Spatial Distribution Of Available Micronutrients In Agricultural Soils From Selected Areas Of Semi-Arid Regions Of Telangana State

Nemani Gangothri, Anima Sunil Dadhich

Abstract: Micronutrients are essential for improving the fertility of soil thereby enhancing the crop yield. Soils of two different crops (Paddy and Groundnut) were collected from Sakapur village in Mahbubnagar district. These are the Principal crops of these zones are grown in black soils and red soils which are featured the character of that area and only two crops are grown from decades without any crop rotation. Physico-chemical parameters were analyzed using APHA standard methods and the available DTPA (Diethylene Triamine Penta Acetic acid) extractable micronutrients Zn, Fe, Cu and Mn were investigated by using MP-AES. Boron was estimated by using AAS. The results revealed that the dominance of Fe followed by Mn, Zn, Cu, Mo and B. There is no uniformity observed in micronutrient in paddy soils and groundnut soils the only exception is Mn. In paddy soils, all four micronutrients are more when compared with groundnut soils. The micronutrient status in the present study area is in order of Mn > B > Fe > Cu > Zn in paddy soils and Mn> B>Zn> Fe>Cu in groundnut soils. The soil analysis results helped in giving precise suggestion to the farmers for better soil quality and crop yield and farmers are advised to rotate the crops.
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Index Terms: Soil fertility, Micronutrients, Total nutrients, Semi-arid Regions, Soil Organic Carbon,

1 INTRODUCTION

The Plant growth is determined by the fertility of the soil and it is determined by the presence/absence of macro or micronutrients [1]. Soil health and yield of the crop is maintained by the micronutrients [2] and Deficiency of these nutrients has become foremost restraint to agricultural sector [3]. The quantification of total and available forms of nutrients in the soil is important [5]. The principal source of these nutrients in the soil are due to weathering and natural atmospheric depositions [6]. During the course of weathering trace elements are locked in the crystal lattice of the minerals (like clay) and thus relatively unavailable. Clay minerals adsorb the trace elements rapidly, but the displacement of these minerals into the soil is very difficult. Micronutrients in soil occur in diverse forms i.e. soluble in water, exchangeable, complex or chelated form, primary minerals, secondary minerals etc. [7]. Many studies have revealed that availability of micronutrients in the soil depends on pH of the soil, organic matter, % of clay, and other physical, chemical and biological conditions in the rhizosphere region [8]. Micronutrients availability is also affected by the interactions among the other nutrients in the soil. Many researchers from their studies revealed that micronutrients deficiency occur more in sandy soils compared to other soils, as the increase in sand content will decrease the iron ion concentration in soil [9]. Iron is the fourth abundant element on the earth, but the availability of these ions to the plant and microorganisms are very low due to its lower solubility.

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Ions like Iron, Copper, Zinc and Boron shows a positive correlation with clay soils. Soil pH plays an important role in the availability of copper in the soils as these ions are immobile and partially soluble. Altering (decreasing) the pH of the soil will increase the solubility of copper approximately 100-fold for each unit. Chhabra et al. (1996) had reported that available copper ion in the soil will increase with % of clay and organic carbon, whereas Manganese and Iron decreased with soil pH [10]. Synergism and antagonism are the two interactions generally exhibited by the micronutrients available in the soil. synergism is a positive effect between nutrients where two or more elements working together to create an overall improved physiological state in the plant. antagonism is a negative effect between nutrients where the excess of one nutrient reduces the uptake of another nutrient [8]. Iron and boron are deficient in alkaline soils, arid and semi-arid regions. Soils developed by sandstone, ingenious rock and calcareous materials are deficient with copper. Zinc deficiency is most common in a wide range of soils. Zn deficiency is most common in soils of Mahbubnagar, Telangana. Even though the soils are rich with total Fe, the solubility of these nutrients are very low due to its conversion into less available ferric form. Organic carbon also reduces the solubility of Fe and mostly seen in Mahbubnagar district. Similarly, Mn is very high in soils of these regions [11]. But according to Katyal et.al Mn deficiency in India is observed in light-textured soils. Cu varies with soil pH and texture. Cu is not mobile in soils and attracted to soil organic matter and clay minerals. Cu deficiency is also noted in Mahbubnagar. B is mobile in the soil profile and often gets leached down. Its deficiency and toxicity are very narrow in range. Deficiency status of available DTPA and hot water-soluble Boron in Andhra Pradesh is as Zn>Fe>B.Mn>Cu. [12]. Based on the above facts this research was conducted to estimate the micronutrient level and their relation to the soils of the study area.

2 MATERIALS AND METHODS

2.1 Study area

Shakapur is an Agro-based village which was previously in Mahabubnagar district now it is part of Wanaparthi District, Pebbairu Mandal, of Telangana state which is part of Deccan plateau semi-arid region. Pebberu is located at 16.2167°N 77.9833°E. It has an average elevation of 300 meters (987 ft). Mahbubnagar district is mainly covered by three types of soils Viz. red sandy soil, Red earth and black cotton soils. The Jurala canal of Krishna River irrigates this area. From 20 hectares of land 20 samples from paddy fields (codes P1 to P 10) and 20 samples from groundnut fields (codes G1 to G10) were collected for the current study (figure 1).

Figure 1: *Sampling Sites*

2.2 soil sampling and laboratory analysis of soil sampling

The soil samples were collected from a depth of 0 to 15cm by a 20x20 m grid keeping in view the variation in soil colour and texture. Theses samples were air-dried and sieved with 2-mm sieve. The samples were tested by following standard methods given by "Methods Manual-Soil Testing in India".

Parameter	*Instrument used*
pH	*pH Meter*
Electrical Conductivity (EC)	*Conductivity Meter*
Organic carbon	*Walkley and Black Method*
Phosphorus (P)	*calorimetry*
Potassium (K)	*Flame Photometer*
Mn, Zn, Cu	*MP AES Agilent 4200*
Fe	*Spectroscopic Method*
Boron	*Atomic Absorption Spectrophotometer (AAS)*
Particle-size	*Bouyoucos Hydrometer method*
Total Nutrients	*XRF (A Philips MagiX PRO, Model PW 2440)*

3 RESULTS AND DISCUSSION:

3.1 Physicochemical analysis of soils

Soils were found to be slightly acidic in nature in a range of 6.4-7.2 (paddy soils) and 6.2 to 6.8 (ground nut soils) (Table 1a) and non-saline with EC 0.17 to 0.42 dS/m (ground nut soils) (Table 1b), 0.24 to 0.67 dS/m (paddy soils) in character with the mean value of 6.9 for soil pH in ground nut soils, 6.6 for paddy soils and 0.39 dS/m and 0.24 for EC. The organic carbon in Paddy soils are in a range of 1.52 to 3.31% and 0.89 to 2.16 % in ground nut soil. Our results support the findings of Reddy et al. (1996) and Satyavathi and Reddy (2004) [14] who reported wide ranges for soil pH, EC, and OC in the region. This is due to the prevailing climatic conditions of particular regions and various Agricultural practices. The available B, Cu, Fe, Mn and Zn concentrations in paddy soils with mean values of 0.98, 1.50, 2.69, 17.07 and 0.92 mg/kg, respectively and 1.7, 0.42, 0.57,13.64 and 0.76 mg/kg respectively in ground nut soils. It was found that these zones were deficient in micronutrients in an order of Mn > B > Fe > Cu > Zn in paddy soils and Mn> B>Zn> Fe>Cu in ground nut soils as per the study conducted by Shukla et al., 2016 [14]. Our finding is similar to the results reported by Shukla et al. (2016) [14] who recorded the mean values of 1.66, 1.37, 12.20, and 10.30 mg/kg for available Zn, Cu, Fe, and Mn concentrations, respectively in soils of Indian TGP region. The DTPA-extractable Zn ranged 0.38 to -1.35mg kg-1 in paddy soils with 30% deficiency and 0.5 to 1.06 ranged from 0.17 to 1.92 mg kg-1in ground nut soil considering 0.60 mg kg-1 as critical level. DTPA-extractable Cu ranged 0.59 to 2.56 mg kg-1 in paddy soils with 0% deficiency and 0.27 to 0.73 ranged mg kg-1in ground nut with 20% deficiency as 0.2 mg kg-1critical level suggested by Lindsay and Norvell (1978)[15].Available Mn varied from 2.01 to 44.25 mg kg-1 in paddy soils with 0%deficiency and 10.91 to 18.77 mg kg-1in ground nut with 0% deficiency. The soils were found to be sufficient in available manganese as all the values were above critical limit of 1.0 mg kg-1 as suggested by Lindsay and Norvell (1978) [15]. 1N NH_4 OAc by uv spectrometer method used for available Fe content varied from 0.5 to 6.9 mg kg-1 in paddy soils with 50%deficiency and 0.5 to 1.2 mg kg-1in ground nut with100% deficiency The soils were found to be deficiency in available Fe as all the values were below critical limit of 1.0 mg kg-1 as suggested by fundamentals of soil sciences,2009. Hot plate method AAS for available B content varied from 0.48 to 1.90 mg kg-1 in paddy soils with 30% deficiency and 0.72 to 3.6 mg kg-1in ground nut with 0% deficiency The soils of paddy were found to be deficiency whereas soils of groundnut were sufficient in available B as critical limit of 1.0 mg kg-1 suggested by fundamentals of soil sciences,2009. Shukla et al. (2016) [14] also reported the mean concentration of 2.24, 1.49, 19.01, and 36.76 mg/kg soil for plant available Zn, Cu, Mn, and Fe, respectively, in the soils of SHR of India (Table 2a and 2b). Soil properties exhibited low (only soil pH) to moderate (rest of soil properties) variability with <10, 10 to 100 and > 100% of CV values indicating variability to the extent of low, moderate, and high degree, respectively. Bogunovic et al. (2017) [17] reported low, medium, and high variability for pH, organic matter, and EC, respectively in soils of Rasa river valley of Croatia. Behera and Shukla (2015) [17] reported low (for pH and EC) to moderate (for SOC content) variability in Indian acid soils. Similarly, variability was low for pH and medium for EC and organic matter in soils of Alequeva reservoir of Portugal. In soils of northern Ethiopia, low (for pH) and medium variability (for OC and available Fe) were reported. Moderate variability for available Zn, Fe, Cu, and Mn was recorded by Wang, Wu, Liu, Huang, and Fang (2009) [17] in China's paddy growing soils and by Shukla et al. (2016) [14] in Indian TGP and SHR soils. However, Foroughifar, Jafarzadeh, Torabi, Pakpour, and Miransari (2013) [18] recorded high variability for available Fe and moderate variability for available Cu, Mn, and Zn in Dasht-e-Tabriz soils of Iran. Among the soil properties, available Zn, Fe, Cu, and Mn (Table 3) had higher CV values than soil pH, EC, and OC (Table 4a and 4b) content. High variability in soil micronutrients is ascribed to different micronutrients content of parent material, pedogenic processes, and diversity in weathering regimes.

Table 1: *Physico chemical analysis data of paddy field soils and ground nut fields soils:*

1a)

S.NO	CODE	pH	Electrical conductivity	%Organic Carbon
1	P1	7.1	0.67	3.31
2	P2	7.2	0.47	2.8
3	P3	7.2	0.6	1.52
4	P4	7.2	0.4	2.67
5	P5	7.2	0.24	2.54
6	P6	6.4	0.32	1.52
7	P7	6.7	0.38	2.29
8	P8	7.2	0.28	3.31
9	P9	6.5	0.24	2.29
10	P10	6.4	0.34	2.93
	Mean	6.9	0.39	2.52

1b

S.NO	CODE	pH	Electrical conductivity	%Organic Carbon
1	G1	6.8	0.42	1.52
2	G2	6.6	0.33	2.04
3	G3	6.6	0.25	2.16
4	G4	6.6	0.24	0.89
5	G5	6.8	0.25	1.52
6	G6	6.7	0.22	1.3
7	G7	6.6	0.24	0.89
8	G8	6.7	0.18	1.3
9	G9	6.2	0.22	1.45
10	G10	6.4	0.17	1.27
	Mean	6.6	0.24	1.4

Table 2: *Plant available micronutrient data of soils of paddy fields and ground nut fields:*

2a)

S.No	Code	B	Cu	Fe	Mn	Zn
1	P1	0.96	1.74	6.9	32	1.11
2	P2	1.68	0.59	4.6	44.25	1.27
3	P3	0.48	1.49	3.7	2.01	1.11
4	P4	0.96	1.13	4.4	24.76	1.02
5	P5	0.48	1.74	1.6	8.94	1.35
6	P6	0.96	1.43	0.8	8.49	0.96
7	P7	0.96	2.56	0.5	16.02	0.54
8	P8	0.96	0.82	0.5	8.04	0.46
9	P9	0.48	1.97	1.8	13.78	0.38
10	P10	1.92	1.62	2.1	12.47	1.04
	Mean	0.984	1.509	2.69	17.076	0.924

2b)

S.No	Code	B	Cu	Fe	Mn	Zn
1	G1	1.2	0.39	1	12.18	0.89
2	G2	0.72	0.73	0.3	12.21	0.98
3	G3	2.16	0.27	1.2	11.93	0.8
4	G4	1.44	0.32	0.3	11.75	0.92
5	G5	3.6	0.4	0.7	18.77	0.64
6	G6	0.96	0.32	0.9	16.7	0.54
7	G7	2.16	0.62	0.1	16.02	0.5
8	G8	1.92	0.45	0.5	11.57	1.06
9	G9	2.88	0.41	0.2	14.33	0.76
10	G10	0.72	0.27	0.5	10.91	0.53
	Mean	1.78	0.42	0.57	13.64	0.76

The available micronutrient status in studied area is in order of: Mn > B > Fe > Cu > Zn in paddy soils and Mn> B>Zn> Fe>Cu in ground nut soils (Figure 2).

Table 3: *Critical soil test values of DTPA extractable micronutrients*

S.No	Micronutrient	Low	Medium	High
1	Iron (Lindsay and Norvell, 1978)	<4.5	4.5 – 9.0	>9.0
2	Manganese (Sakal et al., 1985)	<2.5	2.5-3.5	>3.5
3	Copper (Lindsay and Norvell, 1978)	<0.2	0.2-0.4	>0.4
4	Zinc (Takkar and Mann, 1975)	<0.6	0.6-1.2	>1.2

Table 4: *Descriptive statistics and observation are as follows (Based on critical limits):*

4a) Paddy soils

Parameters	Range	Mean	Status
pH	6.4 - 7.2	6.9	Slightly acidic
SOC	1.52% - 3.31%	4.34%	High
Micronutrients	ppm		
B	0.48 - 1.92	0.98	Medium
Cu	0.39 - 2.56	1.51	High
Fe	0.5 - 6.9	2.69	Low
Mn	2.01 - 44.25	17.08	High
Zn	0.46 - 1.35	0.92	Low

4b) Ground nut soils

Parameters	Range	Mean	Status
pH	6.2 - 6.8	6.6	Slightly acidic

SOC	*0.89% - 2.16%*	*2.36*	*High*
Micronutrients	*Ppm*		
B	*0.24 - 3.6*	*1.64*	*High*
Cu	*0.27 - 0.73*	*0.4*	*Medium*
Fe	*0.3 – 1*	*0.58*	*Low*
Mn	*10.28 - 18.77*	*12.35*	*High*
Zn	*0.5 - 1.06*	*0.74*	*Low*

3.2 Relationship among the soil properties and available micronutrients

Correlation analysis of P1-P10 (Paddy soils):
Available B, Cu of soil showed less negative correlation (r=-0.228 B r= -0.483 Cu) with pH, but very poor positive correlation with Mn ,Zn (0.282 Mn , 0.387 Zn)and effective positive correlation with Fe (r=0.471).The study of correlation between SOC and each micronutrients state that SOC has shown positive correlation with B and Mn(r= 0.424 B,0.488Mn),negative correlation with Cu and Zn (r=-0.270Cu,-0.031Zn), and less positive correlation with Fe(0.305).B has shown negative correlation with Cu (r=-0.353), Strong positive correlation with Mn (r=0.493) and poor positive correlation Fe and Zn (r=0.137 Fe,0.219 Zn). Cu has poor negative correlation with all micronutrients (r=-0.259 Fe. -0.337 Mn, -0.309 Zn) Fe has strong good positive correlation Mn and Zn (0.669 Mn,0.539 Zn). Zn has shown poor positive correlation with Mn (r=0.307) (Table 5).

Table 5: *Correlation analysis of soil samples of paddy fields*

Correlation analysis of soil samples of paddy fields							
	Soc	*pH*	*B*	*Cu*	*Fe*	*Mn*	*Zn*
soc	*1*						
pH	*0.320*	*1*					
B	*0.424*	*-0.228*	*1*				
Cu	*-0.270*	*-0.483*	*-0.353*	*1*			
Fe	*0.305*	*0.471*	*0.137*	*-0.259*	*1*		
Mn	*0.488*	*0.282*	*0.493*	*-0.337*	*0.669*	*1*	
Zn	*-0.031*	*0.387*	*0.219*	*-0.309*	*0.539*	*0.307*	*1*

Correlation analysis of G1 – G10 (groundnut soils):
SOC has shown significant positive correlation with Fe and Zn (r=0.528 Fe, 0.402 Zn),little positive correlation with Cu and Zn (r=0.179 Cu, 0.140 B) and less negative correlation with Mn (r=-0.039).Available B has shown positive correlation with Mn (r=0.653), no significant correlation with Cu Fe and Zn. Available Cu has shown strong negative correlation with Fe (r=0.533), less positive correlation with Mn and Zn (r=0.222 Mn, 0.302 Zn). Available Mn has negative correlation with Zn (r=-0) (Table 6).

Table 6: *Correlation analysis of soil samples of groundnut fields.*

Correlation analysis of soil samples of groundnut fields							
	Soc	*pH*	*B*	*Cu*	*Fe*	*Mn*	*Zn*
soc	*1*						
pH	*0.146*	*1*					
B	*0.140*	*0.124*	*1*				
Cu	*0.179*	*0.160*	*0.096*	*1*			
Fe	*0.528*	*0.468*	*0.010*	*-0.533*	*1*		
Mn	*-0.039*	*0.342*	*0.653*	*0.222*	*0.015*	*1*	
Zn	*0.402*	*0.273*	*0.079*	*0.302*	*0.038*	*-0.350*	*1*

3.3 Particle Size

Particle size analysis was done to the soil samples and found to be high in P1, P5, P9, G3 and G7 with 91%,90.9%,92%,71.7% and 67.9%. Silt % was in a range of 1.1% to 29.8% and clay is 0.6% to 1.4% respectively. Particles size analysis revealed that in P1, P5, P9, G3 and G7 soils (Table 7) are affected by low fertility as the sand particles are more in comparison with other fractions.

Table 7: *Particle size analysis*

Particle size analysis					*Particle size fraction analysis*			
S. No	*Code*	*Sand %*	*Silt %*	*Clay %*	*>500 µ*	*<300 µ*	*<60 µ*	*<30 µ*
1	*P1*	*91.0*	*7.4*	*0.7*	*4.3*	*5.1*	*1.9*	*0.3*
2	*P5*	*90.9*	*7.8*	*0.6*	*8.5*	*4.9*	*1.2*	*0.8*
3	*P9*	*92.0*	*1.1*	*6.1*	*14.4*	*1.1*	*2.9*	*1.1*
4	*G3*	*71.7*	*26.8*	*1.3*	*14.8*	*16.5*	*2.3*	*0.8*
5	*G7*	*67.9*	*29.8*	*1.4*	*25.7*	*21.6*	*2.4*	*0.9*

3.4 Reserves of total Micronutrients

The data on distribution of total content of micronutrients reveals dominance of Fe followed by Mn, Zn, Cu, Mo and B. There is no uniformity observed in micronutrient in paddy soils and groundnut soils only exception is Mn. In paddy soils the all four micronutrients are more when compared with groundnut soils. This variation may be due to percentage of sand, slit and clay in both type of soils and land elevation high and low lands. In this case study percentage of clay did not show any influence in total and available micronutrients distribution (Figure 3).

3.5 XRF Analysis

Total micronutrients in the soil is estimated by XRF analysis and Iron oxide (Fe_2O_3) was found to be 3.48, 3.32, 2.53, 1.93 and 1.60 in P3, P6, P9, G4 and G8. Whereas Manganese oxide (Mno) was found to be 0.04, 0.03, 0.03, 0.03 and 0.03. Zinc (Zn) was found to be 53.96, 27.32, 32.88, 23.21 and 24.03 in P3, P6, P9, G4 and G8 and Molybdenum (Mo) was found to be 1.25, 0.01, 2.70, 1.69 and 2.29. Boron(B) was found to be 11.505, 13.903, 10.849, 12.935 and 11.275 in P3, P6, P9, G4 and G8 (Table 8)

Table 8: *Total micronutrients analysis by XRD*

Code	Fe2O3	MnO	Zn	Mo	B

	(%)	(%)	(ppm)	(ppm)	ppm
P3	3.48	0.04	53.96	1.25	11.505
P6	3.32	0.03	27.32	0.01	13.903
P9	2.53	0.03	32.88	2.70	10.849
G4	1.93	0.03	23.21	1.69	12.935
G8	1.60	0.03	24.03	2.29	11.275

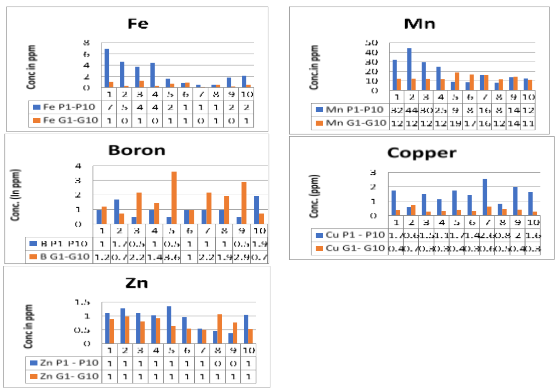

Figure 2: *Graph representing the concentration of available individual micronutrients in paddy and groundnut fields soils*

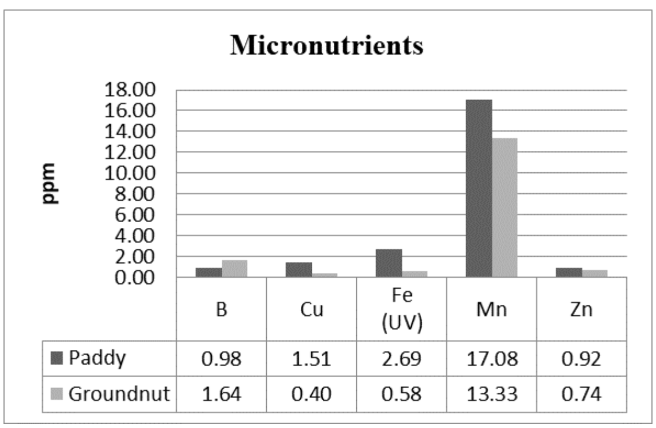

Figure 3: *Graph representing Total values of concentration of available micronutrients in paddy and groundnut fields soils.*

4 CONCLUSIONS

Availability of micronutrients in the study area is varied with regions, even though the variations were not significantly different. The average concentrations are is in the order of Mn > B > Fe > Cu > Zn in paddy soils and Mn> B>Zn> Fe>Cu in groundnut soils. Soil pH was shown least correlation positively with Mn, Fe, and Mn and negatively with Cu and B in paddy soils whereas in groundnut soils all the micronutrients showed positive relation. The Correlations among micronutrients were found to be significant and implied that micronutrients are affected by analogous factors. Soil pH showed influenced the availability of Micronutrient in paddy and groundnut soils, But B and Cu showed that it is not affected by the ph. To increase the productivity of crop in the current study area needs to take into account soil. Some parts in the study area require lime treatment to reduce the pH and addition of organic matter also helps in enhancing the nutrients load on the soils. Crop rotation systems are required to these soils and it will reduce the stress on soil and also increase the levels of micronutrients. Application of organic matter to these lands may ensure a slow release of the micronutrients at levels which are sufficient to support plant growth.

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