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# SUITABILITY OF MULTINUTRIENT EXTRACTANTS FOR EVALUATION OF AVAILABLE SOIL ZINC FOR TOMATO NUTRITION OF KARNATAKA SOILS

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***Keywords:*** Extractants, Critical limits, DTPA, Mehlich-3, AB-DTPA, Tomato

**Abstract**

Pot experiment was conducted at University of Agricultural Sciences, Bangalore, Karnataka, which received five treatments ***i.e.***, 0, 5, 10, 15, 20 kg $ZnSO_4$/ha. Among all the treatments Recommended NPK + $ZnSO_4$ @ 20 kg/ha recorded highest mean dry matter yields of tomato. The amount of zinc extracted by different extractants were in the following order as Mehlich-3 - Zn > 0.1 N HCl - Zn > AB-DTPA - Zn > 0.01 N EDTA - Zn > DTPA - Zn > 0.01 M EDTA + 1 N $NH_4OAc$ - Zn > 1 N $NH_4OAc$ (pH 4.6) - Zn > 1 N $NH_4OAc$ (pH 7) - Zn. Among the various extractants tried DTPA - Zn gave positive and higher significant correlation with Brays per cent Yield (r = 0.781). The next better extractants were Mehlich-3 (r = 0.726) and AB-DTPA (r = 0.576) which were also significantly positively correlated with Brays per cent yield. The critical limits of DTPA, Mehlich-3, AB-DTPA, tomato plant and tomato fruit by graphical method were 1.12, 2.15, 1.20, 34 and 58 mg/kg, respectively.

## Introduction

The importance of micronutrients in India has been realized during the past four decades when widespread micronutrient deficiencies such as zinc and boron were observed in most of the soils, where intensive agriculture was practiced. Periodic assessment of soil test data revealed that zinc deficiency might increases from 49 to 63 per cent by the year 2025 as most of the marginal soils brought under cultivation showed zinc deficiency (Singh 2006). A detailed account of information on micronutrients in soils and plants has been published by many pioneers under the aegis of the AICRP (Shukla and Behera 2012. Shukla *et al*. 2016). In achieving nutritional security fruits and vegetables play important role (Ganeshamurthy *et al*. 2011). To fulfill the needs of nutritional requirements, many efforts should be given to increase the production of fruits and vegetables through a rational and balanced use of production inputs, with the fertilizers. Tomato (*Solanum lycopersicum* L.), ranks first as processing crop among the vegetables as it is a rich source of lycopene, vitamin ‘A’, vitamin ‘C’, minerals and organic acids.

Soil testing is often used to determine the nutrient status of crops and to develop the cost effective nutrient management practices to recommend farmers. Extractants are designed to remove or extract a portion of soil available nutrient that can be correlated with plant growth factors such as dry matter production, uptake and yield parameters. The portion that is extracted represents only a very small fraction of the total amount of nutrient present in soil and is related to the amount of the nutrient that may be potentially utilized by the plant through uptake. Wide number of extractants have been developed by soil chemists to assess the relative available nutrient status of soils for making nutrient recommendations of which, multinutrient extractants are gaining much importance. In this context, the concept of critical limits proposed by Cate and

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Nelson (1965) is more appropriate for managing nutrient needs of different crops to reduce nutrient wastages, besides preventing environmental pollution. The hypothesis is that the plant with nutrient concentration below the critical limit will respond to the addition of fertilizers and very low response was observed above the critical limit. For clear prediction of possible deficiencies, these critical limits must be refined, as crops and soils vary widely in their nutrient supplying and utilization efficiency. However, such studies have not yet been carried out for zinc in tomato crop in Karnataka. Although critical limits for many nutrient elements are available for Indian soils, the work related to the zinc nutrient is very much limited for tomato soils. Hence present study was undertaken to determine the suitability of extractants in soils and establishing its critical limits for tomato growing areas of Karnataka.

**Materials and Methods**

Fifteen surface soil samples were collected from tomato growing soils of Karnataka. The representative soil samples were air dried and processed for analysis of various soil parameters. Pot experiments were conducted with 10 kg soil with dimensions of 35 cm width × 30 cm depth. The experiment consisted of five treatments ***i.e.***, 0, 5, 10, 15, 20 kg $ZnSO_4$ $ha^{-1}$ along with recommended dose of fertilizers (RDF) of University of Agricultural Sciences, Bangalore (250:250:250 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$, 38 t of FYM) with three replications. Several earlier investigation studies on application of zinc treatments in green house studies in low volume soil and recommended dose of fertilizers (RDF) of UAS (B) for other few crops is taken into consideration criteria as an index for choosing treatments. Bulk soil samples of 15 locations were collected and were arranged in ascending order based on available zinc status in the soil, all together with total number of 225 pots (15 surface soils × 5 treatments × 3 replications) in completely randomized design (CRD). Seventeen days old seedlings were transplanted to the pot and soils of all pots were maintained near water holding capacity using deionized water with frequent watering to weight. Proper plant protection measures were taken and the crop was harvested after 90 days in order to get reliable information about fruit and plant nutrient content to compute critical limits. The tomato plant and fruit samples were sundried and kept in paper bags and transferred to hot air oven with controlled temperature of 60°C. The oven dried samples were weighed for dry matter yields and finely ground to powder and stored for further analysis. Plant samples were digested by using di-acid mixture and concentrations of zinc in the digest solutions were determined by using AAS. The Bray's per cent yields (BPY) and plant responses were calculated by using following formulae.

Brays per cent yield (BPY) = Control Yield / Maximum crop yield × 100

Crop response = Maximum yield – Control yield

The critical limits of multii nutrient extractants of zinc and tomato were determined by plotting BPY against soil test values of various extractants and separately with nutrient content of plant, respectively, following the procedure of Cate and Nelson (1965).

**Results and Discussion**

The soils of pot experiment collected from different locations were sandy clay to sandy clay loam in texture. The details of all various soil parameters and the amount of zinc extracted by various extractants are presented in Table 1. The amount of zinc extracted by different extractants, were in the following order as Mehlich-3 - Zn > 0.1 *N* HCl - Zn > AB-DTPA - Zn > 0.01 *N* EDTA - Zn > DTPA - Zn > 0.01 *M* EDTA + 1 *N* $NH_4OAc$ - Zn > 1 *N* $NH_4OAc$ (pH 4.6) - Zn > 1 N $NH_4OAc$ (pH 7) - Zn. The zinc extracted by DTPA was categorized from low to high. DTPA extracted less amount of zinc than Mehlich-3, 0.1 *N* HCl, AB-DTPA and 0.01 *N* EDTA. The results indicated that chelating agents reacting with zinc will form soluble complexes. During the reaction the chelated zinc accumulates in solution as the chelating agent, combines with $Zn^{2+}$ causing more Zn to be released from labile solid phases. As a result soluble metal chelates are easily separated from solid matrix of the soils by filtration and can be measured by AAS. When all soils were considered, there is advantage of chelate extractants over strong acids as pH of the extracting media can be carefully selected and controlled. This prevents the gross destruction of acid soluble soil minerals like carbonates and oxides. Similar results were reported by Manchanda *et al*. (2011). AB- DTPA extracted more amount of zinc than DTPA and lesser than Mehlich-3 and 0.1 *N* HCl. Mehlich-3 extracted higher amount of zinc when compared to all other extractants tried. The greater Zn extraction capacity of Mehlich-3, than the DTPA or AB-DTPA might have been due to the presence of acid and chelating agent EDTA also in Mehlich-3. EDTA a strong chelating agent which can be capable of forming complexation and decreases adsorption of zinc on the clay particles and it resulted in increasing the solubility of zinc in soils, whereas dilute acids will partially dissolves metal oxides. These two mechanisms made Mehlich-3 to extract highest amount of zinc from the experimental soils. These results were similar to the findings made by Takrattanasaran *et al*. (2010).

Zinc extracted by 0.1 *N* HCl extracted more amount of zinc than DTPA and AB-DTPA and extracted less amount of zinc than Mehlich-3. This might be due to dilute acids remove zinc from soil solution, exchangeable and from non exachangeble sites on clays and soil organic matter. This is applicable to most of the soils because they are not sufficiently buffered to extract meaningful levels of zinc from soils. These findings are similar to the reports made by Manchanda *et al*. (2011).The lowest amount of zinc was extracted by 1*N* $NH_4OAc$ (pH 7) and $NH_4OAc$ (pH 4.6) which are not chelating agents and will not form complexation with the zinc metal ions and it has not having any acid component to displace the zinc from oxide bound minerals, so it extracts very lower amounts of zinc. These results are in agreement with the findings reported by Marchi *et al*. (2009).

The concentration of available zinc extracted by EDTA was more than that of DTPA and it might be due its strong chelating capacity of forming complexation and decreases adsorption of zinc on clay particles by EDTA which results in increasing the solubility of zinc in soils. These results are in conformity with the findings of Bibiso *et al.* (2015).

Results of the statistical analysis presented in Table 2 showed that DTPA was positively and significantly correlated with all other extractants except with 1 *N* $NH_4OAc$ (pH 7) and 0.01 *M* EDTA + 1 *N* $NH_4OAc$. The correlation coefficient between DTPA and AB-DTPA was 0.768** and with DTPA and Mehlich-3 was 0.849**. The correlation between AB-DTPA and Mehlich-3 was 0.834**. All forms of extractable zinc were highly and significantly correlated with each other indicating that they could extract zinc from more or less similar pools from soil. These results are in conformity with the findings of Rahman *et al*. (2007), Zare *et al*. (2009), Muthukumararaja and Sriramachandrasekharan (2012). DTPA-Zn correlated highest with Bray's per cent yield (BPY) followed by Mehlich-3 and AB-DTPA gave better positive and significant relationship compared to other extractants. Correlation coefficient between BPY and DTPA was 0.781** whereas with Mehlich-3 and BPY was 0.726** and AB-DTPA with BPY was 0.576*. Among the eight extractants tried, DTPA extractant was considered as best zinc extractant followed by Mehlich-3 and AB-DTPA for influencing available zinc in soils. These results are more or less similar to the observations made by Rahaman *et al*. (2007), Muthukumararaja and Sriramachandrasekharan (2012).

Brays per cent yields (BPY) worked out for tomato crop was calculated and presented in Table 3. Results confirmed that highest BPY are recorded in high zinc soils. This might be due to initial soil zinc contributes more for better growth and uptake by activating different enzymes,

**Table 1. Details of various soil parameters and extracting power of various extractants tried for experimental soils.**

| Soil properties | Units | Minimum | Maximum | Mean | References |
|---|---|---|---|---|---|
| pH | | 5.98 | 7.76 | 7.01 | Jackson (1973) |
| EC | ( dS/m) | 0.13 | 1.13 | 0.39 | |
| Organic carbon | (%) | 0.42 | 1.81 | 1.09 | |
| Available N | kg/ha | 216.38 | 326.14 | 252.85 | |
| Available $P_2O_5$ | | 43.72 | 124.50 | 74.15 | |
| Available $K_2O$ | | 110.50 | 775.49 | 389.64 | |
| Available S | | 28.68 | 98.34 | 61.19 | |
| Available B | mg/kg | 0.42 | 1.19 | 0.77 | Berger and Troug (1939) |
| Available Fe | | 1.90 | 14.06 | 5.73 | Lindsay and Norwell (1978) |
| Available Cu | | 0.83 | 3.01 | 1.53 | |
| Available Mn | | 2.00 | 15.35 | 5.89 | |
| Extractans | Units | Minimum | Maximum | Mean | References |
| DTPA-Zn | mg/kg | 0.17 | 4.89 | 1.67 | Lindsay and Norwell (1978) |
| AB- DTPA-Zn | | 0.54 | 3.59 | 1.85 | Soltanpour and Schwab (1977) |
| Mehlich-3-Zn | | 0.69 | 5.42 | 2.36 | Mehlich (1984) |
| 0.1 *N* HCl-Zn | | 0.39 | 4.45 | 2.18 | Osiname *et al.* (1973) |
| 1 *N* $NH_4OAc$ (pH 7)-Zn | | 0.04 | 0.93 | 0.23 | |
| 1 *N* $NH_4OAc$ (pH 4.6)-Zn | | 0.11 | 2.76 | 0.98 | |
| 0.01 *N* EDTA-Zn | | 0.57 | 3.83 | 1.85 | |
| 0.01 *M* EDTA + 1 *N* $NH_4OAc$-Zn | | 0.20 | 2.90 | 1.37 | |

**Table 2. Correlation between extractants and Brays per cent yield of the experimental soils.**

| | DTPA-Zn | AB-DTPA-Zn | Mehlich-3-Zn | 0.1 *N* HCl-Zn | 1 *N* $NH_4OAc$ (pH 7)-Zn | 1 *N* $NH_4OAc$ (pH 4.6)-Zn | 0.01 *N* EDTA-Zn | 0.01 *M* EDTA + 1 *N* $NH_4OAc$-Zn | Brays percent Yield |
|---|---|---|---|---|---|---|---|---|---|
| DTPA-Zn | 1.000 | | | | | | | | |
| AB-DTPA-Zn | 0.768** | 1.000 | | | | | | | |
| Mehlich-3-Zn | 0.849** | 0.834** | 1.000 | | | | | | |
| 0.1 *N* HCl-Zn | 0.568** | 0.903** | 0.776** | 1.000 | | | | | |
| 1 *N* $NH_4OAc$ (pH 7)-Zn | NS | 0.636* | NS | 0.754** | 1.000 | | | | |
| 1 *N* $NH_4OAc$ (pH 4.6)-Zn | 0.546* | 0.881** | 0.706** | 0.954** | 0.883** | 1.000 | | | |
| 0.01 *N* EDTA-Zn | 0.537* | 0.628* | NS | 0.616* | 0.625* | 0.671** | 1.000 | | |
| 0.01 *M* EDTA + 1 *N* $NH_4OAc$-Zn | NS | 0.883** | 0.736** | 0.979** | 0.746** | 0.945** | 0.590* | 1.000 | |
| Brays percent Yield | 0.781** | 0.576** | 0.726** | NS | NS | NS | NS | NS | 1.000 |

**Significant at 0.01 level, *Significant at 0.05 level.

**Table 3. Brays per cent yields and yield responses of the experimental soils.**

| Sl. No. | Samples collected | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ | Check yields (g/pot) | Maximum yield (g/pot) | Brays per cent yield | Yield response |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Dry matter yields (g/pot) | | | | | | | | |
| 1 | Location 1 | 43 | 60 | 62 | 69 | 77 | 43 | 77 | 55.56 | 34.2 |
| 2 | Location 2 | 49 | 50 | 55 | 66 | 68 | 49 | 68 | 71.62 | 19.3 |
| 3 | Location 3 | 54 | 63 | 67 | 72 | 70 | 54 | 72 | 75.00 | 18.0 |
| 4 | Location 4 | 50 | 56 | 62 | 68 | 74 | 50 | 74 | 67.24 | 24.2 |
| 5 | Location 5 | 54 | 66 | 64 | 68 | 74 | 54 | 74 | 73.61 | 19.5 |
| 6 | Location 6 | 66 | 64 | 80 | 82 | 98 | 66 | 98 | 67.35 | 32.0 |
| 7 | Location 7 | 58 | 76 | 74 | 76 | 82 | 58 | 82 | 70.73 | 24.0 |
| 8 | Location 8 | 72 | 84 | 84 | 80 | 94 | 72 | 94 | 76.60 | 22.0 |
| 9 | Location 9 | 60 | 72 | 90 | 80 | 94 | 60 | 94 | 63.83 | 34.0 |
| 10 | Location 10 | 62 | 62 | 80 | 96 | 90 | 62 | 96 | 64.58 | 34.0 |
| 11 | Location 11 | 62 | 84 | 71 | 72 | 70 | 62 | 72 | 86.11 | 10.0 |
| 12 | Location 12 | 61 | 68 | 74 | 75 | 66 | 61 | 75 | 81.33 | 14.0 |
| 13 | Location 13 | 62 | 68 | 70 | 72 | 72 | 62 | 72 | 85.56 | 10.5 |
| 14 | Location 14 | 63 | 68 | 75 | 66 | 65 | 63 | 68 | 93.24 | 4.6 |
| 15 | Location 15 | 70 | 72 | 78 | 74 | 72 | 70 | 78 | 89.74 | 8.0 |

$T_1$ = RDF (Control), $T_2$ = Rec. NPK + $ZnSO_4$ @ 5 kg/ha, $T_3$ = Rec. NPK + $ZnSO_4$ @ 10 kg/ha, $T_4$ = Rec. NPK + $ZnSO_4$ @ 15 kg/ha, $T_5$ = Rec. NPK + $ZnSO_4$ @ 20 kg/ha.

whereas lowest relative yields was recorded in low zinc soils. The yield response was more in medium zinc and low zinc soils compared to that of high zinc soils. This might be due to external application of zinc source fertilizers to the low and medium zinc soils, might increase zinc ion concentration in soil solution, which may readily available for root system and helps in better growth and development of the crop compared to high zinc soils where fixation will occur. Results of pot experiments are plotted as per Cate and Nelson (1965) for arriving at critical concentration of nutrient for the crops. Plotting the plant available soil Zn extracted by extractants on X-axis and Bray's per cent yield on the Y-axis, a transparent overlay with a vertical line and an intersecting horizontal line of maximum number of points in the first and third quadrants. Afterwards, the soil test value corresponding to the intersection was taken as the critical limit. The critical limit (level below which response to the added zinc fertilizer is expected) for zinc in the soil calculated as given by Cate and Nelson (1965) procedure are presented in Fig.1 and the critical limits of extractants for DTPA, Mehlich-3, AB-DTPA, tomato plant and tomato fruit were

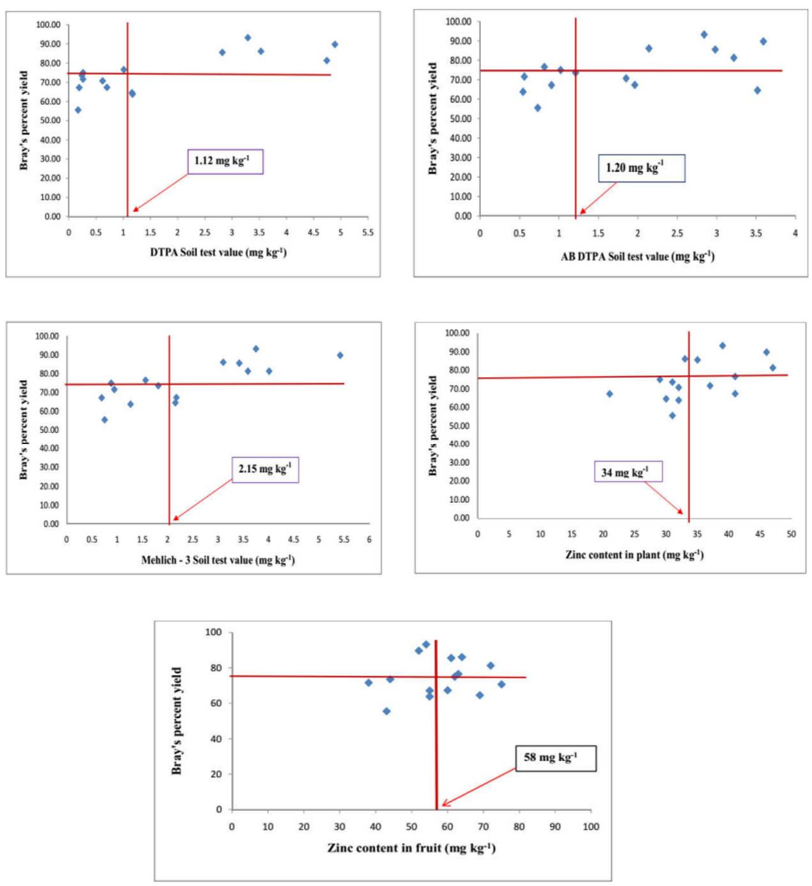


Fig. 1. Critical limits of zinc for various soil extractants, tomato plant and fruit.

1.12, 2.15, 1.20, 34.00 and 58.00 mg/kg, respectively. The critical limit of zinc generated in the present study is important for decision making at farm level planning particularly for the application of balanced nutrient to harness the yield potential of tomato crop.

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