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# Evaluation and Comparison of DTPA Extractanting Methods for Available Cationic Micronutrients in Non-acidic Soils of Andhra Pradesh, India

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**Abstract:** The research work was carried out to compare and evaluate the extractability of cationic micronutrients (Zn, Cu, Fe and Mn) using widely employed diethylene triamine pentaacetic acid (DTPA)-triethanolamine (TEA)-$CaCl_2$ method with that of multinutrient extractant (ammonium bicarbonate (AB)-DTPA) in Inceptisols, Alfisols and Entisols in the erstwhile united Andhra Pradesh. The percent variation of extraction of Zn was higher in soils with DTPA-TEA-$CaCl_2$ over AB-DTPA method in all the soil orders (types) in the range of 35.3% to 46.2%. AB-DTPA extracted high amounts of Cu to an extent of 10%-21% in Entisols and Alfisls, respectively. In Inceptisols both extracatants extracted equal amounts of Cu. AB-DTPA extracted high amounts of Fe 13% and 18% in Alfisols and Entisols compared to that of DTPA-TEA-$CaCl_2$ method and DTPA-TEA-$CaCl_2$ method was good extract for Fe in Inceptisols and even for Mn in Alfisols. The amounts of micronutrient contents extracted were found to be highly and significantly correlated with soil properties like electrical conductivity (EC) and organic carbon (OC). The individual micronutrient contents of Zn, Cu and Fe extracted by DTPA-TEA-$CaCl_2$ methods were found to be highly correlated with that of AB-DTPA extractant. However, such correlation was not observed for Mn extraction when all soils were grouped.

**Key words:** Cationic micronutrients, multinutrient extractant, correlation and regression equation.

## 1. Introduction

Soil testing is a proven diagnostic tool to estimate plant nutrient availability in soil. Soil tests measure the quantity of nutrient element that is extracted from a soil by a particular extracting solution. The measured quantity of extractable nutrient in a soil is then used to correlate with nutrient uptake and thus to predict the crop yield in response to application of the nutrient as a fertilizer, organic manure, or other amendments [1]. An assessment of the nutrient status in the soil using conventional method requires a separate extraction and measurement process for most elements; this is costly process in terms of both time and labour [2].

Universal soil extractant is the term that has been adopted to designate a reagent that can be used to extract more than one class of elements, and/or ions from a soil with the concentration found to be a means of assessing the soil fertility status or levels of toxicity [3]. Universal soil extractant has its own advantage in increasing the reliability of soil test, increasing accuracy and precision of the tests and it saves time and increase the efficiency of the methods in routine soil analysis [4].

The first universal soil extracting reagent was developed by Morgan [5], which was modified by Wolf [6] by using chelate-diethylene triamine pentaacetic acid (DTPA) to the extractant. The other methods include dilute acids [7],

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DTPA-triethanolamine (TEA)-$CaCl_2$ [8], DTPA and ethylene diamine tetra acetic acid (EDTA) [9] and ammonium bicarbonate (AB)-DTPA [10] also drew attention as multinutrient extractants in soil analysis. Soltanpour and Workman [11] modified their earlier version of AB-DTPA method for the determination of the micronutrients Cu, Fe, Mn and Zn. This method was demonstrated for soil testing not only for cationic micronutrients but also other nutrients like $NO_3^-$-N, P, K and S that are routinely estimated in soil testing laboratories.

In India, DTPA-TEA-$CaCl_2$ is widely used for estimating cationic micronutrient availability [12]. At the same time, efforts are being made to shift to multinutrient extractant with in state run soil testing laboratories and in research works. Therefore, it is necessary to compare the currently used DTPA-TEA-$CaCl_2$ method used for cationic micronutrient extractability with that of AB-DTPA that has potential for extraction of both cationic micronutrients and other available nutrients in one go.

## 2. Materials and Methods

In order to compare the AB-DTPA ($NH_4HCO_3$-DTPA) extractant with standard extractant (DTPA-TEA-$CaCl_2$) used for available cationic micronutrients, 75 surface soil samples (0-20 cm) comprising 25 each belonging to Inceptisols, Alfisols and Entisols in the erstwhile united Andhra Pradesh (now Andhra Pradesh and Telangana states) in India were employed. The soil sampled locations were depicted in Fig. 1. The collected soil samples were air dried and grounded using wooden pestle and mortar and subsequently sieved through a 2 mm sieve. Some important soil properties like pH, electrical conductivity (EC) and organic carbon (OC) were analysed following the standard procedures [13]. These soils were extracted for available cationic micro nutrients using AB-DTPA method developed by Soltanpour and Workman [11] in one set and by DTPA extracting solution (0.005 M DTPA, 0.1 M triethanolamine, 0.01 M $CaCl_2$) [8]. The data on micronutrients extracted amounts were compared for their variation among themselves and correlations & regression equations were computed [14] for understanding their competitive preferences in micronutrient extraction.

## 3. Results and Discussion

Soil pH in Inceptisols ranged from 5.0 to 9.2 and it

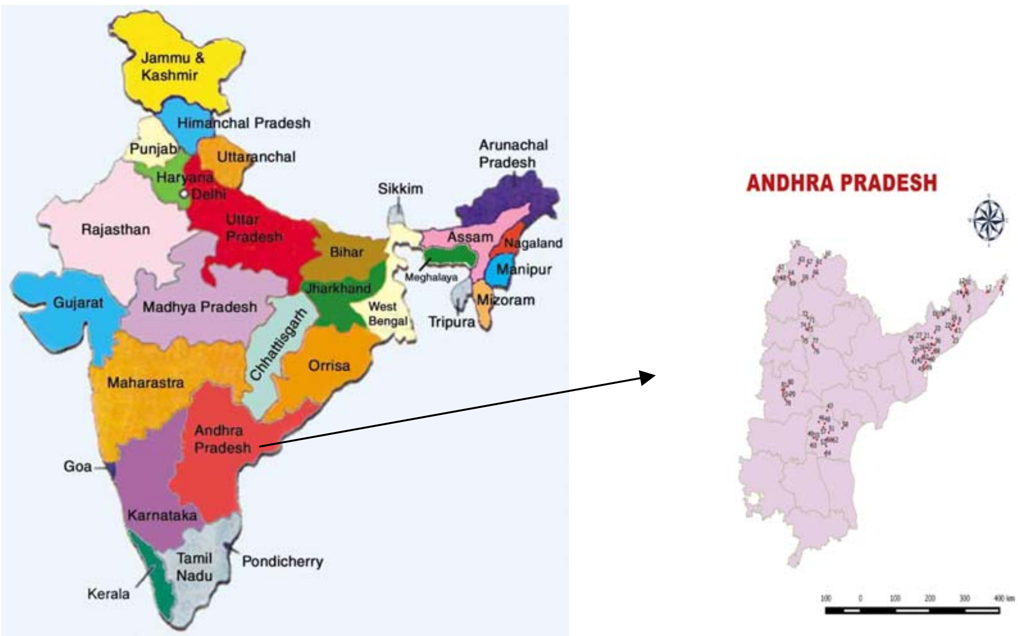


**Fig. 1 Soil sampled location in Erstwhile Andhra Pradesh state of India (now Andhra Pradesh and Telangana states).**

was 5.4 to 8.3 and 6.0 to 8.7 in Alfisols and Entisols, respectively. EC in all three soil types ranged from 0.1 dS/m to 1.1 dS/m, 0.1 dS/m to 1.2 dS/m and 0.04 dS/m to 0.5 dS/m with mean values of 0.4, 0.5 and 0.2 dS/m in Inceptisols, Alfisols and Entisols, respectively without any salt problem. Similarly, the OC in these soils ranged from 0.1% to 1.8% with a mean of 0.8% in Inceptisols and it ranged from 0.1% to 1.7% (0.7%), 0.1% to 1.6% (0.7%) and 0.1% to 1.8% (0.7%) in Alfisols, Entisols and in all soils together, respectively (Table 1).

The available Zn extracted by DTPA-TEA-$CaCl_2$ method ranged from 0.2 mg/kg to 4.4 mg/kg with a mean value of 1.7 mg/kg (Table 1) in Inceptisols, 0.5 mg/kg to 4.4 mg/kg with a mean of 1.8 mg/kg and 0.5 mg/kg to 3.2 mg/kg with a mean of 1.3 mg/kg in Alfisols and Entisols, respectively. These values for all soils together ranged from 0.2 mg/kg to 4.4 mg/kg with a mean value of 1.5 mg/kg. The extent of extraction of Zn with AB-DTPA procedure ranged from 0.2 mg/kg to 2.9 mg/kg with a mean of 1.1 mg/kg and 0.3 mg/kg to 2.6 mg/kg with a mean of 1.0 mg/kg in Inceptisols and Alfisols, respectively. In case of Entisols the Zn values ranged from 0.3 mg/kg to 1.8 mg/kg with a mean of 0.7 mg/kg and in all 75 soils together extracted Zn ranged from 0.2 mg/kg to 2.9 mg/kg with a mean of 1.0 mg/kg. The extent of variation in extraction of Zn was higher in soils with DTPA-TEA-$CaCl_2$ extractant over AB-DTPA method in all the soil orders (types) in the range of 35.3% to 46.2% (Table 2). These results are in accordance with the findings of Elrashidi *et al.* [15] and Takrattanasaran *et al.* [16] who have reported such variations for different soils (alkaline and calcareous soils). This could be due to chelation by reducing the activity by complexion, causing the dissolution of the labile forms in soils.

Soil available Cu values in 75 soils belonging to three orders ranged from 0.3 mg/kg to 9.1 mg/kg with a mean value of 3.2 mg/kg when extracted by DTPA-TEA-$CaCl_2$ procedure and it was in the range of 0.5 mg/kg to 13.6 mg/kg with a mean of 4.0 mg/kg with AB-DTPA method in Inceptisols. In Alfisols and Entisols, the AB-DTPA extracted more amounts of Cu than those of DTPA method. AB-DTPA extracted high amounts of Cu to an extent of 10% and 21% over that of DTPA-TEA-$CaCl_2$ method in Entisols and Alfisols, respectively. This may due to the presence of $NH_4^+$ in AB-DTPA which may render in displacing the exchangeable Cu. These results are in conformity with Refs. [17, 18].

The available Fe extraction ranged from 5.7 mg/kg to 38.1 mg/kg and 5.7 mg/kg to 37.5 mg/kg (Table 1) with mean values of 28.3 mg/kg and 22.7 mg/kg by DTPA and AB-DTPA extractants, respectively, in Inceptisols. Mean available Fe content of 28.7 mg/kg and 20.6 mg/kg extracted by AB-DTPA extractant was higher by 13% and 18% in Alfisols and Entisols, respectively, than those of DTPA extraction. However, available Fe content extracted by DTPA-TEA-$CaCl_2$ was 20% higher than that of AB-DTPA in Inceptisols (Table 2). When data were pooled for 75 soils belonging to three orders, the mean available Fe extracted by AB-DTPA and DTPA-TEA-$CaCl_2$ method remained similar.

DTPA-TEA-$CaCl_2$ extracted soil available Mn ranged from 27.5 mg/kg to 32.9 mg/kg with a mean value of 31.0 mg/kg and AB-DTPA extracted Mn ranged from 22.0 mg/kg to 36.0 mg/kg with a mean of 28.0 mg/kg (Table 1) in Inceptisols. DTPA-Mn extraction was higher by 10% (Table 2) in Inceptisols, 15% in Entisols and 9% in soils together when compared to that of AB-DTPA. In Aalfisols, the AB-DTPA extracted high amounts of Mn to an extent of 23% and these results are inconformity with Sharma *et al.* [19] and Chatzistathis *et al*. [20] who worked on acidic soils of Himachal Pradesh and on Greek soils.

**Table 1 Cationic micronutrients content in different soils as affected by different extractants.**

| Soil type | pH | EC | OC | DTPA-TEA-$CaCl_2$ | | | | AB-DTPA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Zn | Cu | Fe | Mn | Zn | Cu | Fe | Mn |
| | (1:2.5 SWS) | (dS/m) | (%) | (mg/kg) | | | | (mg/kg) | | | |
| Inceptisols (25 ) | | | | | | | | | | | |
| Range | 5.0-9.2 | 0.1-1.1 | 0.1-1.8 | 0.2-4.4 | 0.3-9.1 | 5.7-38.1 | 27.5-32.9 | 0.2-2.9 | 0.3-9.1 | 5.7-37.5 | 22.0-36.0 |
| Mean | 6.9 | 0.4 | 0.8 | 1.7 | 3.6 | 28.3 | 31 | 1.1 | 3.6 | 22.7 | 28 |
| Alfisols (25) | | | | | | | | | | | |
| Range | 5.4-8.3 | 0.1-1.2 | 0.1-1.7 | 0.5-4.4 | 0.6-5.7 | 17.4-37.2 | 27.5-32.6 | 0.3-2.6 | 0.9-7.7 | 21.2-37.5 | 23.4-47.2 |
| Mean | 6.9 | 0.5 | 0.7 | 1.8 | 2.8 | 25.3 | 31 | 1.0 | 3.4 | 28.7 | 30.8 |
| Entisols (25) | | | | | | | | | | | |
| Range | 6.0-8.7 | 0.04-0.5 | 0.1-1.6 | 0.5-3.2 | 1.1-7.9 | 4.2-28.2 | 28.9-335.0 | 0.3-1.8 | 1.3-6.9 | 6.5-32.9 | 20.7-35.3 |
| Mean | 7.8 | 0.2 | 0.7 | 1.3 | 3.3 | 17.5 | 32.2 | 0.7 | 3.6 | 20.6 | 27.3 |
| All soils (75) | | | | | | | | | | | |
| Range | 5.0-9.2 | 0.04-1.2 | 0.1-1.8 | 0.2-4.4 | 0.3-9.1 | 4.2-38.1 | 27.5-35.0 | 0.2-2.9 | 0.5-13.6 | 5.7-37.5 | 20.7-47.2 |
| Mean | 7.2 | 0.3 | 0.7 | 1.5 | 3.2 | 24.0 | 31.4 | 1.0 | 4.0 | 23.9 | 28.7 |

EC: electrical conductivity; OC: organic carbon; DTPA: diethylene triamine pentaacetic acid; AB: ammonium bicarbonate.

**Table 2 Percent variation (+/-) in ammonium bicarbonate (AB)-diethylene triamine pentaacetic acid (DTPA) extractable micronutrients in agricultural soils in comparison with DTPA-TEA-$CaCl_2$ method.**

| Soil type | Mean content (mg/kg) | | Percent variation of extraction (+/-) over DTPA-TEA-$CaCl_2$ method |
|---|---|---|---|
| | DTPA-TEA-$CaCl_2$ | AB-DTPA | |
| Inceptisols | | | |
| Zn | 1.70 | 1.10 | (-) 35 |
| Cu | 3.60 | 3.60 | - |
| Fe | 28.30 | 22.70 | (-) 20 |
| Mn | 31.00 | 28.00 | (-) 10 |
| Alfisols | | | |
| Zn | 1.80 | 1.00 | (-) 44 |
| Cu | 2.80 | 3.40 | (+) 21 |
| Fe | 25.30 | 28.70 | (+) 13 |
| Mn | 31.00 | 38.00 | (+) 23 |
| Entisols | | | |
| Zn | 1.30 | 0.70 | (-) 46 |
| Cu | 3.30 | 3.60 | (+) 10 |
| Fe | 17.50 | 20.60 | (+) 18 |
| Mn | 32.20 | 27.30 | (-) 15 |
| All soils | | | |
| Zn | 1.50 | 1.00 | (-) 33 |
| Cu | 3.20 | 4.00 | (+) 25 |
| Fe | 24.00 | 23.90 | - |
| Mn | 31.40 | 28.70 | (-) 9 |

**Table 3 Correlation coefficients of soil properties with different extractants due to DTPA and AB-DTPA extraction.**

| Soil type | DTPA-TEA-$CaCl_2$ | | | | AB-DTPA | | | |
|---|---|---|---|---|---|---|---|---|
| | Zn | Cu | Fe | Mn | Zn | Cu | Fe | Mn |
| Inceptisols (25) | | | | | | | | |
| pH | 0.01 | -0.33 | -0.45 | -0.08 | -0.001 | -0.23 | -0.26 | -0.18 |
| EC | 0.19 | 0.62* | 0.26 | -0.27 | 0.02 | 0.60* | 0.18 | 0.15 |
| OC | 0.30 | 0.61* | 0.30 | 0.01 | 0.13 | 0.46* | 0.14 | 0.34 |
| DTPA-TEA-$CaCl_2$ | | | | | 0.8** | 0.99** | 0.5 | 0.1 |
| Alfisols (25) | | | | | | | | |
| pH | -0.1 | 0.45 | 0.16 | -0.32 | -0.14 | 0.12 | 0.03 | 0.2 |
| EC | -0.3 | 0.46 | -0.39 | -0.14 | -0.2 | 0.41 | -0.47 | 0.22 |
| OC | 0.10 | 0.56* | 0.21 | 0.15 | 0.13 | 0.65* | 0.27 | 0.22 |
| DTPA-TEA-$CaCl_2$ | | | | | 1** | 0.8** | 0.5 | 0.3 |
| Entisols (25) | | | | | | | | |
| pH | -0.1 | -0.26 | -0.44 | 0.14 | -0.1 | -0.02 | -0.56 | -0.11 |
| EC | 0.02 | -0.01 | 0.03 | -0.31 | -0.002 | 0.04 | 0.04 | 0.08 |
| OC | 0.1 | 0.19 | 0.02 | 1** | 0.07 | 0.08 | 0.09 | 0.2 |
| DTPA-TEA-$CaCl_2$ | | | | | 1** | 0.9** | 0.8** | 0.2 |
| All soils (75) | | | | | | | | |
| pH | -0.1 | -0.1 | -0.5 | 0.1 | -0.2 | -0.2 | -0.3 | -0.1 |
| EC | -0.3 | 0.09 | 0.01 | -0.3 | -0.01 | -0.03 | 0.0 | 0.2 |
| OC | 0.1 | 0.66 | 0.19 | 0.15 | 0.09 | 0.04 | 0.26 | 0.04 |
| DTPA-TEA-$CaCl_2$ | | | | | 0.9** | 0.8** | 0.6* | 0.1 |

EC: electrical conductivity; OC: organic carbon. *$p$ = 0.01; **$p$ = 0.001.

The correlation coefficients between the extracted amounts of Zn by DTPA-TEA-$CaCl_2$ and AB-DTPA were found to be highly significant ($r$ = 0.8 to 1**), when all soils were pooled together (Table 3) and their relations in terms of regression equation between both the extractants were given in Fig. 2. Sharma *et al.* [19] and Molina *et al.* [21] reported significant correlations between DTPA-TEA-$CaCl_2$ and AB-DTPA extracted cationic micronutrients and these findings also agree with that of reported by Sharma *et al*. [19], Aruna Sree *et al.* [22], Malathi and Stalin [23] and Nazif *et al.* [24]. In case of Cu, the regression equation between both the extractants was given in Fig. 3 for all three types of soils and extracted Cu was significantly correlated ($r$ = 0.8 to 0.9**) when extracted by the two extractants. Fe extracted was significantly correlated with both extractants in all soils and Entisols ($r$ = 0.6 to 0.8**) and regression equations are presented in Fig. 4. The micronutrients extracted by these two reagents were also found to be highly correlated with soil properties like EC and OC (Table 3) and such results were also reported by Sharma *et al*. [19] and Nazif *et al*. [24].

## 4. Conclusions

The study revealed that AB-DTPA method, in general, extracts lower amounts of Zn and Mn and higher amounts of Cu and Fe in most of the soils that were tested when compared to DTPA-TEA-$CaCl_2$. However, good correlations in extracted amounts were observed with these two extractants. The complete acceptability of AB-DTPA in routine soil analysis in place of individual methods depends on comparison of AB-DTPA performance with that of standard measures for P & K as well.

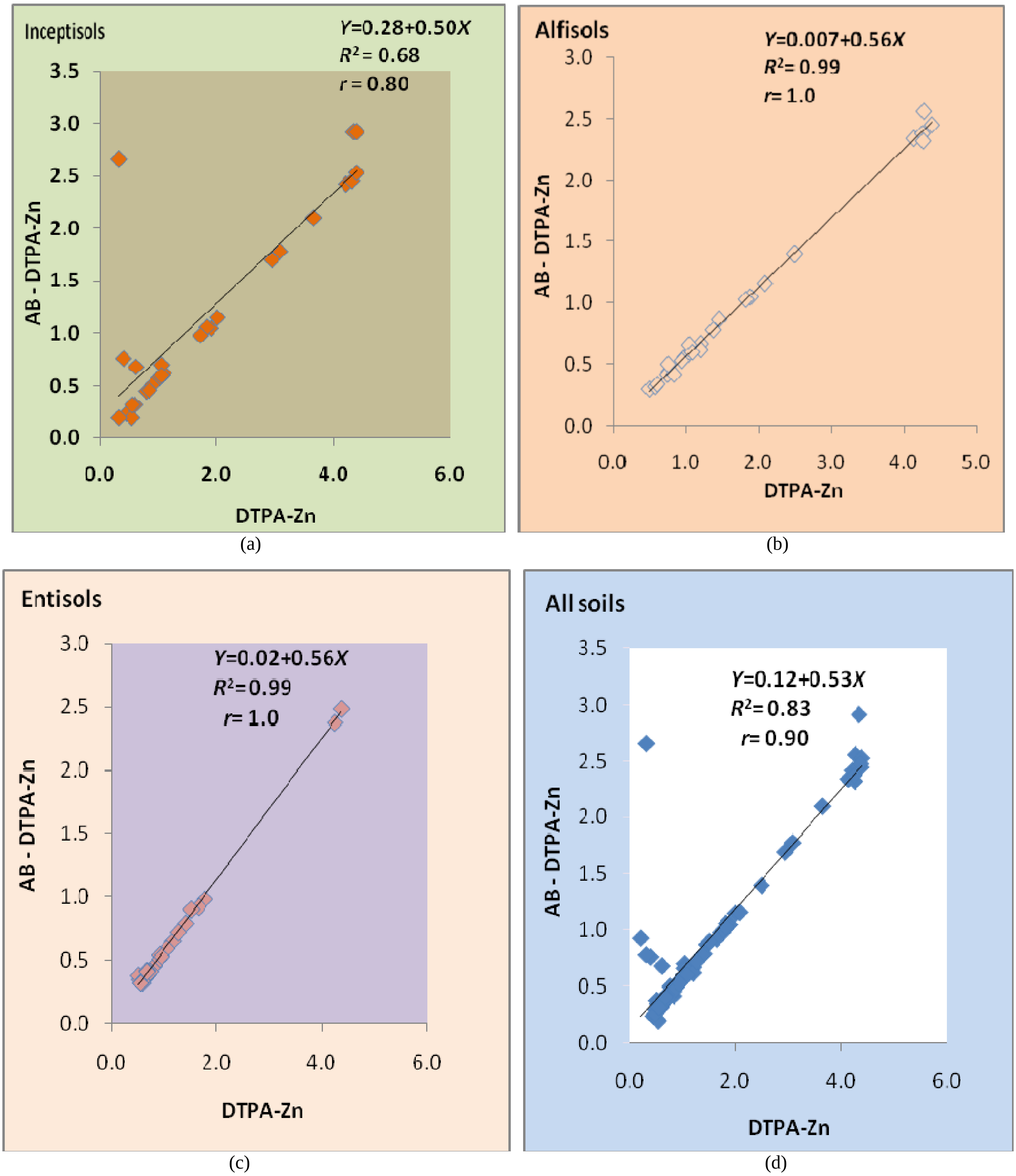


**Fig. 2 Relationship between the diethylene triamine pentaacetic acid (DTPA)-Zn and ammonium bicarbonate (AB)-DTPA-Zn in Inceptisols, Alfisols, Entisols and in all soils.**

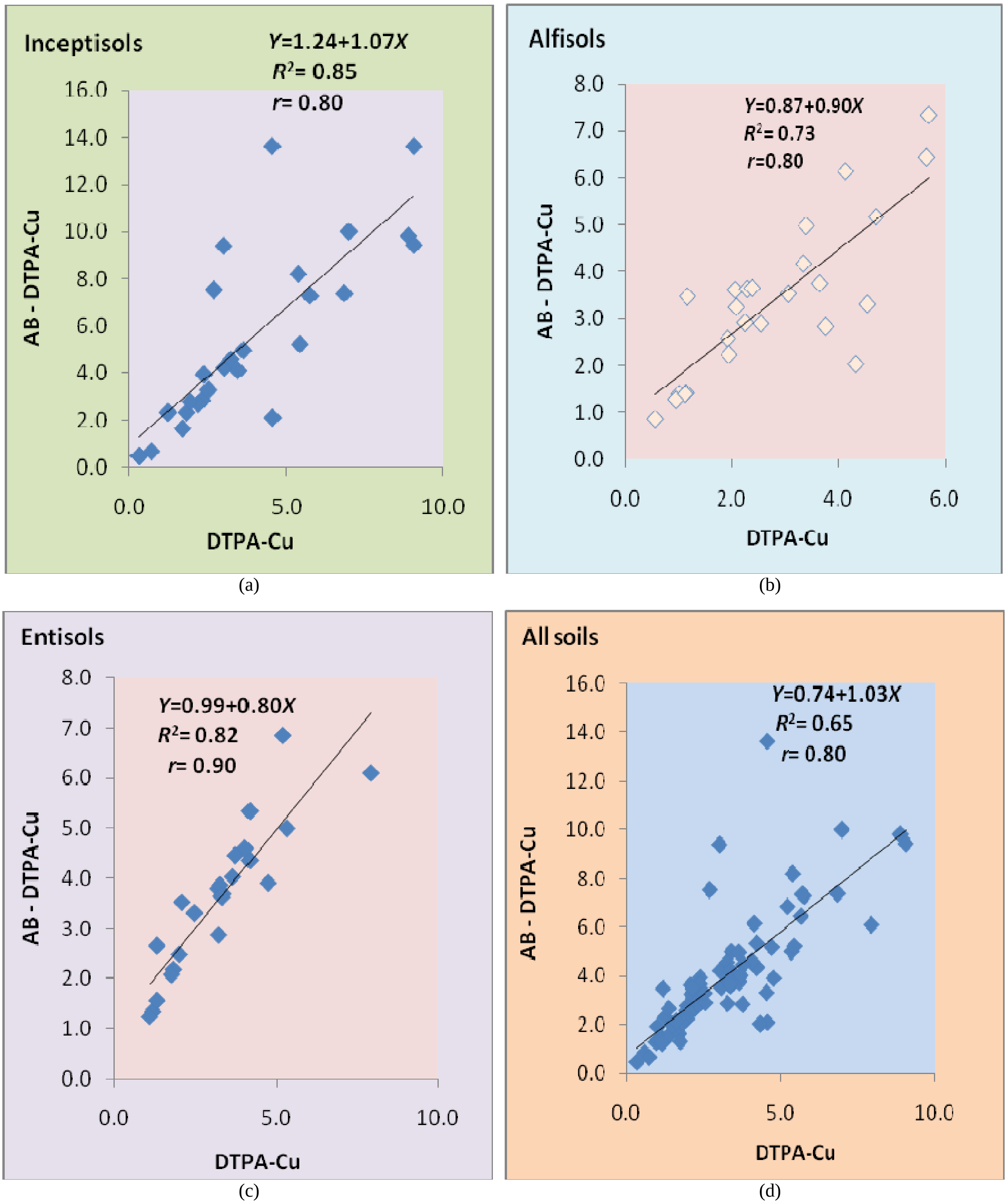


**Fig. 3 Relationship between the DTPA-Cu and AB-DTPA-Cu in Inceptisols, Alfisols, Entisols and in all soils.**

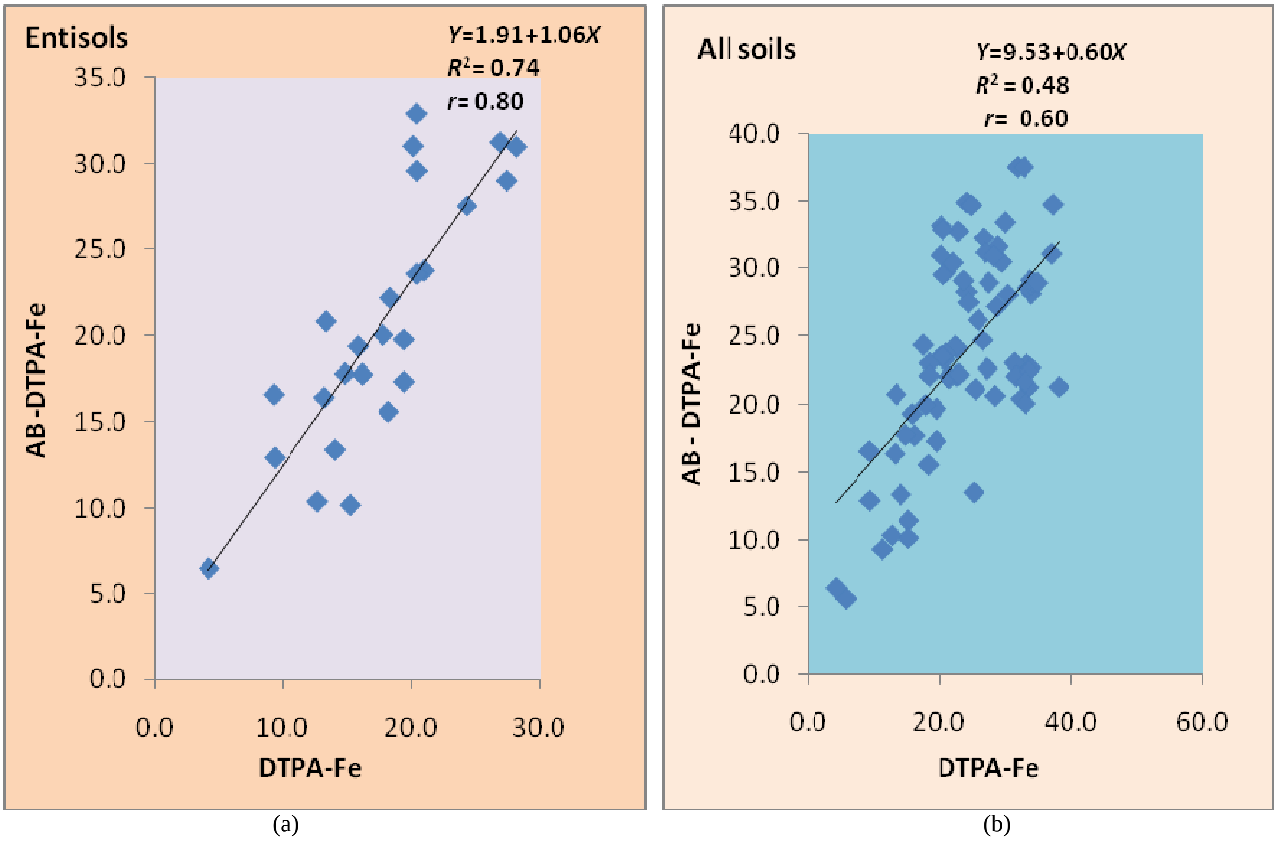


**Fig. 4 Relationship between the DTPA-Fe and AB-DTPA-Fe in Entisols and in all soils.**

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