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Comparative Studies on the Effects of Different Extractants to Extract Zinc from Various Soils of Bangladesh

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Abstract: Investigations were conducted to examine the effects of different extractants on the amount of zinc extracted from the soils of six locations in Bangladesh. In this study, some extractants such as EDTA, HCl, ASI and CH_3COONH_4 were selected to use for comparative studies of their extract ability to extract soil zinc. The extraction period was set to fix for 4 h for shaking of different soil samples adding with cited above proper reagent in polypropylene centrifuge tube on an end-over-end shaker. Results showed that the maximum amount of Zinc was extracted by using the extractant 0.05 M HCl in Tea, Madhupur, Farm of BAU (Bangladesh Agricultural University) and Poorly drained (Mymensingh). With the action of other reagents, the amount of extractable zinc was very little in all the supplied soil samples. Some exceptions occurred in the case of Ishurdi and Saline soils extracted by EDTA that showed the higher amount of zinc concentration than by the others. CH_3COONH_4 and ASI exposed to be poor reagents as to effective for the extraction of soil zinc. In the experimental results, it can be concluded that the ability of different extractants to extract soil zinc decreased in the order HCl> EDTA> CH_3COONH_4 > ASI.

Key words: Soil, zinc, extractants, extraction

Introduction

Zinc plays an important role as a micronutrient required for plant growth. It is perhaps the second in position after major nutrients (NPK) for most of the plant growth as a whole. In Bangladesh, prior to 1975, there was no study or published information and as such no data were available about the zinc status of soils and plants. After 1975, there were some works done in BINA (Bangladesh Institute of Nuclear Agriculture) in collaboration with IAEA (International Atomic Energy Agency). However, these data are not even sufficient to assess the status of zinc in relation to agro-climatic conditions of Bangladesh; particularly when zinc is exhausted continuously by crop uptake without replenishment (Mannan and Rahim, 1988).

Many chemical solutions have been evaluated in the search for a universal extractant to predict zinc availability in soils (Lindsay and Cox, 1985). The extract ability of soil zinc by various chemical reagents is often used for predicting the availability of soil zinc to plants. The amount of zinc extracted from a soil varies according to the reagent used, but it also influenced by the physico-chemical characteristics of the soil. It can be seen from Table 1 that various extractant were used by different authors to extract soil zinc with variable results.

Before using different reagents, it can be evaluated for their ability to predict soil zinc availability and the factors which can effect the amount of zinc extracted from soil should be investigated. Two such factors are the length of the extraction period and the number of extractants (Tucker and Kutrz, 1955). In Bangladesh, the reagents that are used to extract soil zinc, among some of those are expensive and also time consuming. By assessing the extract ability of different extractants it may be possible to choose a suitable extractant in our soil conditions which may be comparatively cheaper, less time consuming and also easily available.

The present investigation was therefore, designed to study the extract ability of soil zinc by a range of extractants under different conditions.

Materials and Methods

Samples of unfertilized top soils within 0-150 mm depth from six different locations of Bangladesh were used in this study. The soils were tea soil from Manipur tea garden in Sylhet, Madhupur soil from Madhupur, Ishurdi soil from Ishurdi, Saline soil from Khulna, Farm soil from Bangladesh Agricultural University (BAU) and Poorly drained soil from Maskanda, Mymensingh. These soils were air-dried and ground to pass through a 2 mm stainless steel sieve before use. Some characteristics of the soils are presented in the Table 2.

Table 1: Chemical extractants used for soil zinc extraction by different authors

Extractants	Soil/soln. ratio	Time of extraction (min.)	Critical level (mg/g-1)	Additional note	Ref*
0.05N HCl	10 g/20 ml	5	1.0		1
0.1N HCl	5 g/50 ml	30	1.75	Wheat, non-	3
0.1N HCl	2 g/20 ml	60	0.43	Calcareous soil	9
2M $MgCl_2$	10 g/50 ml	45	0.4	Maize	12
1N CH_3COONH_4	10 g/50 ml	390		Millet	10
CH_3COONH_4, NH_4OH,					
Dithizone, CCl_4, HCl	2.5 g/25 ml	60	0.4		2
0.005M DTPA + 0.01M	10 g/20 ml	120	0.8	Rice	4
$CaCl_2$ + 0.1M TEA		120	0.6	Corn	4
(pH 7.3)		120	0.76	Sorghum	5
		120	1.0	Rice	6
DTPA-NH_4CO_3	10 g/20 ml	15	0.86	Calcareous soil	7
(pH 7.6)				Rice	
EDTA-$(NH_4)CO_3$	10 g/20 ml	30			11
(pH 8.6)					
0.04M EDTA	10 g/20 ml	120			8
(pH 6.0)					

*References : 1. Katyal and Ponnamperum (1974), 2. Vites and Boawn (1965), 3. Singh and Sukla (1985), 4. Lindsay and Norvell (1978), 5. Sakal *et al.* (1968), 6. Sakal *et al.* (1985b), 7. Sakal *et al.* (1984), 8. MacLaren *et al.* (1984), 9. Takkar and Mann (1975), 10. Halder and Mandal (1979), 11. Trierweiler and Lindsay (1969), 12. Stewart and Berger (1965)

Table 2: Some properties of the experimental soils

Soil samples	% Organic matter	pH	EDTA extractable zinc (ppm)	Olsen P (ppm)
Tea soil (Manipur, Sylhet)	1.10	4.5-5.8	0.47	10
Madhupur soil	1.00	6.5	0.50	12
Ishurdi soil	0.81	7.8	0.65	05
Saline soil (Khulna)	0.75	8.3	0.90	08
Farm soil (BAU)	1.20	6.8	0.50	15
Poorly drained soil (Mymensingh)	1.25	6.9	1.90	12

The properties of different soils were determined by the following methods

Soil pH

The pH of the air-dried 2 mm sieved soils was determined from the suspension of soil and distilled water (1:2.5 i.e. 10 g soil with 25 g distilled water). The soil suspensions were allowed to equilibrate for 4 h. The pH was measured by using a combined glass and reference electrode saturated with KCl.

Organic Carbon in soils

The amount of organic Carbon present in soil samples was determined by the Walkey and Black (1934) method. Finely ground soil samples (0.2 g in triplicate) were oxidized with $K_2Cr_2O_7$ and H_2SO_4. The unreacted $Cr_2O_7^{-2}$ was titrated against ferrous ammonium sulphate. The percentage of Organic Carbon was calculated by using the empirical correction factor of 1.3 as suggested by Kalembasa and Jekinson (1973),

$$\% \text{ OC} = \frac{V_1(V_2 \times N)}{W} \times 0.39\ (0.003 \times 1.3 \times 100)$$

Here,

V1 = Volume of the $K_2Cr_2O_7$

V2 = Volume of the $Fe(NH_4)_2(SO_4)_2.6H_2O$

N = Normality of $FeSO_4$

W = Wt. of soil

Olsen Phosphate in soil

Olsen Phosphate was determined by extracting 1 g soil (air-dried, 2mm sieved) with 20 ml of 0.05N $NaHCO_3$ (adjusted to pH 8.5 with NaOH) on an end-over-end shaker for 30 min. After extraction, the sample was centrifuged for 20 min and then filtered through Whatman No. 42 filter paper. The amount of P in the filtrate was determined using the phospho-molybdate method as described by Blackmore ***et al.*** (1987).

Experimental procedure for the extraction of Zinc from soils

Samples of air-dried 2 mm sieved soil (10 g in triplicate) were extracted with 25 ml of the proper reagent in polypropylene centrifuge tubes on an end-over-end shaker at 20°C.

The reagents used were 0.05 M HCl, 1M NH_4COOCH_3 (pH 7), 0.04 M EDTA [Disodium salt of ethylenediaminetetra acetic acid, pH adjusted to 6 with NaOH (7)] and ASI (Agro Service International that contains 0.25 N $NaHCO_3$-0.01 M EDTA-0.0 N NH_4F).

The extraction period was selected for 4 h. After removing from the shaker, the samples were centrifuged for 10 min and filtered through Whatman No. 42 filter paper. The supernatant solutions were taken to analyze for Zinc using atomic absorption spectrophotometer with the standard solution prepared in the same reagents used to extract the soils.

Results and Discussion

The amount of zinc was extracted from the six soils by different extractants that are presented in the Fig. 1-10. In this study, it was observed that the trends in zinc extraction with EDTA, HCl, ASI and CH_3COONH_4 were similar to those reported by Tucker and Kurtz (1995) and Chowdhury ***et al.*** (1992). All soil samples showed a continuing release of zinc by using these extractants.

Extraction of zinc from different soils with specific extractant

Extraction with CH_3COONH_4

In releasing zinc, ammonium acetate (CH_3COONH_4) showed it's weak capacity as an extractant. Here, Poorly drained soil released zinc (1.83 ppm) in a greater amount than the other soil samples, the second highest (0.90 ppm) quantity of Zn concentration was extracted from Saline soil while Ishurdi (0.40 ppm) soil exhibited the smaller amount of extractable Zn (Fig. 1). With this reagent, the amount of extractable soil Zn in Tea (0.47 ppm), Madhupur (0.50 ppm) and Farm (0.50 ppm) soils were in moderate amount and not so identically different.

Barrow (1986) reported that zinc is more strongly absorbed by soils as the pH rise up; thus, extract ability was likely to be reduced. The combination of high pH relatively weak displacing power of the NH_4^+ ion for cations such as Zn^{2+} was the most likely reason for the relatively slow attainment of the equilibrium with the CH_3COONH_4 extractant.

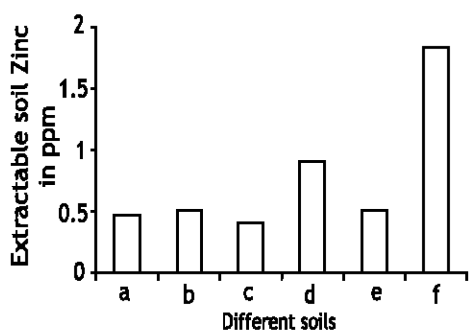

Fig. 1: Extraction of zinc from different soils by Ammonium acetate Legends : a. Tea soil, Sylhet; b. Madhupur soil; c. Ishurdi soil; d. Saline soil, Khulna; e. Farm soil, Bangladesh Agricultural University; f. Poorly drained soil, Mymensingh

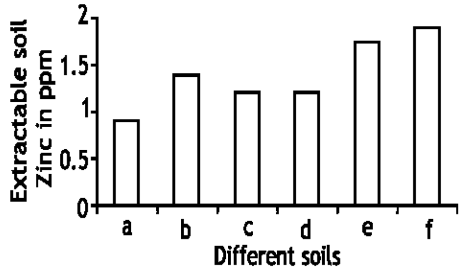

Fig. 2: Extraction of zinc from different soils by EDTA: a, b, c, d, e and f have been shown in Fig. 1

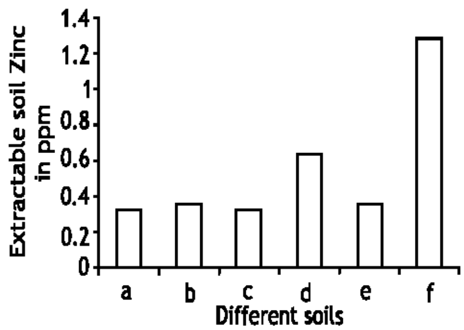

Fig. 3: Extraction of zinc from different soils by ASI: a, b, c, d, e and f have been shown in Fig. 1

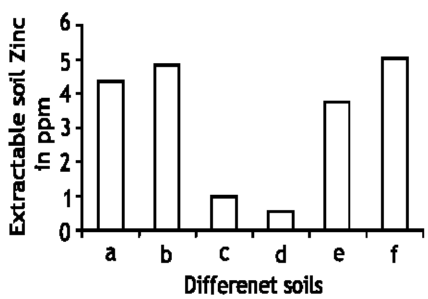

Fig. 4: Extraction of zinc from different soils by HCl: a, b, c, d, e and f have been shown in Fig. 1

Extraction with EDTA

When EDTA was used as an extractant, all six experimental soils responded to remove zinc in various amount, but this amount of extractable Zn were much higher than by used CH_3COONH_4 in the case of every soil. On an average, it was observed that moderate amount of zinc was extracted from all the soils by EDTA (Fig. 2). In Tea soil, zinc was extracted comparatively in a lesser amount (0.92 ppm) than other soils. But in the case of Farm (1.75 ppm) and Poorly drained (1.90 ppm) soils, zinc was extracted in higher amounts than the others. Ishurdi and saline soils released the same amount (1.20 ppm) of Zn extract. Both of these soils comprised the pH value more than 7. A better amount of Zn was extracted (1.40 ppm) in Madhupur soil.

Chowdhury ***et al.*** (1992) reported that the extraction of Zn in poorly drained soil has anomalous behavior due to Fe/Mn concretionary material containing occluded Zn in the soil, the graduation solution of such material by EDTA could have been responsible for the continuing release of zinc from this soil with longer extraction period.

Extraction with ASI (Agro Services International)

By using ASI extractant in the present study, a little variation of zinc extract was found from all the soils. The Poorly drained soil with ASI released the greater amount (1.30 ppm) of zinc extract than all other soils and then the Madhupur soil was second (0.80 ppm) in position in releasing zinc (Fig. 3). In Ishurdi (0.27 ppm) and Farm (0.24 ppm) soils, there found fewer differences and fewer amount in extractable soil zinc. The differences of the extraction of zinc were also exposed to be negligible in Tea (0.60 ppm) and Saline (0.65 ppm) soils. It was observed that ASI had been showed it's poorest extract ability among all extractants from all the soils by releasing a little amount of zinc.

Extraction with HCl

HCl exhibited as an excellent extractant for extracting zinc in this trail. By using HCl, zinc was extracted in a bigger amount (Fig. 4). Especially, four soils i.e. Tea (4.30 ppm), Madhupur (4.80 ppm), Farm (3.70 ppm) and Poorly drained (5.00 ppm) soils released zinc in higher amounts than extracted by CH_3COONH_4 or EDTA or ASI. Ishurdi (0.92 ppm) and Saline (0.55 ppm) soils responded poorly, may be due to the neutralization of acids by the soils.

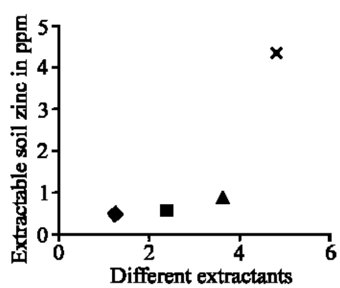

Fig. 5: Extraction of zinc with different extractants from Tea soil

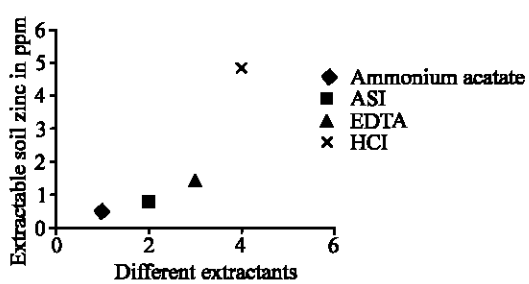

Fig. 6: Extraction of zinc with different extractants from Madhupur soil

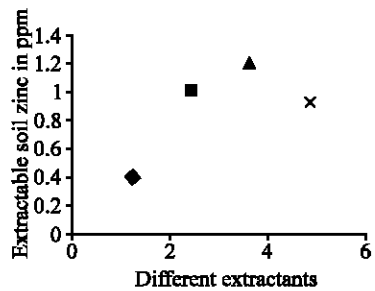

Fig. 7: Extraction of zinc with different extractants from Ishurdi soil

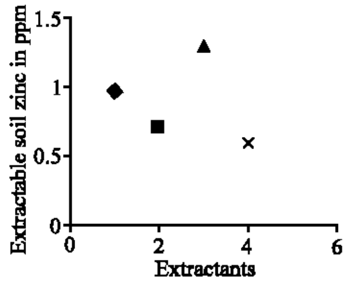

Fig. 8: Extraction of zinc with different extractants from Saline soil, Khulna

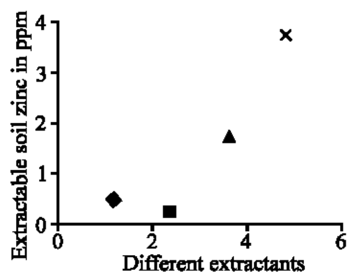

Fig. 9: Extraction of zinc with different extractants from Farm soil (BAU)

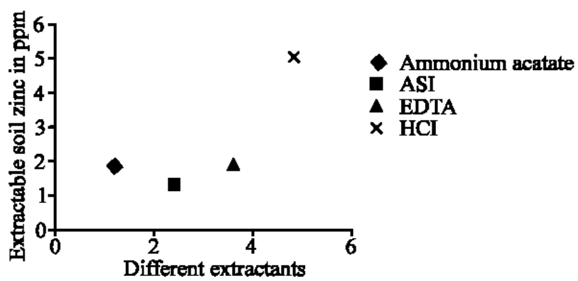

Fig. 10: Extraction of zinc with different extractants from Poorly drained soil, Mymensingh

Tucker and Kurtz (1955) reported that the amount of zinc extracted from 5g of soil with 50 ml of 0.1N HCl increased steadily with the time of contacting experiment.

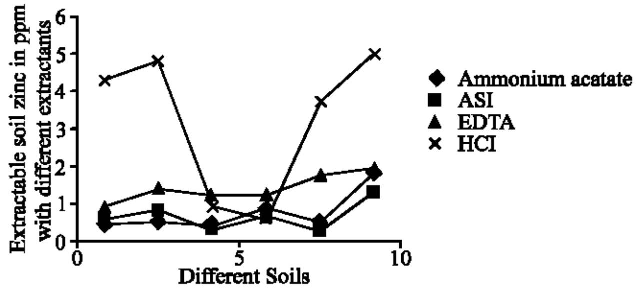

Fig. 11: Comparison of extract ability among different extractants in various soils

Extraction of zinc in a specific soil with different extractants

To examine the comparative strength of different extractants, discussion can be made about the extract ability of those extractants upon different soils. In the case of Tea soil (Fig. 5), the highest amount of zinc was extracted shown by HCl (4.30 ppm) and then by EDTA (0.92 ppm). Ammonium acetate (CH_3COONH_4) showed itself as a poorer extractant for Tea soil in extracting zinc while ASI released a little bit higher than it. Madhupur soil also released the maximum amount of zinc by the extractant HCl and the immediate following was EDTA (Fig. 6). ASI and CH_3COONH_4 showed their capability as extractants like the preceding respectively. The pH in both Tea (4.5-5.8) and Madhupur (6.5) soils retained in the range of acute and moderately acidic while their percentages of organic carbon were 1.1 and 1.0 (Table 1). These might be the causes to extract zinc in a higher amount with the strong acid HCl.

Ishurdi and Saline soils exposed comparatively the larger and the same amount of zinc extracted by EDTA and the respectively followings were HCl, CH_3COONH_4 and ASI for Ishurdi, as well as CH_3COONH_4, ASI and HCl for the Saline soil (Fig. 7, 8). These two soils were alkaline as belonged to high pH contentment (Ishurdi 7.8 and Saline 8.3) and the lesser amount of organic carbon percentages (Ishurdi 0.81% and Saline 0.75%) induced EDTA to extract zinc in a high rate.

The amount of extracted zinc was greater by HCl shown in Farm and Poorly drained soils (Fig. 9, 10). Here, EDTA, CH_3COONH_4 and ASI released zinc in a decreasing order. These soils were little bit enriched with the increasing percentages of organic carbon (Farm 1.2% and Poorly drained 1.25%) and moderately acidic with the value of pH at 6.8 and 6.9.

From the Fig. 11, it has clearly shown that HCl activated as a better reagent than the others in releasing maximum amount of zinc in the case of most soil samples. The next capable strength has shown as the extractant EDTA, but compare to HCl it exposed poorer strength of extract ability. Ammonium acetate (CH_3COONH_4) and ASI released zinc in a lower quantity with the decreasing order.

This study has shown that for some soils at least, HCl and EDTA extractants may be adequate for extracting soil zinc in an ample amount. It is clear from the above results that the amount of extractable soil zinc in different soil samples varied among different extractants. Thus, the importance of establishing appropriate extraction conditions for individual extractant is to be emphasized. While studying a particular soil for zinc extraction, it would be seen important to check if appropriate condition and facilities are provided for the particular type of soil.

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