Farm in the Tiruvannamalai District, Tamil Nadu, India

ABSTRACT

The experiment delineated micronutrient (Zn, Cu, Fe and Mn) availability in the soils of experimental farm of Agricultural college and Research Institute, Vazhavachanur under the Alfisols soil order of Tamil Nadu, India. Available Zn in the varied from 0.09 to 1.69 mg kg^{-1} with an average value of 0.83 mg kg^{-1}. The major portion of the soil samples (71.2%) falls under low category while only 1.7 per cent samples were high in available Zn. Nutrient index value (NIV) of Zn availability in soil was also calculated (NIV=1.31) and found to be low. Similarly Iron content in 43.2 per cent of the soil samples falls under low category and 55.1 per cent of the samples were under medium category. The NIV value of Fe was found to be low. The Cu availability is high in 51.7 per cent of the soil samples and the NIV was medium and Mn content in 67 per cent of the soils falls under medium category and NIV was also medium. Thus, results revealed that soils of the experiemental farm were potential Zn and Fe deficient areas. Application of Zn and Fe both as soil as well as soil plus foliar might be beneficial in enhancing the yield and quality of crops of the experimental farm.

Keywords: *Cationic micronutrients, Nutrient index value, soil fertility, farm*

1.INTRODUCTION

Deficiency of Fe and Zn rank 5^{th} and 11^{th}, respectively among the 20 most important risk factors responsible for the development of illnesses and diseases throughout the world; while in developing countries; according to a WHO report, this deficiency stands in 5^{th} position among the 10 most important factors [1]. The Indian agricultural soils are becoming a greater deficient of plant nutrients day by day [2,3]. Zinc, cobalt, molybdenum, copper, selenium and manganese are out of 25 nutrients required for balancing of life in animal, plant and human, which are considered as micronutrients [4].

Micronutrient deficiencies in soils not only limit crop production, but they also have negative effects on human nutrition and health, thus gaining an importance of its proper delineation in the farm. Micronutrients distribution may diverse through the different soil profiles based on their development from dissimilar parent materials and agro-climatic situations. Cationic micronutrients (Zn, Cu, Fe and Mn) requirement is very low for growth and development of crop.

Micronutrients deficiency is becoming prominent due to intensive crop cultivation practice by adopting high yielding varieties of crops leading to loss of crop yields as well as quality of crops [5]. The Indian soils are of deficient in essential micronutrients in districts, states and different Agro-ecological zones across the country [2] leading to suffering from micronutrient deficiency that reducing the productivity and degrading the food quality. So, delineation of available quantities of these micronutrients with frontier technologies *viz.,* use of global positioning system (GPS) and geographical information system (GIS) has gained a prime importance in Indian agriculture and would be useful to give ready reckoner to farmers for optimization of management of these high value nutrients to maintain yield and quality of crops. Keeping the above in view, the study was undertaken in an experimental farm falling under Alfisol soil order to delineate and to prepare GPS-GIS based delineation map of available Zn, Cu, Fe and Mn. The results would be immensely helpful in deciding the micronutrients fertilization of crops in the experimental farm of Agricultural College.

2. MATERIALS AND METHODS

The study was conducted in soils of experimental farm of Agricultural college and Research Institute, Vazhavachanur, Tamil Nadu Agricultural university in Tiruvannamalai district (Fig. 1). Geographically the study area is located between 12°4'15" N to 12°4'45" N Latitude and 78°59'0" E to 77°59'25" E Longitudes. The annual rainfall of the region is 759.4 mm. The mean maximum and minimum temperatures are 38°C and 21°C, respectively.

Commented [DK1]: Spacing problem

Grid wise (50 x 50 m grids) surface soil samples were collected from 118 locations. A global positioning system (GPS) device was used to record the coordinates of each sampling point. Samples were air dried in shade and passed through 2 mm sieve and analyzed for physico-chemical properties. Thereafter, these samples were analysed for physico-chemical properties *viz*., soil pH and organic carbon as well as DTPA extractable Zn, Cu, Fe and Mn contents. The collected samples were differentiated as deficient (low), moderate (medium) and sufficient (high) by their availability within soils system [5] as stated in Table 1. Nutrient indexing of available Zn, Cu, Fe and Mn in cultivated soils of Agricultural College and Research Institute farm, was calculated and presented. The soils of the studied soils are falling in the soil order Alfisols. The NIV was calculated after collecting and analysing soil samples of 118 number from Agricultural college farm.

Nutrient index value (NIV) for soils of individual district was calculated using Parker's equation [6] from the proportion of soils under low, medium and high available nutrient categories, as represented by

$$NIV = \frac{[(P_H \times 3) + (P_M \times 2) + (P_L \times 1)]}{100}$$

Where,

NIV = the nutrient index value

P_L, P_M and P_H are the percentage of soil samples falling in the category of low, medium and high nutrient status and given weightage of one, two and three, respectively (Ramamoorthy and Bajaj, 1969). Three different classes are assigned to soil on the basis of nutrient index value as described: Low 1.67, Medium 1.67- 2.33, High >2.33 as modified by [7].

UNDER PEER REVIEW

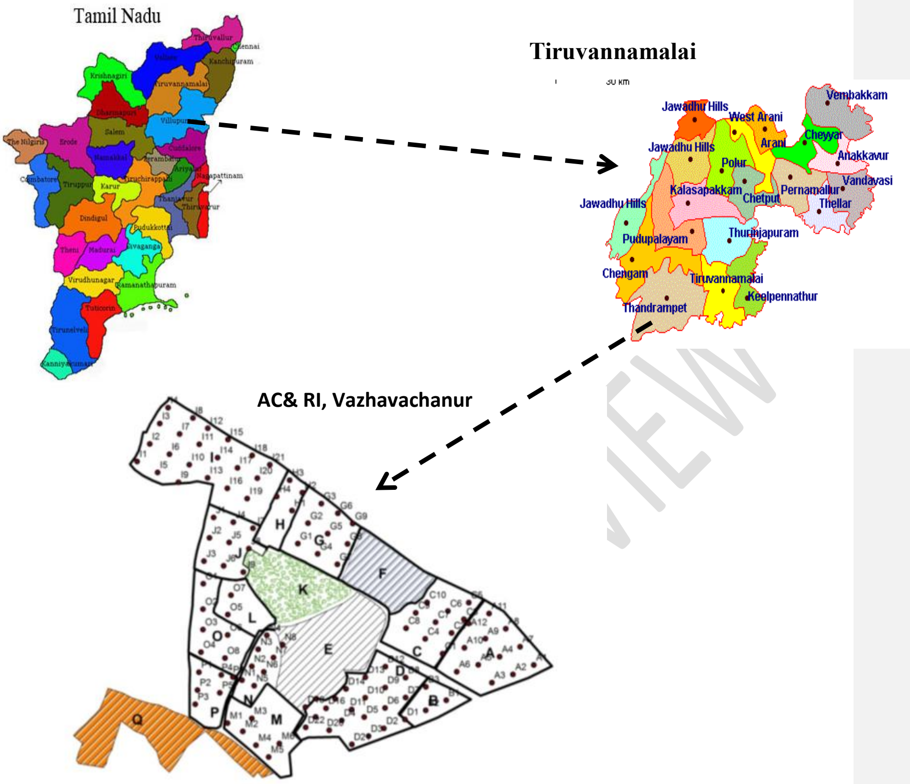

Fig.1. Study area located in AC & RI, Vazhavachanur farm (showing sampling points) of Tiruvannamalai District, Tamil Nadu, India

3. RESULTS AND DISCUSSION

3.1 SOIL pH

Results (Table 2) revealed that soil pH of the soils ranged from 6.31 to 7.84 with an average of 6.96. Almost 66.1% of samples were in between the pH range of 6-7 (slightly acidic); whereas, 33.9% recorded a pH range of 7-8 (slightly alkaline). So, from the survey report it was clear that major portion of the samples were under acidic in nature, may be due to the loss of basic cations from the soil. Availability of zinc decreases with increasing soil pH and in general, neutral and calcareous soils are deficient in pH induced Zn, though few showed exceptional status due to their availability increased form Zn chelation. The trace elements availability is controlled through various soil reactions such as precipitation, adsorption, desorption, ion exchange, inorganic and organic ligands, acid base equilibria and solid dissolution [8].

Table 1: Categorization of available micronutrients status in soil

Nutrient	Soil status (mg kg^{-1})

UNDER PEER REVIEW

	Deficient (low)	Moderate (medium)	Sufficient (High)
Zinc (mg kg^{-1})	<1.2	1.2-1.8	>1.8
Copper (mg kg^{-1})	<1.2	1.2-1.8	>1.8
Iron (mg kg^{-1})	<3.7	3.7-8.0	> 8.0
Manganese (mg kg^{-1})	<2.0	2.0-4.0	>4.0

3.2 SOIL ORGANIC CARBON

Results revealed that organic carbon in soil samples varied between 0.8 to 6.7 g/kg with an average value of 3.97 g/kg (Table 2). There was 57.6% samples which fall under low category (<5 g/kg), and 42.4% was categorized as medium (5-7.5 g/kg). It is clear from the survey data that organic carbon in soil belongs under low to medium range because of poor soil development and high intensive crop cultivation practices in some parts of the farm. The soil organic carbon enhances the availability of essential cation micronutrients and also reduces the toxicity by chelation [9]. The organic matter improved in plant nutrients uptake from the soil [9]..

Table 2. Descriptive statistics of soil properties

Soil properties	Minimum	Maximum	Mean	Median	Standard Deviation	CV (%)
pH	6.31	7.84	6.96	6.95	0.33	4.71
EC (d Sm^{-1})	0.10	0.80	0.25	0.20	0.14	56.69
Organic Carbon (g/kg)	0.80	6.70	3.97	3.15	2.28	57.38
Zn (ppm)	0.09	1.69	0.84	0.74	0.51	61.05
Cu (ppm)	0.09	3.88	1.88	1.83	0.96	51.22
Fe (ppm)	0.26	8.58	4.15	4.12	1.66	39.88
Mn (ppm)	0.26	6.10	2.92	2.80	1.12	38.54

Commented [DK2]: Unit is incorrect

Commented [DK3]: Unit of OC is % and difference between maximum and minimum is very high, so check the data.

3.3 Available Zn status of soil

Results of available Zn content in soils of Nadia district ranged from 0.09 to 1.69 mg kg^{-1} with a mean value of 0.84 mg kg^{-1} (Table 2). Results also demonstrated that major portion of the soil samples (71.2%) were low in available Zinc (<1.2 mg kg^{-1}), 27.1 % under medium and only 1.7% samples were high category. NIV of Zn availability in soil was 1.31, showed that Zn availability is under low category (Table 3). The index value of different nutrients calculated from the 14 blocks soil samples of Tiruchirapalli district (Tamil Nadu) suggested that the value was under the range of low to high for different study blocks [11]. The low Zn content may be due to poor soil formation and due to high cropping intensity in some areas.

3.4 Available Cu status of soil

The Copper availability in soil samples ranged between 0.09 to 3.88 mg kg^{-1} with an average of 1.88 mg kg^{-1}. Data obtained under survey showed soil samples belongs under the following categories: high (51.7%), medium (22.00%) and few samples (26.3%) are deficient in Copper. Its NIV value is also in the category of medium (2.25). GPS-GIS based nutrient map is presented in Fig. 2. The mapping was done according to availability in soil and reported sufficiency and deficiency of cationic micronutrients [12, 13].

UNDER PEER REVIEW

Table 3. Summary of the available status of Micronutrients in the soils

Nutrients	No. of Samples falling in the category of			NIV	Fertility Status
	Deficient (low)	Moderate (medium)	Sufficient (High)		
Zn (ppm)	71.2	27.1	1.7	1.31	Low
Cu (ppm)	26.3	22.0	51.7	2.25	Medium
Fe (ppm)	43.2	55.1	1.7	1.58	Low
Mn (ppm)	18.6	67.0	14.4	1.96	Medium

3.5 Available Fe status of soil

Fe availability in soil samples demonstrated that its magnitude varied between 0.26 to 8.58 mg kg^{-1} with an average value of 4.15 mg kg^{-1}. Results also displayed that almost all the samples (55%) were medium in available Fe content. NIV of available soil Fe is 1.58 (Table 3). GPS-GIS based nutrient map is presented in Fig. 2. The mapping of cationic micronutrients availability in soil was effective to identifying the sufficiency and deficiency of micronutrients in soil [13].

3.6 Available Mn status of soil

Mn availability in the soil samples varied from 0.26 to 6.10 mg kg^{-1} with an average value of 2.92 mg kg^{-1}. Results also showed that among all the soil samples, most of the soil (67%) recorded a medium value in its content, 14.4 % of the samples were high in its content and rest of the samples (18.6%) was low, NIV (Table 3) calculation for its amount in this farm also recorded a medium value (1.96) which is corroborated with aforesaid view. GPS-GIS based soil nutrient maps was presented in Fig. 2.

4. CONCLUSION

Information on micronutrients in soils of AC &RI, Vazhavachanur is not available. Attempts have, therefore been made in the present study to know the status of micronutrient availability in soils. Results revealed that available Zn content in soils varied between 0.09 to 1.69 mg kg^{-1} with an average value of 0.83 mg kg^{-1}. It was also noticed that major portion of the samples (71.2%) were under low category, while only 1.7% samples were high in Zn. Among micronutrients Zn and Fe showed low fertility index value whereas Mn and Cu had medium NIV. These micronutrients (in particular Zn and Mn) are becoming deficient day by day due to intensive cultivation of high yielding varieties of crops leading to loss of crop yields as well as quality of crops. So, delineation of available quantities of these micronutrients with frontier technologies could help the scientists for recommendations.

References

UNDER PEER REVIEW

1. Graham R.D, Welch R.M, Bouis, H.E. 2001. Addressing micronutrient malnutrition through enhancing the nutritional quality of staple foods: Principles, perspectives and knowledge gaps. Advances in Agronomy. 2001; 70: 77-142.

2. Shukla A.K, Behera S.K, Singh V.K, Prakash C., Sachan A.K, Dhaliwal S.S, Srivastava P.C, Pachauri S.P, Tripathi A, Pathak, J. Pre-monsoon spatial distribution of available micronutrients and sulphur in surface soils and their management zones in Indian Indo-Gangetic Plain. Islam R, editor. PLoS One. 2020;15(6):e0234053. https://doi.org/10.1371/journal.pone.0234053

3. Shukla A.K, Tiwari P.K, Prakash C. Micronutrients deficiencies vis-a-vis food and nutritional security of India. Indian Journal of Fertilizers. 2014;10(12): 94–112.

4. Denton-Thompson S.M. Sayer E.J. Micronutrients in food production: what can we learn from natural ecosystems. Soil System. 2022;6(1):8.

5. Singh M.V. Micronutrient nutritional problems in soils of India and improvement for human and animal health. Indian Journal of Fertilizers. 2009; 5(4):11-56.

6. Parker F.W, Nelson W.L, Winter Eric Miller I.E. The broad interpretation of soil test informations. Agronomy Journal. 1951; 43:105-102.

7. Ramamoorthy B, Bajaj J.C. Available Nitrogen, Phosphorus and Potassium status of Indian Soils. Fertilizer News. 1969;14:25-36.

8. Dhaliwal S.S, Naresh R.K, Mandal A, Singh R, Dhaliwal M.K. Dynamics and transformations of micronutrients in agricultural soils as influenced by organic matter build-up: A review. Environment Sustainability Indicators.2019; 1-2;100007. https://doi.org/10.1016/j.indic.2019.100007

9. Stevenson, F.J. Organic matter micronutrient reactions in soil. Micronutrient Agriculture*.1991;* 145–86

10. Kumar M, Singh S.K, Singh P. Effect of integrated use of organic and chemical fertilizers on growth, yield and micronutrients uptake in rice (*Oryza sativa*) – wheat (*Triticum aestivum*) system. Journal of Indian Society of Soil Science.2020; 68(1):78.http://dx.doi.org/10.5958/0974- 0228.2020.00009.2

11. Amar A, Shanmugasundaram R. 2020. Nutrient Index Values and Soil Fertility Ratings for Available Sulphur and Micronutrients of Tiruchirappalli District of Tamil Nadu, India. International Journal of Current microbiology and applied science*. 2020;* 9(3):337-347.

12. Mistry S, Sahu K.K, Sengar A.S, Dadsena R. GIS and GPS based soil fertilitymapping of village Dhodha, district Balodabazar, Chhattisgarh. The Pharma Innovation Journal, 2022; 11(12):432-438.

13. Vikas P, Borcherding N, Chennamadhavuni A, Garje R.Therapeutic potential of combining PARP inhibitor and immunotherapy in solid tumors. *Frontier Oncology,2020;* **10**:570.

UNDER PEER REVIEW

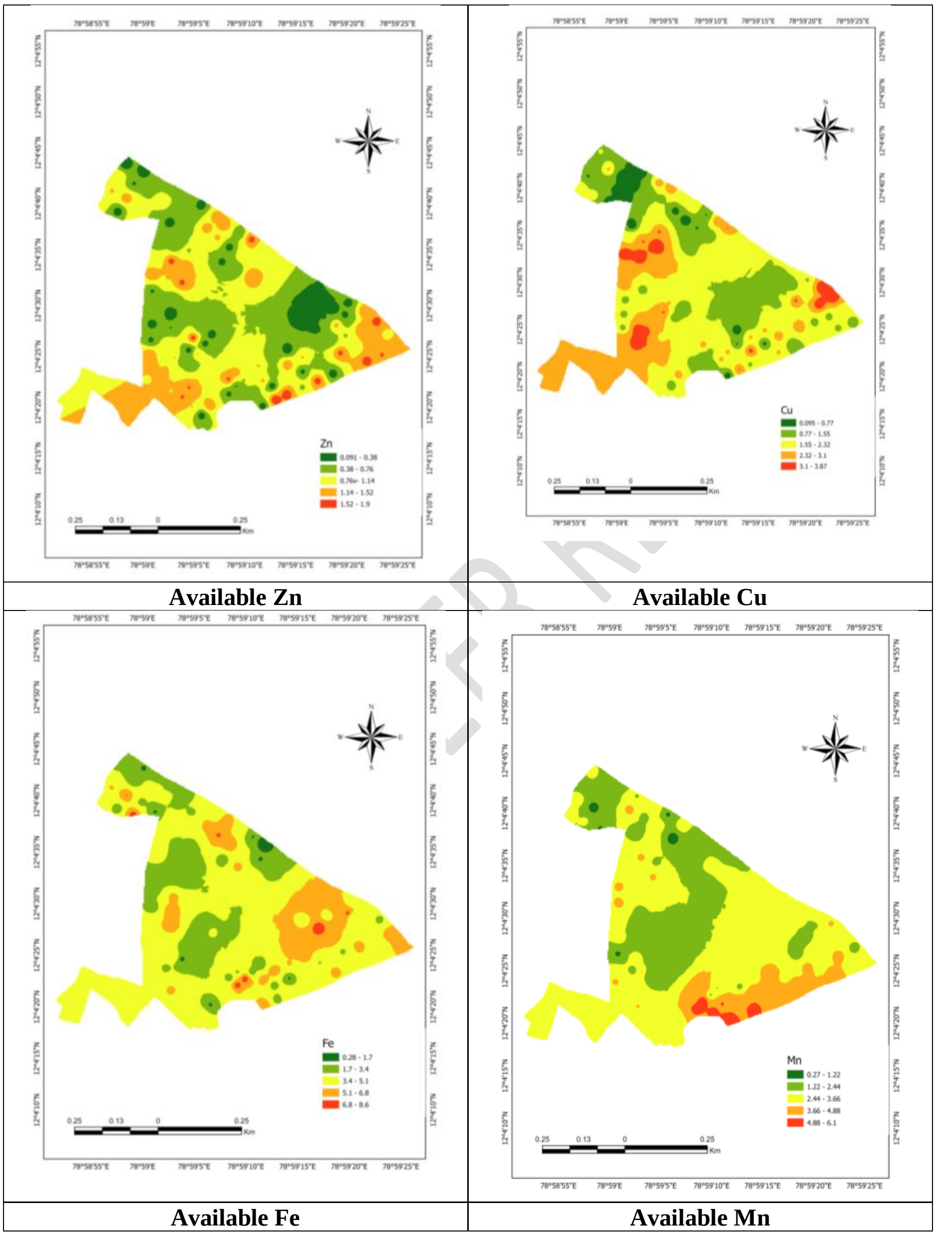

Fig. 2. Micronutreint maps of AC &RI, Vazhavachanur (Available Zn, Cu, Fe and Mn)