Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(6): 1317-1320
Received: 04-09-2017
Accepted: 05-10-2017

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Evaluation of suitable extractants for zinc and establish its critical limits in soil and wheat plant grown under temperate condition of Kashmir Valley

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Abstract
A pot culture experiment was conducted in a greenhouse at the SKUAST-K Shalimar. Polythene lined pots were filled with 5kg processed soils of each location in a randomized block design with three replications. Recommended doses of nitrogen, phosphorus and potassium @ 120, 60 and 30 mg kg^{-1} N, P and K, were applied through. Urea, DAP and MOP, respectively. The treatments consisting of four levels of zinc (0, 7.5, 1.5 and 2 mg Zn pot^{-1}) applied through zinc sulphate. Among three zinc extrantants DTPA, HCL and ammonium acetate, only DTPA zinc extractant was significant and positively correlated with bray's per cent yield and chemical properties such as pH, O.C and available nitrogen. The critical limit of zinc in soil and plant was found to be 0.64 and 22.0 mg kg^{-1}, respectively. Among three extractants Zn extracted by DTPA was correlated significantly with brays percent yield (r=0.832**) and also significantly correlated with O.C(r=0.799**), CaCo3(r=0.965**), and N(r=0.978**).

Keywords: Zinc, wheat, zinc extractants, critical limits

Introduction
Zn deficiency is widespread throughout the world, especially in rice-wheat cropland of Asia (Srivastava and Gupta, 1996, Tisdale *et al*., 2009) [11, 12]. According to Cakmak (2009) [1] 50% of the Indian soils under intensive cultivation of wheat and rice are deficient in plant available Zn. The deficiency of Zn is usually attributed to low solubility of Zn rather than low total content of Zn in most agricultural soils. On the other hand crops such as wheat and rice due to Zn deficiency the crop yield as well as quality are severely affected. Generally, grain Zn concentration in commercial wheat cultivars are 20–35 mg/kg (Rengel *et al*., 1999; Cakmak *et al*., 2004) [10, 2]. These concentrations are not adequate for human nutrition in diets with wheat constituting the main source of essential minerals. Hence, Zn fertilization is recommended to enhance availability of Zn. As a result of prevalent Zn deficiency, the production of cereal crops suffers leading to the twin problems of low food production and Zn malnutrition as their staple diet. Wheat (*Triticum aestivum L.*) is an important cereal crop in India and occupies second position next to China in the world with regard to area (27.7 million hectares) and production (77.6 million tons) of wheat. (FAO, 2010). Furthermore, Wheat is the major cereal crop of Jammu and Kashmir and occupies an area of 245,000 hectares with an average productivity of 1.85 t ha^{-1} (Anonymous, 2012). The soil test values are of little use unless and until some fixed soil value is determined experimentally below which the fertilizer application to crops will be truly economical. Thus critical limit of the applied nutrient decides the fate of applied nutrient. Therefore, the situation justifies a need to determine the critical limit of Zn for wheat in alfisols soils in order to formulate the optimum fertilizer dose of Zn for obtaining satisfactory yield. However, no critical value can be used for all crops and varieties under variable soils and environmental conditions. Thus, the threshold value of Zn in soil and plant plays greater importance in monitoring the sustainability of soil health. Large numbers of efforts have been made to establish critical values of micronutrient for soil and crop. (Malewar *et al*., (1999) [8].

Materials and Methods
Soil samples in bulk from plough layer (0-20 cm) were collected from ten different locations of wheat growing areas of Kashmir. The collected soil samples were air dried and passed through 2 mm size sieve for analysis. Soil pH was determined by pH meter (Jackson 1973) [5]. Organic carbon was estimated by Walkey and Black (1965). Available zinc content was extracted with DTPA (pH 7.3) following the procedures of Lindsay and Norvell (1978) [7].

A pot culture experiment was conducted in a greenhouse at the SKUAST-K Shalimar. Polythene lined pots were filled with 5kg processed soil of each location in randomized block design with three replications. Recommended doses of nitrogen, phosphorus and potassium @ 120, 60 and 30 mg kg^{-1} N, P and K, respectively were applied through. Urea, DAP and MOP respectively. The treatments consisting of four levels of zinc (0, 7.5, 15, 22 mg Zn pot^{-1}) applied through zinc sulphate. Wheat plants of above ground portion were harvested after 30 days of sowing and dry-matter yield was recorded. Zn content was recorded by Atomic Absorption Spectrophotometer (AAS). The available zinc was extracted from soil by using DTPA, HCL and Ammonium acetate methods Correlation was carried out between DTPA- Zn and bray's per cent yield and soil propertied as per the standard statically procedures. The data emerged out from the experiment, soil zinc concentration, threshold yield plateau yield and leaf zinc concentration comparing the critical limits were utilized as per procedure outlined by Cate and Nelson (1965) [3].

$$\text{Brays percent yield} = \frac{\text{Yield without zinc treatment}}{\text{yield at optimum zinc treatment}} * 100$$

Results and discussion

The data of DTPA extracted zinc and chemical properties of different soils are presented in (table 1). The soil pH value ranges from 6.28-7.00 with mean value of 6.50. The soils where slightly acidic to neutral in reaction. The organic carbon range from 0.83 to 1.31 with mean value of 1.03. Per cent. The available N, P and K range from 490.18 to 560.61, 15.04 to 21.13, 175.02 to 235.28 with a mean value of 530.07, 17.94, 198.80$kgha^{-1}$ respectively (table 1).

Estimation of Zn by different extractants

The available zinc in soil was estimated by different extractants and the amount extracted by each method is presented in (table 2). The available zinc extracted by DTPA method varied from 0.40 to 1.09 with average value of 0.73 ppm. The available zinc content extracted by HCL method varied from 0.58 to 3.08 with average value of 1.56 ppm. The available zinc content extracted by NH_4OAC-zinc method varied from 0.33 to 0.68 with the average mean of 0.54 ppm. (Table 3). DTPA-Zn extracted method showed higher values of correlation coefficient than other methods. The correlation coefficient (r values) of soil zinc extracted by DTPA showed significant and positive correlation with brays percent yield and chemical properties (table 3 &4). Zn extracted by DTPA was correlated significantly with brays percent yield (r=0.832**) and also significantly correlated with O.C(r=0.799**), CaCo3(r=0.965**), and N(r=0.978**). (Table no 3&4)

Critical limits of zinc in soil and plant

The available zinc content varied from 0.4 to 1.09 with mean value of 0.73 mg/kg. (Table 1). The Bray's per cent yield of wheat range between 50 to 81 with mean value of 50.81 $mgkg^{-1}$. The critical limits of available zinc in soil and plant tissue were worked out to be 0.64 and 22.0 ppm Zn respectively (Fig.1 & 2). Kuldeep Singh (1986) [6] reviewed that the critical level of Zn concentration in plant below which plant response to Zn application may be expected was found to be 15.4 ppm in cluster bean. Mehra *et al.* (2004) reported that the soil containing DTPA- Zn ranging from 0.50 to 0.60 mg kg^{-1}.

Conclusion

From the present study it was concluded that the DTPA-Zn extractants was found to be a suitable extractant for Zn. The critical limits of Zn in soil and plant were found to be 0.65 and 22 mg kg^{-1} respectively.

Table 1: Chemical properties of soil sample collected from different locations

Locations	DTPA-Zinc	pH	Caco3 (%)	OC (%)	$Kgha^{-1}$			$Mgkg^{-1}$			
					N	P	K	Zn	Cu	Fe	Mn
1	0.40	7.00	0.22	0.83	490.18	16.17	182.24	0.40	1.09	15.64	1.67
2	0.56	6.56	0.29	0.96	512.20	16.41	205.18	0.56	1.29	18.14	5.19
3	0.61	6.48	0.38	1.09	520.60	17.91	235.28	0.61	1.80	26.25	4.07
4	0.69	6.44	0.42	0.98	525.32	19.69	188.45	0.69	1.57	25.75	3.69
5	0.65	6.52	0.35	1.04	522.66	16.20	175.02	0.65	1.21	24.03	4.33
6	0.73	6.39	0.54	0.98	535.58	21.13	193.84	0.73	1.66	24.72	4.02
7	0.74	6.34	0.59	0.84	537.00	17.77	190.80	0.74	1.46	17.64	2.07
8	0.85	6.30	0.67	1.19	542.98	18.72	218.19	0.85	1.72	24.51	1.70
9	1.00	6.28	0.73	1.16	553.60	15.04	202.24	1.00	1.58	22.06	2.41
10	1.09	6.74	0.80	1.31	560.61	20.44	196.80	1.09	1.18	26.25	3.53
Mean	0.73	6.51	0.50	1.04	530.07	17.95	198.80	0.73	1.46	22.50	3.27
Range	0.40-1.09	6.28-7.00	0.22-0.80	0.83-1.31	490.18-560.61	15.04-21.13	175.02-235.28	0.40-1.09	1.09-1.80	15.64-26.25	1.67-5.19

Table 2: Extraction of Zn by different methods and bray's percent yield

Location	DTPA Zinc (ppm)	HCl-Zinc	NH_4OAC-Zinc	Plant Zinc Conc.(ppm)	Control yield g/pot	Optimum yield g/pot	Brays Yield %
1. Telbal	0.4	1.48	0.54	12	9.94	18.54	54
2. Burzahama	0.56	1.90	0.33	14	9.00	18.00	50
3. Saidapora	0.61	0.58	0.54	16	11.00	19.00	58
4. Batpora	0.69	1.68	0.50	18	11.5	17.00	68
5. Bakoora	0.65	2.12	0.65	17	10.3	18.50	56
6. Warpoh	0.73	3.08	0.46	30	12.4	16.70	74
7. Khalmul	0.74	1.40	0.53	21	12.00	16.00	75
8. Shuhama	0.85	1.09	0.64	28	9.76	13.85	70

9. Baserbugh	1.00	0.98	0.53	32	10.02	12.32	81
10. Mulfaq	1.09	1.36	0.68	41	9.00	11.82	76
Range	0.73	1.57	0.54	22.90	10.49	16.17	66.20
Mean	0.40-1.09	0.58-3.08	0.33-0.68	12.00-41.00	9.00-12.40	11.82-19.00	50.00-81.00

Table 3: Correlation of available Zinc extracted by differ methods with Brays percent yield

Extractants	:	Bray's per cent yield
0.005M DTPA	:	0.832**
0.1 M HCL	:	0.057
1M NH_4OAC	:	0.312

Significant at 0.01%

Table 4: Correlation of DTPA extractable zinc with soil properties

DTPA-Zn	pH	$CaCO_3$	OC	N	P	K
DTPA-Zn						
PH	-0.418^{NS}					
$CaCO_3$	0.965^{**}	-0.459^{NS}				
OC	0.799^{**}	-0.197^{NS}	0.697			
N	0.978^{**}	-0.557^{NS}	0.967^{**}	0.739		
P	0.301^{NS}	-0.089^{NS}	0.354^{NS}	0.242^{NS}	0.366^{NS}	
K	0.147^{NS}	-0.335^{NS}	0.189^{NS}	0.416^{NS}	0.188^{NS}	0.085^{NS}

Significant at 0.01%

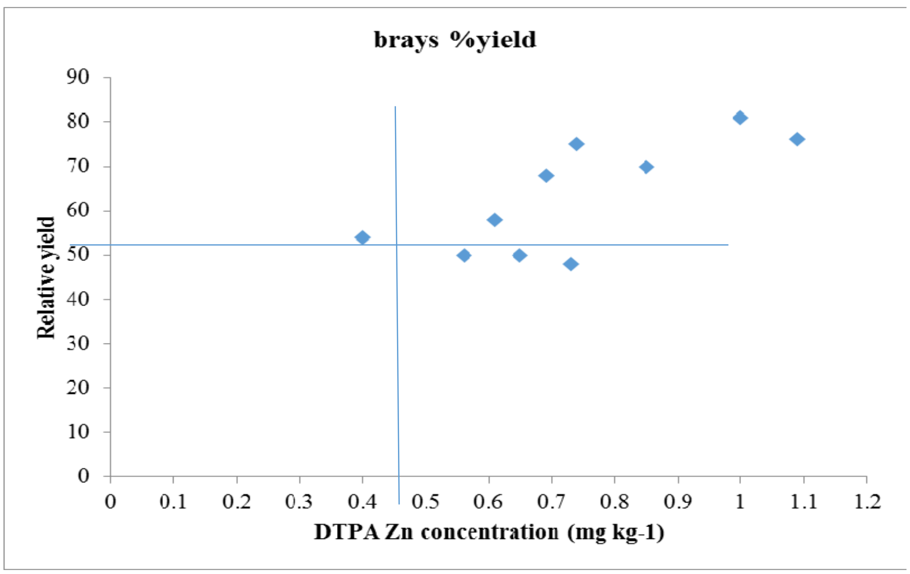

Fig 1: Scatter diagram for critical limit in soil Zn concentration of wheat

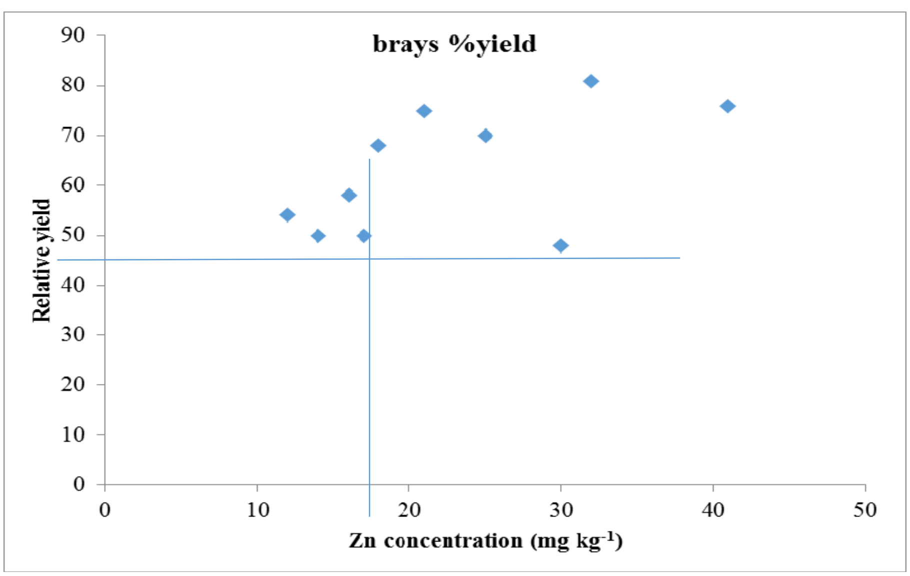

Fig 2: Scatter diagram for critical limit in plant Zn concentration of wheat

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