Distribution of DTPA Extractable Micronutrients in Soils of Central Telangana Region of Telangana

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Authors’ contributions

This work was carried out in collaboration among all authors. Author MRP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors PR and KS managed the analyses of the study. Author PR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Forty soil samples from ten pedons of the Central Telangana region, Telangana were studied for the vertical distribution of DTPA extractable. Zn, Cu, Fe and Mn and their relationship with some soil properties. Soil pH, CaCO₃, organic carbon and particle-size distribution had a strong influence on the distribution of these micronutrients. The content of the micronutrient increased with the an increase in organic carbon and decreased with an increase in pH and CaCO₃. There was a decreasing trend for the distribution of these micronutrients with respect to depth. As per the critical limit prescribed for Zn, and Fe, 55 and 12% of the soil could be rated as deficient in available zinc and iron, respectively. Copper and manganese were found to be adequate.

Keywords: Available micronutrients; alkaline soil; soil horizons; critical limit.

1. INTRODUCTION

The knowledge of the vertical distribution of micronutrient cations in soils provides an idea of the inherent capacity of soils to supply micronutrients from lower horizons. Studies conducted by other researchers [1-4] to understand the content and distribution of the

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nutrient cations in different soils and their relationship with soil properties were for other soils and information in this regard for the soils of central Telangana is scanty. Therefore, an attempt has been made to assess the micronutrient status in these soils and their relationship with some important soil properties.

2. MATERIALS AND METHODS

The Central Telangana region is located between 17°14’ to 18°21’ N latitude and 78°5’ to 81°6’ longitude in the south India. Climatically, the Central Telangana zone falls under semi-arid (wet) tropics with mean annual rainfall is 1167.7 mm, 74 per cent of which is received during monsoon (mid-June to mid-September). Ten representative pedons (P1 to P10) from Madhira, Aswaraopeta, Pinapaka, Sanga Reddy, Siddipeta, Gajwel, Warangal, Malyal, Eturnagaram and Ghanpur were exposed where all horizons were visible. The study area is covered by igneous and metamorphic rocks. Northwestern plateau and interior rugged plains from the Telangana. The moisture regime in the study area is ustic and soil temperature is iso-hyperthermic. The major crops grown in the study area are rice, maize, sorghum, cotton, black gram, green gram, and red gram.

Horizon-wise soil samples were collected from the studied pedons. All the samples were analyzed for pH, Soil organic carbon (SOC), carbonate minerals (CaCO₃), and particle-size distribution following standard procedures. The micronutrient cations were extracted with Diethylene Triamine Penta Acetic acid (DTPA) solution (to represent available forms) and determined with Atomic Absorption Spectrophotometer (AAS) as described by Lindsay and Norvell [5]. Simple correlations were calculated between DTPA-extractable micronutrient cations and soil properties [6,7].

3. RESULTS AND DISCUSSION

In general, soil reactions were neutral to alkaline with pH ranged from 6.5 to 8.7. Soil organic carbon content was very low to low (2.0-11.4 g kg⁻¹ soil) and decreased with depth. Soils are slightly calcareous and calcium carbonate content varied from 0.13 to 3.9% in different horizons Table 1. The soils were sandy clay loam to clay in texture with clay content ranging from 19.7 to 68.6% (197-686 g kg⁻¹ soil). Higher content of micronutrients was found in surface layers which might be due to their regular addition through plant residues, organic manures, and fertilizers [4]. There was no definite trend of distribution for micronutrients through depth Table 1.

3.1 Zinc

DTPA-extractable zinc varied from 0.17 to 1.92 mg kg⁻¹ soil. Out of 40 soil samples, 22 samples are deficient in zinc, according to the critical limit (0.6 mg kg⁻¹ soil) [8]. Zinc deficiency was not observed in soil samples of pedon, 2, 7 and 9, whereas pedon 3, 4, 5, 6, and 10 appeared to be deficient in zinc. Zinc deficiency was noticed after 54 cm and 66 cm in pedon 1 and 8, respectively. Lower zinc content in black soils is due to its sorption (exchange and chemical sorption) by clay [9] or due to high pH values, which have resulted in the formation of insoluble compounds of zinc [10]. Available Zn content was significantly and a negatively correlated (r=−0.33**) with calcium carbonate. Soil sand and silt also had a negative correlation but soil organic carbon and clay a had positive influence on DTPA-Zn Table 2. The results of the present investigation were in close agreement with the findings of Bhanwari et al. [7].

3.2 Copper

DTPA extractable Cu content in soils ranged from 0.30 to 10.10 mg kg⁻¹ soil with a value of 2.17 mg kg⁻¹ soil. Considering the critical limit of 0.20 mg kg⁻¹ for Cu for normal plant growth [11], the soils are rated adequate in available Cu. Soil pH and CaCO₃ content had a significant negative correlation (r=−0.56** and −0.31** respectively) with Cu, but soil organic carbon and clay had a significant positive relation with Cu. These findings are in agreement with Satyavathi and Reddy [2], Pati and Mukhopadhyay [12] and Thakur et al. [4].

3.3 Iron

DTPA extractable Fe content in these soils varied between 4.2 and 42.3 mg kg⁻¹. Considering the critical limit of 4.5 mg kg⁻¹ for Fe [5], 11 samples, which represent 12% of soil samples were deficient in iron. The Fe was deficient in pedons 6, 8, and 10 due to high pH and medium in CaCO₃ [13,14]. Soil organic carbon had a significant positive relation (r=0.37”) with Fe Table 2.
Table 1. Some physical and chemical properties of the soils and DTPA-extractable cations

| Location                      | Horizon | Depth (cm) | pH (1:2.5) | OC (g kg⁻¹) | CaCO₃ (%) | Particle size distribution | Zn  | Cu  | Fe  | Mn  |
|-------------------------------|---------|------------|------------|-------------|-----------|---------------------------|-----|-----|-----|-----|
|                               |         |            |            |             |           | (%) Sand Silt Clay        |     |     |     |     |
| Pedon 1: Fine, smectitic, iso-hyperthermic Vertic Haplusterts |         |            |            |             |           |                           |     |     |     |     |
| Madhira                       | Ap      | 0-18       | 7.8        | 8.8         | 1.8       | 36.0 18.2 45.8            | 0.87| 3.90| 10.90| 14.80|
| Dist: Khammam                | Bw₁     | 18-54      | 8.0        | 6.1         | 2.4       | 31.3 20.1 48.6            | 0.63| 2.80| 9.80 | 12.30|
|                               | Bw₂     | 54-100     | 7.9        | 5.2         | 3.1       | 28.7 19.8 51.4            | 0.48| 2.80| 8.20 | 9.80 |
|                               | Bw₂     | 100-140    | 7.9        | 4.1         | 3.6       | 27.3 22.3 60.3            | 0.41| 2.10| 7.10 | 8.20 |
| Pedon 2: Fine-loamy, mixed, iso-hyperthermic Typic Haplusterts |         |            |            |             |           |                           |     |     |     |     |
| Aswaraopeta                   | Ap      | 0-12       | 6.6        | 8.2         | 0.0       | 52.2 21.8 25.9            | 0.65| 0.33| 6.78 | 5.35 |
| Dist: Khammam                | Bw₁     | 12-26      | 7.3        | 5.6         | 0.1       | 51.6 20.3 28.1            | 0.76| 0.39| 7.15 | 4.87 |
|                               | Bw₂     | 26-60      | 6.9        | 3.1         | 0.1       | 63.9 16.3 19.7            | 0.87| 0.34| 7.20 | 5.45 |
|                               | Bw₃     | 60-95      | 7.0        | 3.2         | 0.2       | 59.5 18.6 21.8            | 0.93| 0.46| 8.34 | 6.52 |
| Pedon 3: Fine, smectitic, iso-hyperthermic Chromic Haplusterts |         |            |            |             |           |                           |     |     |     |     |
| Pinapaka                      | Ap      | 0-24       | 7.8        | 8.1         | 1.6       | 29.2 18.9 51.9            | 0.44| 0.72| 5.20 | 9.40 |
| Dist: Khammam                | Bw₁     | 24-42      | 7.9        | 7.6         | 1.8       | 28.3 19.2 52.5            | 0.36| 0.56| 4.60 | 6.50 |
|                               | Bw₂     | 42-89      | 8.0        | 6.1         | 1.8       | 29.4 17.7 52.9            | 0.35| 0.42| 6.20 | 9.20 |
|                               | Bw₃     | 89-120     | 8.1        | 5.6         | 2.8       | 27.8 15.2 57.0            | 0.36| 0.30| 4.50 | 7.40 |
| Pedon 4: Fine-loamy, mixed, iso-hyperthermic Udic Paleustalfs |         |            |            |             |           |                           |     |     |     |     |
| Sangareddy                    | Ap      | 0-14       | 6.8        | 11.4        | 1.4       | 53.4 21.0 26.6            | 0.38| 10.10| 42.30| 18.24|
| Dist: Medak                   | Bw₁     | 14-28      | 6.6        | 9.0         | 4.6       | 50.7 17.0 32.3            | 0.36| 8.61| 30.25| 12.81|
|                               | Bt₁     | 28-60      | 6.3        | 6.0         | 3.7       | 35.2 11.6 54.8            | 0.27| 8.42| 30.61| 12.23|
|                               | Bt₂     | 60-95      | 6.2        | 4.1         | 1.8       | 32.8 12.4 54.8            | 0.21| 8.04| 22.18| 8.63 |
|                               | Bw₁     | 95-120     | 6.1        | 2.0         | 2.3       | 34.7 13.2 52.1            | 0.21| 7.21| 21.06| 8.22 |
| Pedon 5: Fine, smectitic, iso-hyperthermic Typic Haplusterts |         |            |            |             |           |                           |     |     |     |     |
| Siddipeta                     | Ap      | 0-16       | 8.2        | 7.0         | 2.0       | 20.0 23.3 56.7            | 0.49| 0.91| 11.60| 25.60|
| Dist: Medak                   | Bss₁    | 16-35      | 8.4        | 5.2         | 2.3       | 16.5 24.2 59.3            | 0.46| 0.86| 10.40| 24.20|
|                               | Bss₂    | 35-74      | 8.3        | 5.0         | 3.2       | 13.3 21.0 65.7            | 0.39| 0.72| 8.20 | 15.60|
|                               | Bss₃    | 74-100+    | 8.4        | 4.6         | 3.6       | 14.0 17.4 68.6            | 0.31| 0.46| 6.40 | 14.20|
| Pedon 6: Fine-loamy, mixed, iso-hyperthermic Udic Ustorthents |         |            |            |             |           |                           |     |     |     |     |
| Gajwel                        | A       | 0-25       | 7.3        | 7.6         | 3.9       | 58.7 12.4 29.0            | 0.32| 0.49| 4.20 | 14.80|
| Dist: Medak                   | AC      | 25-75+     | 7.7        | 5.0         | 3.6       | 66.2 9.4 24.4             | 0.26| 0.44| 3.80 | 12.14|
| Location                          | Horizon | Depth (cm) | pH (1:2.5) | OC (g kg⁻¹) | CaCO₃ (%) | Particle size distribution | Zn (mg kg⁻¹ soil) | Cu (mg kg⁻¹ soil) | Fe (mg kg⁻¹ soil) | Mn (mg kg⁻¹ soil) |
|-----------------------------------|---------|------------|------------|-------------|-----------|---------------------------|-------------------|-------------------|-------------------|-------------------|
| Pedon 7: Fine, smectitic, iso-hyperthermic Typic Haplusterts |         |            |            |             |           |                           |                   |                   |                   |                   |
| Warangal                          | Ap      | 0-16       | 7.9        | 7.9         | 2.3       | 44.0 14.6 41.4 1.92 2.30 6.94 12.04 |                   |                   |                   |                   |
| Dist: Warangal                    | Bg₁     | 16-50      | 7.8        | 5.8         | 2.6       | 40.0 14.8 45.5 1.57 1.86 6.69 5.31 |                   |                   |                   |                   |
|                                  | Bg₂     | 50-75      | 7.8        | 4.6         | 3.3       | 39.0 15.8 45.2 0.97 1.53 6.32 5.16 |                   |                   |                   |                   |
|                                  | Bw      | 75-110+    | 7.3        | 4.4         | 3.7       | 42.6 13.0 44.6 0.92 1.16 5.81 4.75 |                   |                   |                   |                   |
| Pedon 8: Fine-loamy, mixed, iso-hyperthermic Udic Haplustepts |         |            |            |             |           |                           |                   |                   |                   |                   |
| Malayal                           | Ap      | 0-18       | 7.6        | 7.9         | 1.6       | 56.2 14.2 29.5 1.29 3.90 10.90 10.06 |                   |                   |                   |                   |
| Dist: Warangal                    | Bw₁     | 18-30      | 7.9        | 6.6         | 2.5       | 52.3 17.1 30.6 1.10 2.15 10.21 10.23 |                   |                   |                   |                   |
|                                  | Bw₂     | 30-66      | 7.9        | 5.6         | 3.1       | 56.4 12.3 31.2 0.70 1.65 4.20 9.87 |                   |                   |                   |                   |
|                                  | C       | 66-150+    | 8.0        | 3.1         | 3.8       | 60.2 13.5 26.2 0.34 1.55 3.65 6.91 |                   |                   |                   |                   |
| Pedon 9: Fine-loamy, mixed, iso-hyperthermic Typic Rhodustalfs |         |            |            |             |           |                           |                   |                   |                   |                   |
| Etunagaram                        | Ap      | 0-12       | 6.7        | 9.6         | 1.2       | 67.6 7.9 24.5 1.66 1.95 23.27 12.09 |                   |                   |                   |                   |
| Dist: Warangal                    | AB      | 12 to 50   | 6.5        | 8.1         | 1.8       | 68.1 8.3 23.6 1.60 1.87 19.21 11.80 |                   |                   |                   |                   |
|                                  | Bt₁     | 50-86      | 6.4        | 6.1         | 1.6       | 63.0 8.0 28.9 1.50 1.40 17.31 8.60 |                   |                   |                   |                   |
|                                  | Bt₂     | 86-98+     | 6.7        | 3.2         | 2.1       | 61.5 9.8 28.6 1.25 1.23 12.85 9.20 |                   |                   |                   |                   |
| Pedon 10: Fine, mixed, iso-hyperthermic Typic Haplustalfs |         |            |            |             |           |                           |                   |                   |                   |                   |
| Ghanpur                           | Ap      | 0-15       | 8.0        | 8.0         | 1.8       | 54.6 15.0 30.3 0.56 0.88 8.80 10.60 |                   |                   |                   |                   |
| Dist: Warangal                    | Btg     | 15-40      | 8.2        | 7.6         | 2.5       | 47.8 15.2 36.9 0.49 0.68 6.80 9.20 |                   |                   |                   |                   |
|                                  | Bwg     | 40-80      | 8.4        | 6.1         | 3.6       | 49.8 14.1 36.2 0.38 0.45 3.40 8.40 |                   |                   |                   |                   |
|                                  | Bg      | 80-110     | 8.7        | 5.6         | 2.8       | 48.2 12.5 39.2 0.41 0.66 6.60 8.20 |                   |                   |                   |                   |
|                                  | Bt      | 110+       | 8.5        | 4.9         | 2.6       | 40.6 17.0 42.6 0.32 0.58 5.80 7.90 |                   |                   |                   |                   |
Table 2. Correlations between soil properties and soil available micronutrients

| Micronutrients | Soil Zn | Soil Cu | Soil Fe | Soil Mn |
|----------------|---------|---------|---------|---------|
| Soil pH        | -0.27   | -0.56*  | 0.17    | -0.5    |
| OC (g kg⁻¹)    | 0.29    | 0.25    | 0.37    | 0.44*   |
| CaCO₃ (%)      | -0.33*  | -0.31*  | -0.04   | 0.09    |
| Clay Content   | 0.14    | 0.05    | 0.04    | 0.27    |

* Significant

3.4 Manganese

DTPA extractable Mn content was varied from 4.7 and 42.3 mg kg⁻¹ soil in different horizons which are above the critical limit of 3 mg kg⁻¹ for Mn as suggested by Takkar et al. [15]. Available Mn content was significantly and positively correlated with organic carbon and clay.

In general, calcium carbonate decreased the availabilities of micronutrients owing to their insoluble hydroxides at higher pH [16]. Contrary to it, organic carbon had a positive influence on DTPA-micronutrients due to complexation and chelation [12].

4. CONCLUSION

The soils of the Central Telangana region, Telangana were studied for the vertical distribution of DTPA extractable. Zn, Cu, Fe, and Mn and their relationship with some soil properties. DTPA-extractable zinc, copper, iron and manganese contents ranges from 0.17 to 1.92 mg kg⁻¹ soil, 0.30 to 10.10 mg kg⁻¹ soil, 4.2 to 42.3 mg kg⁻¹ soil and 4.7 and 42.3 mg kg⁻¹ soil, respectively. Out of 40 soil samples 22 samples were deficient in zinc and 11 samples were deficient in iron. Soil pH, calcium carbonate, organic carbon and particle-size fractions had strong influence on the distribution of these micronutrients. The content of the micronutrient increased with the increase in organic carbon and decreased with an increase in pH and CaCO₃.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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