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Evaluation of AB-DTPA and DTPA Extractants for Cationic Micronutrients in Calcareous Soils

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ABSTRACT

This study was conducted in order to evaluate the efficiency of ammonium bicarbonate-DTPA (AB-DTPA) and DTPA extractants for cationic micronutrients (Zn, Fe, Mn and Cu) in calcareous soils of Piduguralla mandal. The relationships between the amounts of micronutrients extracted by AB-DTPA with those extracted by DTPA (the conventional extraction method widely used in soil testing laboratories widely used in soil testing laboratories in India) and those taken up by blackgram were elucidated. Between DTPA and AB-DTPA extractants tested for micronutrient availability, the mean available micronutrient content was the highest in AB-DTPA than DTPA and their efficiency in extracting available micronutrient content of soils was higher in AB-DTPA than DTPA based on correlation values in the pot culture study. Highest positive and significant correlation was observed between zinc, iron, manganese and copper uptake and AB-DTPA extracted micronutrient cations (0.451**, 0.941**, 0.443** and 0.386**, respectively) than with DTPA extracted cationic micronutrients (0.437**, 0.489**, 0.441** and 0.379**, respectively). Since DTPA and AB-DTPA extractants showed significant positive correlation (r = 0.902**, 0.939**, 0.907**, 0.897**) with each other and with that of blackgram uptake, suggested that AB-DTPA could be used effectively for estimating available cationic micronutrients in calcareous soils.

Key words: *AB-DTPA, Cationic micronutrients, DTPA, Multinutrient extractant, Soil test.*

The assessment of available micronutrients in soils depend upon the efficacy of the extractant. No single extractant can be universally recommended for soils of diversified nature in predicting the supplying capacity of micronutrients. As the soil testing is becoming costlier nowadays, use of cost effective and time saving multinutrient extractants for estimation of micronutrients in soils need careful consideration. Soil tests measure the quantity of nutrient element that is extracted from a soil by a particular chemical extracting solution. The measured quantity of extractable nutrient in a soil is then used to predict the crop yield response to application of the nutrient as a fertilizer, manure, or other amendments. One of the major advances in micronutrient soil testing was the development of extracting solutions that contain chelating agents, primarily DTPA (Diethylene Triamine Pentaacetic Acid) (Lindsay and Norvell, 1978) and AB-DTPA (Ammonium Bicarbonate Diethylene Triamine Pentaacetic Acid) (Soltanpour and Schwab, 1977) etc., many of the extractants in routine analyses are used for multiple elements, in general developed for other nutrients and used for determination of copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn) due to the operational ease in laboratories for routine soil testing. However, the lack of standardization of extraction methods can affect the reliability of the analytical results, since the success of this practice is associated with the choice of an extractant suited for the specific agricultural conditions in the region under study.

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. The purpose of this work was, therefore, to assess and compare the effectiveness of both DTPA and AB-DTPA extractants for calcareous soils. DTPA being the most commonly used extractant, was used for comparison. AB-DTPA extractant is attractive to soil testing laboratories, since AB-DTPA reagent simultaneously extract several nutrients (macro and micronutrients). Using a single extracting solution for extraction of multiple elements reduces the cost of labour and reagents. The objective of the current research was to evaluate the efficiency of DTPA and AB-DTPA extractants for predicting available cationic micronutrients in calcareous soils of Piduguralla mandal of Guntur district, A.P. The exact amount of nutrient that is extracted is a function of the nature of the particular extractant as it interacts with soils of varying properties.

MATERIAL AND METHODS

Soils used

One hundred and ten surface (0-15 cm) soil samples were collected from cultivated areas composed of calcareous soils in the Piduguralla mandal of Guntur district. The soil samples were thoroughly mixed, air dried and ground to pass through a 2-mm sieve.

Laboratory analysis

The soil samples were analyzed for some properties. Analysis of soils for textural classification was done by Bouyoucos hydrometer method (Bouyoucos, 1962), pH was determined in 1:2.5 soil : water suspension using combined glass electrode (Jackson, 1973)., The EC of soil samples was determined in supernatant liquid of 1:2 soil:water suspension using electrical conductivity bridge (Jackson,1973), cation exchange capacity (CEC) by was estimated flamephotometrically. The CEC was calculated and expressed as cmol (p+) kg-1 soil (Bower et al., 1952), organic matter (OM) by the Walkley and Black method (Walkley and Black, 1934) and Calcium carbonate content of the soil is determined by titrating the soil suspension with 0.5 N H_2SO_4 in the presence of bromothymol blue and bromocresol green indicators (Puri, 1930). Each soil sample was also analyzed for available Zn, Fe, Mn and Cu by extraction with AB-DTPA (Soltanpour and Schwab, 1977) and DTPA (Lindsay and Norvell, 1978) (Table 1). The concentration of Zn, Fe, Mn and Cu in the extracts was determined by atomic absorption spectrophotometer.

POT CULTURE STUDY

A pot culture study was conducted in the green house of Department of Soil Science and Agricultural Chemistry , Agricultural College, Bapatla during 2015 to correlate the cationic micronutrient uptake with with soil micronutrient contents extracted with DTPA and AB-DTPA extractants.

Hundred and ten pots (one pot for each sample) of equal size was filled with 3 kg of soil sample and blackgram seeds (5 seeds) were sown in each pot with 3 kg of soil. After establishment, three seedlings were retained and plant samples were collected at harvest stage. Seed dry matter and haulm dry matter were recorded . The harvested plant samples were washed first with tap water followed by 0.1 N HCl solution and finally rinsed with double distilled water. The samples were air dried and then in a hot air oven at 65p C. The dry matter yield was recorded separately , seed and haulm. The oven dried plant samples were powdered in a stainless steel grinder and stored in butter paper covers for further chemical analysis.

Analysis of Plant Samples

Plant analysis was carried out separately for seed and haulm. One gram of oven dry powdered plant sample (seed or haulm) was digested with 10 mL of di-acid mixture (HNO3:HClO4 in 9:4 ratio) on a hot plate. The digested sample was diluted with double distilled water to100 mL volume and was filtered through Whatman No.1 filter paper and content of cationic micronutrients in the filterate was determined with the help of atomic absorption spectrophotometer. The uptake of cationic micronutrients by seed and haulm separately was computed as per standard formula.

$$\text{Uptake (mg pot}^{-1}) = \frac{\text{Dry matter yield (g pot}^{-1}) \text{ X concentration (ppm) of the nutrient}}{1000}$$

Seed yield and haulm yield were combined to get the total yield. Nutrient uptake by seed and nutrient uptake of haulm were combined to obtain total nutrient uptake.

From the total yield data and total nutrient uptake, nutrient concentration in the plant was computed with the given formula.

$$\text{Nutrient conc. in plants (ppm)} = \frac{\text{Uptake (mg pot}^{-1}) \text{ x } 1000}{\text{Dry matter yield (g pot}^{-1})}$$

Verifying efficiency of extractants

The ability of AB-DTPA and DTPA extractants in measuring soil cationic micronutrients was evaluated based on the amounts of Zn, Fe,

Table 1. Details of the methodology followed for extraction of available micronutrients.

Extractant	Composition	Proposed by	Soil: Extractant ratio	Soil weight (g)	Extractant volume (mL)	Shaking time (min)
DTPA (pH7.3)	0.005M DTPA + 1M $CaCl_2$ + 0.1M TEA	Lindsay and Norvell (1978)	1:2	20	40	120
AB-DTPA (pH7.6)	1M NH_4HCO_3 +0.005 M DTPA	Soltanpour and Schwab (1977)	1:2	20	40	15

Table 2. Physico-chemical properties of of soils of Piduguralla mandal of Guntur district.

S.No.	Name of the village	pH	EC (dS m^{-1})	OC (%)	$CaCO_3$ (%)	CEC (cmol (p^+) kg^{-1})
1	Chennayapalem	7.3	0.33	0.42	15.9	39.3
2	Konamki	7.5	0.67	0.33	24.0	39.6
3	Bramhanapalli	8.0	0.20	0.28	28.2	42.8
4	Kamepalli	7.6	0.27	0.41	17.1	38.5
5	Tummalacheruvu	7.6	1.37	0.40	19.6	41.0
6	Julakallu	7.8	0.94	0.25	25.4	40.1
7	Guthikonda	7.4	0.57	0.40	15.9	36.9
8	Chinnagraharam	7.5	0.76	0.36	21.0	40.5
9	Janapadu	7.7	0.68	0.37	26.2	43.9
10	Piduguralla	7.6	0.22	0.36	18.3	39.8
11	Pathaganeshampadu	7.7	0.20	0.35	24.0	36.5
12	Karalapadu	7.8	0.30	0.35	28.2	40.1
13	Peddagraharam	7.7	1.08	0.41	34.0	46.8
14	Veerapuram	7.8	0.96	0.33	27.7	42.1
15	Panditivaripalem	7.5	0.64	0.40	17.6	40.6
	Overall mean	7.6	0.58	0.38	22.20	40.1

Table 3. Ranges and means of amount of micronutrients extracted by DTPA and AB-DTPA extractants.

Extractant	Zn (mg kg^{-1})		Fe (mg kg^{-1})		Mn (mg kg^{-1})		Cu (mg kg^{-1})	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
AB-DTPA	0.60	0.18-1.32	2.26	0.63-5.02	2.19	1.03-3.47	0.91	0.32-1.56
DTPA	0.39	0.12-0.88	2.07	0.57-4.80	2.15	1.01-3.40	0.43	0.16-0.78

Table 4. Correlations between DTPA and AB-DTPA method of extraction of micronutrients.

	AB-DTPA Zn	AB-DTPA Fe	AB-DTPA Mn	AB-DTPA Cu
DTPA Zn	0.902**			
DTPA Fe		0.939**		
DTPA Mn			0.907**	
DTPA Cu				0.897**

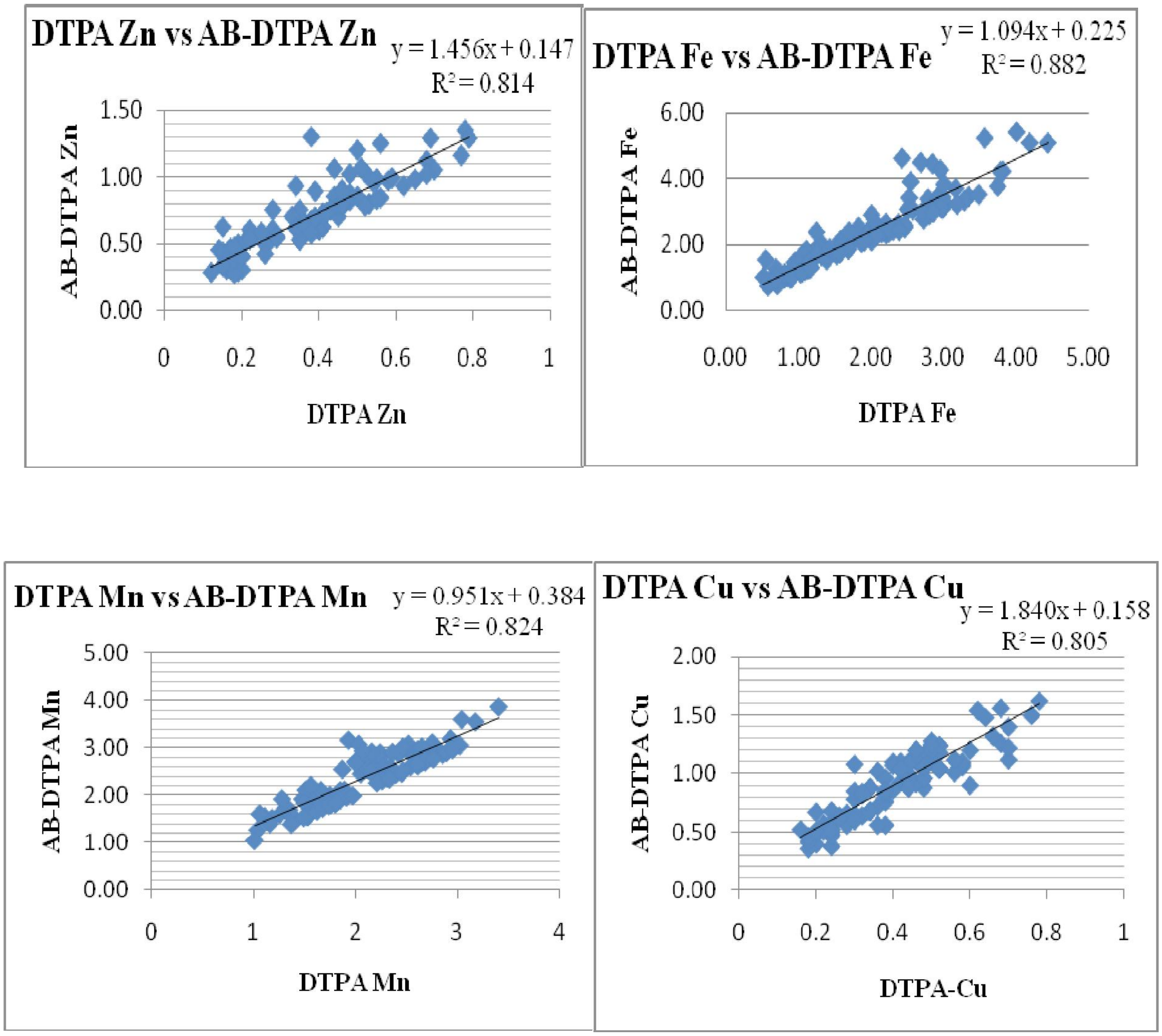

Fig. 1. Regression graphs between DTPA and AB-DTPA extracted Zn, Fe, Mn and Cu.

Mn and Cu extracted by AB-DTPA and DTPA compared with each other and also with those taken up by blackgram. Linear correlation and regression analysis were used to evaluate the relationships. The correlation coefficient (r) and coefficient of determination (r^2) were used to appraise the efficiency of the extractants.

RESULTS AND DISCUSSION

Soil properties

Some physical and chemical properties of the investigated soils are shown in Table 2. The soils were found to vary from sandy clay loam to clay with pH ranging from 7.3 to 8.0, low levels of EC and high level of CEC. The amount of OM ranged from 0.25 to 0.42 per cent and the $CaCO_3$ content ranged from 15.9 to 34.0 per cent (mean values).

The amounts of micronutrients extracted by AB-DTPA and DTPA extractants and their relationships

The amounts of Zn, Fe, Mn and Cu extracted by the DTPA and AB-DTPA extraction methods from soils are shown in Table 3. A large variation in the amount of micronutrients extracted by the two extractants was observed. The amounts of Zn, Fe, Cu and Mn extracted with AB-DTPA showed positive correlation (0.902**, 0.939**, 0.897** and 0.907**, respectively) (Table 4) with DTPA extracted Zn, Fe, Cu and Mn. This finding agrees with that reported by Takrattanasaran *et al*. (2010), Bibiso *et al*. (2015).

The tendency of AB-DTPA to extract more micronutrients compared to DTPA might be due to the extractability of the NH_4^+ in the AB-DTPA

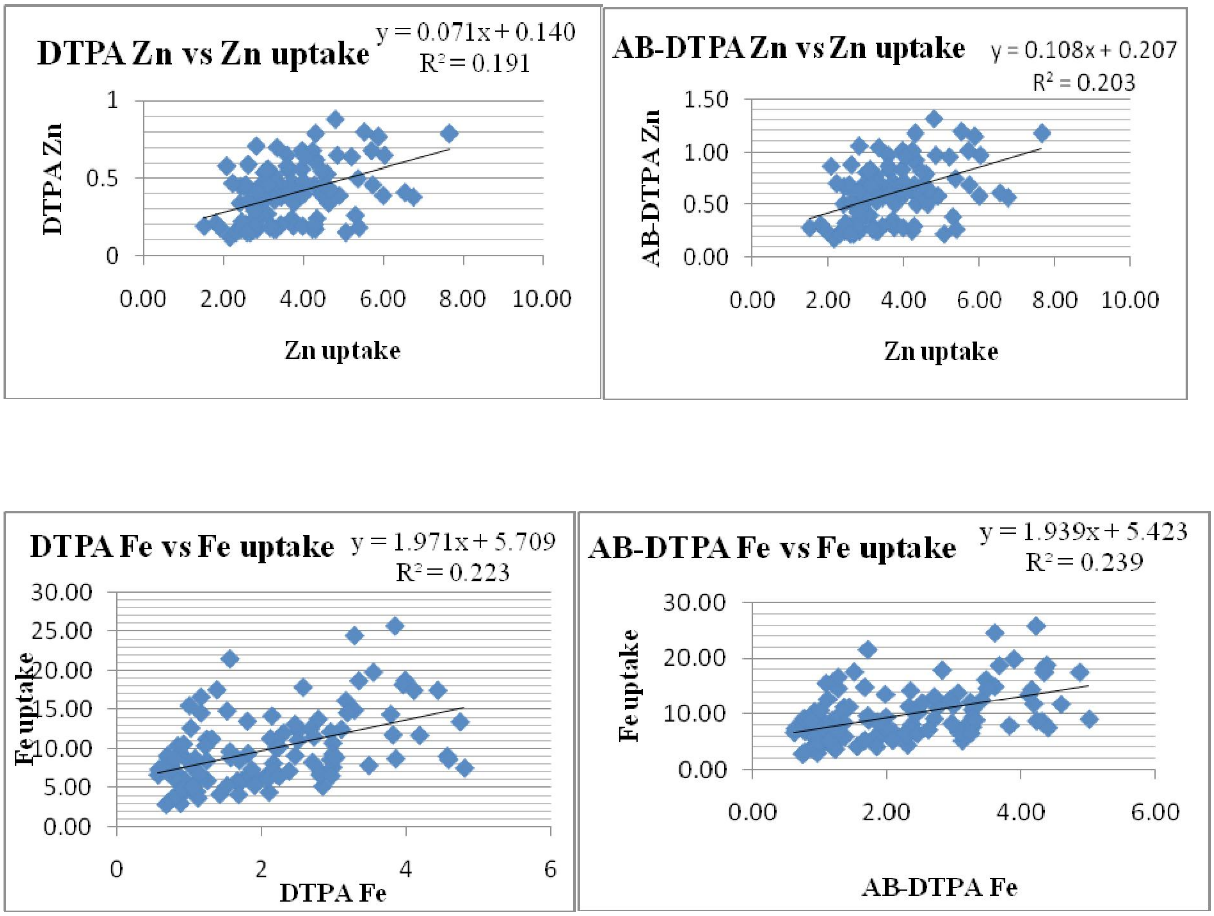

Fig.2. Regression graph between DTPA Zn, Fe / AB-DTPA Zn, Fe and uptake of Zn by blackgram.

mixture to replace the microelements on the exchange complex (Ayed and Chaudary, 1989) and further, it was also due to the presence of chelate and salt in the extractants which could extract more amount of available micronutrients from soils (Aydin., 2003). High pH (7.6) level of AB-DTPA than DTPA (pH 7.1) resulted in quick precipitation and a release of greater amount of micronutrients from soil. AB-DTPA removes micronutrients with HCO_3^- ions from soils (Soltanpour., 1985). Moreover, the correlation coefficients were more with AB-DTPA than with DTPA extractant.

The regression equations and coefficients of determination (r^2) for the relationships between amount of micronutrients extracted by AB-DTPA and DTPA extractants are depicted in graphs (Fig.1). The results showed that there was a strong relationship between the amount of micronutrients extracted by AB-DTPA and that extracted by DTPA.

Relationship between biological indices (dry matter and uptake of micronutrients Zn, Fe, Mn and Cu) by blackgram with micronutrients extracted by extractants (DTPA and AB-DTPA)

The relationship between total micronutrient (Zn, Fe, Mn and Cu) uptake and dry matter by blackgram with the amounts of micronutrients extracted by DTPA and AB-DTPA extractants are presented in table 6 and 7.

The results showed that the total dry matter was negatively correlated with calcium carbonate (-0.954**). Significant and positive relation was observed between the total amount of zinc, iron, manganese and copper extracted by AB-DTPA and total dry matter (0.683**, 0.525**, 0.517**, 0.450**, respectively) which was higher than with the DTPA. The results also showed that the amounts of Zn, Fe, Mn and Cu extracted by DTPA (0.437**, 0.489**, 0.441** and 0.379**, respectively) and

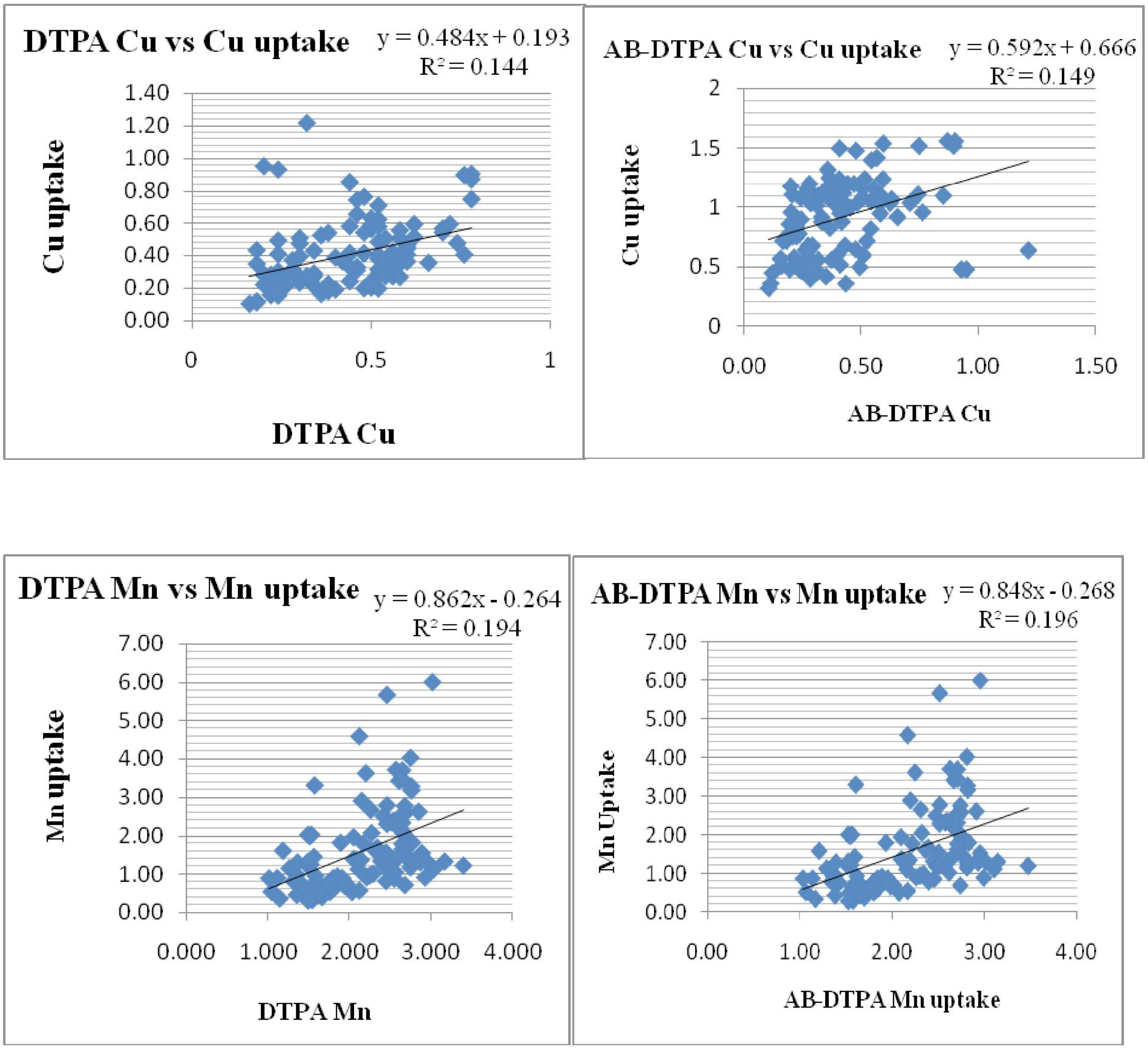

Fig. 3. Regression graph between DTPA Cu, Mn / AB-DTPA Cu, Mn and uptake of Mn by blackgram.

Table 5. Relationship between dry matter of blackgram and the amounts of micronutrients (Zn, Fe, Mn and Cu) extracted by DTPA and AB-DTPA extractants.

	Zn		Fe		Mn		Cu	
	DTPA	AB-DTPA	DTPA	AB-DTPA	DTPA	AB-DTPA	DTPA	AB-DTPA
Dry matter	0.664**	0.683**	0.512**	0.525**	0.516**	0.517**	0.442**	0.450**

Table 6. Relationship between micronutrient (Zn, Fe, Mn and Cu) uptake by blackgram and the amounts of micronutrients extracted by DTPA and AB-DTPA extractants.

	Zn Uptake	Fe Uptake	Mn Uptake	Cu Uptake
DTPA	0.437**	0.489**	0.441**	0.379**
AB-DTPA	0.451**	0.941**	0.443**	0.386**

AB-DTPA (0.451**, 0.941**, 0.443** and 0.386** respectively) were significantly (p d" 0.01) correlated with total Zn, Fe, Mn and Cu uptake. Similar results were observed by Adiloglu (2003), Narender *et al*. (2013). The coefficient of determination (r^2) values for the linear regression between micronutrients (Zn, Fe, Mn and Cu) uptake by blackgram and the amount of micronutrients (Zn, Fe, Mn and Cu) extracted by DTPA and AB-DTPA were depicted in graphs (Fig. 2 and 3). Similar correlations were reported by Mustafa *et al.* (2001) and Motaghian *et al*. (2016).

Since DTPA and AB-DTPA extractants showed significant positive correlation with each other, the correlation coefficient values for uptake were relatively higher with AB-DTPA extractant than with DTPA extractant. Hence, it can be suggested that AB-DTPA can be used as an efficient extractant for available cationic micronutrients in calcareous soils.

CONCLUSIONS

Based on the findings of uptake studies conducted in pot, it could be stated that AB-DTPA can be considered as an efficient extractant for cationic micronutrients in calcareous soils.

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