INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 12, No. 6, p. 283-290, 2018
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Evaluation of zinc (Zn) status in the rice growing area of Taluka Usta Mohammad, Balochistan

Aurang Zaib Jamali*[1], Zia-ul-hassan Shah[1], Muhammed Ali Sial[2], Zafar Ullah[2], Zairan Parveen Tunio[1], Sad ud din[1], Muhammad Nasir Khan[2]

[1]*Department of Soil Science, SAU, Tandojam, Pakistan*

[2]*Agriculture Research Institute, Quetta, Pakistan*

Article published on June 30, 2018

Key words: Soil fertility, Zinc, Rice, Balochistan

Abstract

Soil fertility evaluation is the key to balanced fertilization and sustainable crop production. Regular monitoring of soil fertility status provides sound footings for the precious soil resource management. This study was conducted to evaluate the zinc (Zn) content of the major rice growing areas of taluka Usta Mohammad, Balochistan. A total of 50 soil samples were collected from major rice growing tract of 10 Union councils of taluka Usta Mohammad, from 0-20 cm depth. 66% soils were heavy in texture while 24% were medium textured loams. Electrical conductivity ranged from 0.9-10.4 (dS m^{-1}). About 40% of samples were moderately saline (EC: 4-8), 32% soils were very slightly saline (EC: 2-4), 20% soils were non-saline (EC: <2.0) while 8% samples were strongly saline (EC: 8-16). Soil pH ranged from 7.7-9.0. Lime content ranged from 10.5-16.0%. Organic matter ranged from 0.1-1.5%. Majority (66%) of soils were deficient in organic matter (OM: <0.86%), 32% soil samples were medium in organic matter (OM: 0.86-1.29%) while 2% soils were high in organic matter (OM: >1.29%). The ABDTPA-Zn ranged from 0.1-3.0(mg kg^{-1}). Most of the soil samples (46%) were medium (Zn: 0.9-1.5) while 34% soils were low (Zn: <0.9). Nonetheless, 20% of soil samples were adequate in Zn content (Zn: >1.5). The study concluded that the soils of rice growing areas of taluka Usta Muhammad, Balochistan are deficient in organic matter and zinc content which may adversely affect sustainable rice production.

***Corresponding Author:** Aurang zaib Jamali ✉ jamali.zaib@gmail.com

Introduction

Soil fertility evaluation is the most important tool in determining the correct requirements for balanced fertilization (Rashid, 1996) and is an important factor which determines the growth of plants. Among essential plant nutrients, micronutrients like zinc, boron, iron, manganese and molybdenum are required in minute quantities for plant growth. Although micronutrients are required in small quantities but they play vital roles in the growth of plants. Grains and flower formation do not take place in severe micronutrient deficiency (Fageria *et al.*, 2002). Out of 80.0 million hectare (Mha) geographical area of Pakistan, 22 Mha are cultivated. The soils across much of the cultivated areas were formed from calcareous alluvium and loess and are low in organic matter and many essential plant nutrients. The climate, except for some high mountains in the north, is mostly arid to semi-arid. About 75% of the total cultivated area is irrigated (mostly through canal/river water) and the rest is rainfed. Major cropping systems in the country are cotton+wheat (3.0 Mha), rice+wheat (2.2 Mha), mixed cropping (i.e., maize-based, sugarcane-based, etc.), rainfed cropping (wheat, sorghum, maize, chickpea, peanut, etc.), oilseeds, pulses, vegetables and fruits. Unless moisture is a serious constraint, two crops a year is a norm. The prevalence of free carbonates, low organic matter and high pH of soils, all suggested a risk of micronutrient deficiencies in crops (Rashid, 1996). Soil fertility and nutrient management influence crop productivity and hence, food security (Rehman and Haq, 2006; Khattak and Hussain, 2007). Wasiullah and Bhatti (2006) reported widespread deficiencies of N, P, Zn, Cu and B in both the soils and plants. One of the possible ways to increase the production is to assess macro and micro nutrient contents of soil so that fertilizer recommendations can be made on the basis of soil fertility status for profitable crop production (Rashid, 1996). Rice is the major staple food in around 25 countries, particularly in Asia, it has been reported that 91% of rice is grown and consumed in Asia (Timsina, 2001). Rice provides 35-80% of the calories consumed by 3.3 billion people in Asia and 8% of the calories for 1 billion people in Sub-Saharan Africa, Latin America and the Caribbean.

On a global scale, rice provides 21% of per capita energy and 15% of per capita protein for humans (Doberman *et al.*, 2004). Rice is major food crop after wheat in Pakistan and it is grown on about 2.36 million hectares with total production of 4.82 million tons (GDP, 2012). The average yield of rice in Balochistan is only 683 kg ha^{-1} which is very low as compared to the national average yield of rice (2039 kg ha^{-1}) or as against the average yield of rice noted for other provinces (1701 to 3406 kg ha^{-1}) of Pakistan (GoP, 2012). This big yield gap may be a result of many factors including nutrient deficiencies. Zinc deficiency is a widespread micronutrient deficiency and is one of the major constraints in world food production. It is therefore, essential to identify the zinc-deficient areas, and the different causes of deficiency. The submerged soils are well recognized for less zinc availability to the plants due reaction of zinc with free sulphide (Mikkelsen and Shiou, 1977). Flooding and submergence bring about a decline in available zinc due to pH changes and the formation of insoluble zinc compounds. The soil pH rises with the onset of reducing (gleying) conditions and zinc solubility declines 100 times for each unit increase in pH (Lindsay 1972). The insoluble zinc compounds formed are likely to be with Mn and Fe hydroxides from the breakdown of oxides and adsorption on carbonate especially magnesium carbonate. Under the submerged conditions of rice cultivation, zinc (either native or applied) is changed into amorphous sesquioxide precipitates or franklinite; $ZnFe2O_4$ (Sajwan and Lindsay 1988). Rice has been reported more prone to Zn deficiency than upland crops like wheat (Kausar *et al.*, 1976). Paddy soil conditions are usually not favorable for the availability of zinc and hence zinc deficiency has been reported country wide in rice soils (Bhatti and Rashid, 1985). Zinc deficiency is most frequently found in more than 70% Pakistani soil (Rashid, 1996). Globally, Zn deficiency has been found responsible for yield reduction of rice in more than 30% of rice soils (Fageria *et al.*, 2002; Alloway, 2008). Due to inadequate information available on the subject, cultivation of crops highly susceptible to zinc deficiency may aggravate the situation by adversely affecting the yield as well as human health.

Research efforts are therefore, required to screen the rice genotypes on zinc efficient and zinc inefficient basis, and develop the methods for improving zinc efficiency in rice (Lindsay *et al.,* 2000). Zinc deficiency restricts sustainable crop production, especially that of rice crop. Hence, it is always highly desirable to fulfill zinc requirement of rice through balanced fertilization which in-turn based upon determining the zinc status of soils. Usta Mohammad is the major rice growing area Taluka/sub-division of Balochistan. However, no any study reports zinc status of this important rice tract of Pakistan. This field nutritional survey cum laboratory study aims at evaluating the zinc status of major rice growing areas of Taluka Usta Mohammad, District Jaffarabad, Balochistan.

Materials and methods

This study was conducted to evaluate the zinc content of the major rice growing areas of taluka Usta Mohammad, Balochistan. To achieve the objectives of this study, a total 50 soil samples were collected from major rice growing tract of 10 Union councils i.e. Ali Abad, Faiz Abad, Khanpur, Mehrab Pur, Piral Abad, Qabula, Samaji, Shahalzai Usta Mohammad I, Usta Mohammad (II) of taluka Usta Mohammad. The Union councils with no rice tract were not included in the study. Soil sampled were through ideal random composite sampling with depth of sampling was kept 0-20 cm method as suggested by Ryan *et al.* (2001). All the samples of soil were analyzed in two replicates for various analyses. Soil samples were analyzed; Texture, EC, pH, $CaCO_3$, Organic matter and AB-DTPA-extractable zinc by (Ryan *et al.*, 2001).

Descriptive Statistics and Correlation Analysis

Descriptive statistics (minimum, maximum, mean, mode, standard deviation and coefficient of variation) was performed through spreadsheet software MS-Excel® (Microsoft, 2010) while for correlation analysis Statistix ver. 8.1 was used.

Results

The results on particle size showed that sand ranged 2.0 to 35.5%, silt 12.0 to 61.5% and clay 19.5 to 73.0% with average values of 18.0, 31.8 and 50.2%, and most frequent values of 9.5, 28.5 and 35%, respectively. The coefficient of variation for sand, silt and, clay was 55.6%, 39.2% and 31.3%, respectively (Table 1). Grouping of the soils by various textural classes showed that 70% soils were heavy in texture, i.e. 66% of the soils were clay in texture and 4% soils were silty clay. Moreover, 24% soils were medium textured loams, i.e. 12% soils were silty clay loam, 6% soils were clay loam and 6% soils were silty loam (Fig. 1). The results of electrical conductivity (EC) indicated that ranged from 0.9 to 10.4dS m^{-1} with an average value of 4.3dS m^{-1}. The most frequently noted EC value was 2.8dS m^{-1}. The coefficient of variation was 54% which indicated wide variation in EC values at different sites (Table 1). The soil samples were grouped according to Jackson (1962), as shown in (Table 2). The data revealed that the 40% of soil samples were moderately saline (EC: 4-8dS m^{-1}), 32% soils were very slightly saline (EC: 2-4dS m^{-1}), 20% soils were non-saline (EC: <2.0dS m^{-1}) while the leftover soil samples (8%) were strongly saline (EC: 8-16dS m^{-1}). Whereas, soil pH reaction ranged from 7.7 to 9.0 with an average of 8.2 and most frequent value of 8.3.

The coefficient of variation revealed negligible differences among the soil pH values of different sites (Table 1). The categorization of soil pH (Table 3), as suggested by Ankerman and Richard (1989), indicated that 52% soil samples were medium alkaline in nature with pH values ranged from 7.6 to 8.2 while the remaining soil samples (48%) were strongly alkaline in nature with values ranged from 8.3 to 9.0. Moreover, Lime content (%) ranged from 10.5 to 16.0% with an average of 13.3% and most frequent value of 14.0% (Table 1). The coefficient of variation (11%) revealed little differences among the lime content of different sites. The categorization of lime content (Table 4) revealed that all the soil samples were moderately calcareous containing 3-15% $CaCO_3$. Therefore, organic matter was observed in the range that is typical of Pakistan soils, i.e. in a range of 0.1 to 1.5% with an average value of 0.7% while the most frequent value found was 0.8%. The coefficient of variation highlighted wide differences among the organic matter content of 50 sites (Table 1). The data were categorized according to FAO (1989).

The percentage of soil samples falling in various categories is shown in Fig. 2. Accordingly, 66% soils were deficient in organic matter content having <0.86% organic matter while 32% soil samples were medium in organic matter content with organic matter content in a range of 0.86-1.29%. Moreover, only 2% soils were found high in their organic matter content with >1.29% organic matter.

Furthermore, the ABDTPA-Zn (mg kg^{-1}) content of 50 sites ranged from 0.1mg kg^{-1} to 3.0mg kg^{-1} with an average value of 1.2mg kg^{-1}. The most frequent value noted for AB-DTPA-Zn was 1.0mg kg^{-1}. The coefficient of variability (48.6%) indicated wide variation in soils with regard to their Zn status (Table 1). Using the criteria given by Sultanpur and Schwab (1977), the data were grouped into three categories by percentage of samples falling in each group as expressed in (Fig. 3). Most of the soil samples (46%) were medium in their ABDTPA-Zn content having Zn content ranging from 0.9 to 1.5mg kg^{-1} while 34% soils were low in ABDTPA-Zn content containing <0.9mg Zn kg^{-1}. Nonetheless, 20% of soil samples were adequate in ABDTPA-Zn content with >1.5 mg Zn kg^{-1}.

Table 1. Soil properties and zinc content in major rice growing areas of taluka Usta Mohammad, Balochistan.

Sites	Texture			EC	pH	$CaCO_3$	O/M	AB-DTPA Zn
	Sand	Silt	Clay					
	.........(%).........			(dS m^{-1})		.......(%).......		(mg kg^{-1})
1.	24	55	21	2.2	9	13.5	0.82	1.7
2.	31.5	48	20.5	10.42	8.2	12	0.36	1.3
3.	33.5	28.5	38	2.63	8.4	14	0.15	1.2
4.	29.5	28	42.5	7.62	8.2	11.7	0.57	1.3
5.	34.5	30.5	35	8.97	8.3	16	0.83	2
6.	8.25	23.75	68	2.78	7.9	14	0.18	0.3
7.	12	17.5	70.5	2.97	8.2	12.9	0.57	0.1
8.	29	26	45	4.8	8.4	15	1.13	1.5
9.	27	18	55	1.96	8.4	14.8	0.31	1
10.	35.5	36	28.5	1.61	8.6	13	0.46	1.1
11.	12	61.5	26.5	3.77	8.3	11.6	0.67	1.3
12.	35	40	25	6.5	8.3	15	1.08	0.8
13.	13.5	26.5	60	6.46	8.1	12	0.18	1.5
14.	17	33	50	4.73	8.2	14	1.15	0.5
15.	14.5	15	70.5	3.58	8.1	15	0.88	1.1
16.	17	21	62	2.78	8.2	13	0.85	3
17.	2	30	68	6.24	8.3	14	0.56	1.4
18.	3.5	28.5	68	4.75	8.3	12.5	0.82	0.7
19.	9.5	28	62.5	3.64	8.1	11	0.63	0.2
20.	12	15	73	1.16	8.5	13.5	0.95	1
21.	9.5	22.5	68	3.93	7.8	12.5	0.25	1.8
22.	13.25	16.25	70.5	5.91	7.7	16	0.41	2
23.	27.5	28	44.5	6.25	7.7	14	1.08	0.1
24.	7	38	55	6.24	8.3	11	1.13	1.5
25.	15.5	12	72.5	6.98	8.1	10.5	0.31	1.2
26.	15	17	68	5.63	8.3	11	0.1	1
27.	2	32.5	65.5	1.96	8.6	13	0.85	0.7
28.	7	35	58	4.34	8.6	14	1.19	0.9
29.	2	36	62	2.09	8.6	12	1.47	1.3
30.	12	53	35	2.21	8.4	12.5	0.26	0.6
31.	9.5	55.5	35	2.61	8.4	14.5	0.93	1
32.	18	47	35	7.15	8.3	13.5	0.41	1
33.	9.5	17.5	73	6.32	8	12	0.82	0.7
34.	10.5	39	50.5	8.28	8	12.5	0.1	1.5
35.	10.5	43.5	46	8.74	8	13	0.3	1.8
36.	22	33	45	4.46	8.1	10.5	0.69	1.7
37.	19.5	38	42.5	5.24	8.2	11	0.77	1.5
38.	19.5	38	42.5	3.6	8.3	14	0.42	1.6
39.	30	50.5	19.5	3.28	8.5	16	1.08	1.3
40.	30.5	22	47.5	6.35	8.5	13	0.18	0.7
41.	29.5	13	57.5	4.5	7.9	12.5	0.72	1.9
42.	19.5	45.5	35	2.41	8.3	11.5	0.95	0.1
43.	2	50.5	47.5	1.33	8.2	15	1.15	0.7
44.	30.5	21	48.5	1.81	8.2	15	1.1	1
45.	29.5	28.5	42	1.57	8.3	13	0.87	1.2
46.	29.5	31	39.5	1.68	8.2	16	0.85	1.1
47.	17	42.5	40.5	4.4	7.9	14.5	1.18	1
48.	24.5	33.5	42	1.99	7.9	13	0.27	1.8
49.	9.5	20	70.5	0.89	8.1	13.5	1.46	0.8
50.	19.5	20	60.5	3.58	7.8	15	0.92	1.4
Minimum	2.0	12.0	19.5	0.9	7.7	10.5	0.1	0.1
Maximum	35.5	61.5	73.0	10.4	9.0	16.0	1.5	3.0
Mean	18.0	31.8	50.2	4.3	8.2	13.3	0.7	1.2
Mode	9.5	28.5	35.0	2.8	8.3	14.0	0.8	1.0
S.D ±	10.0	12.5	15.7	2.3	0.3	1.5	0.4	0.6
C.V%	55.6	39.2	31.3	53.8	3.1	11.4	52.6	48.6

Table 2. Categorization of soil samples collected from rice growing areas of taluka Usta Mohammad, Balochistan for electrical conductivity.

EC (dS m^{-1})	Category	No. of samples	% of total samples
<2	Non saline	10	20
2-4	Very slightly Saline	16	32
4-8	Moderately Saline	20	40
8-16	Strongly Saline	4	8
>16	Very strongly saline	-	-

Table 3. Categorization of soil samples collected from rice growing areas of taluka Usta Mohammad, Balochistan for pH.

pH (%)	Category	No. samples	% of total samples
<4.5	Very strongly acid	-	-
4.5-5.2	Strongly acid	-	-
5.3-6.0	Medium acid	-	-
6-1-6.9	Slightly acid	-	-
7.0	Neutral	-	-
7.1-7.5	Slightly alkaline	-	-
7.6-8.2	Medium alkaline	26	52
8.3-9.0	Strongly alkaline	24	48
> 9.1	Very strongly alkaline	-	-

Table 4. Categorization of soil samples collected from rice growing areas of taluka Usta Mohammad, Balochistan for lime content.

$CaCO_3$ (%)	Category	No. of samples	% of total samples
<0.1.00	Non-calcareous	-	-
1-3	Slightly calcareous	-	-
3-15	Moderately calcareous	50	100
>15	Strongly calcareous	-	-

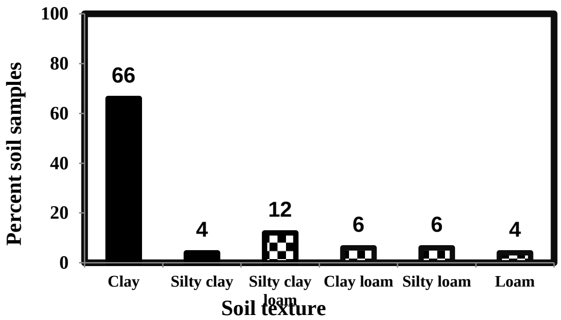

Fig. 1. Categorization of rice growing areas of taluka Usta Mohammad, Balochistan on the basis of soil texture.

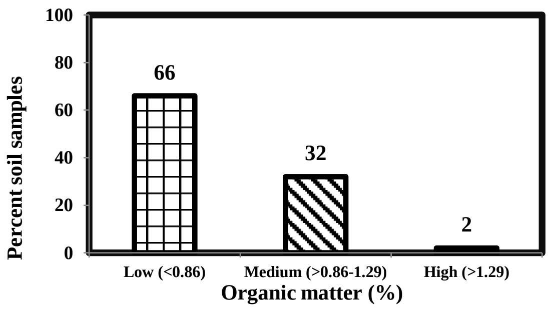

Fig. 2. Categorization of rice soils of taluka Usta Muhammad on the basis of organic matter content.

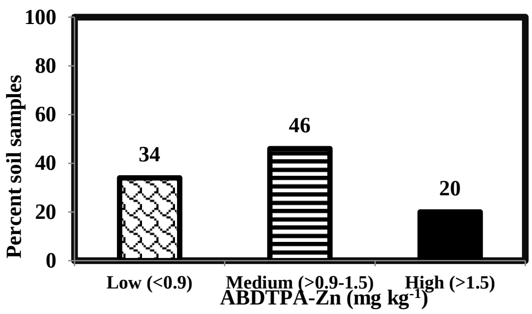

Fig. 3. Categorization of rice soils of taluka Usta Muhammad on the basis of ABDTPA-Zn.

Discussion

Regular monitoring of soil fertility status of any given area is an essential component of efficient soil resource management, balanced fertilization and sustainable production.

This study evaluated zinc (Zn) content of major rice growing areas of taluka Usta Mohammad, Balochistan. Zinc (Zn) is an important essential nutrient. Plant-available Zn is present in the soil solution or is adsorbed to the roots in a labile form (Alloway, 2004). Many soil factors affect the availability of Zn to plants. These include the total Zn content, pH, organic matter content, calcium carbonate content, redox conditions, microbial activity in the rhizosphere, soil moisture status and concentration of other micronutrients and macro-elements (Sillanpaa, 1990; Marschner, 1995). According to the results of present study (Table 1 to 4 and Fig. 1 to 3) the soils of the rice growing areas were heavy to medium in texture, very slightly to moderately saline, medium to strongly alkaline, moderately calcareous and low in organic matter content. It was also noteworthy that only 20% soils had high Zn content while others were either medium or low in their Zn content. Hence, these heavy textured, saline soils are poor fertile with respect to their organic matter and Zn status which may highly likely hinder sustainable rice production as major constraints.

Early studies on the subject of soil fertility monitoring also highlighted similar threats to sustainable agriculture under various agro-ecological zones of Pakistan with different cropping systems. Wagan (1972) reported that 80% of the Larkana soil samples were heavy, 19% per cent medium and 1% per cent were light in texture. The total soluble salts in the soils were not very high thus there was no salinity problem. The pH of soils ranged between 7.3 to 7.6. The soils were calcareous in nature. Later on, Odano (1973) reported that the soils of Larkana varied from sandy clay loam to clay, clay loam to sandy clay and sandy loam to loamy sand. The soils were calcareous and the calcium carbonate varied from 8.5 to 17.5 per cent. The soils were mostly not affected by high salinity. These soils were suitable for most crops. The soil pH was ideal ranging from 7.1 to 7.4. In a preliminary investigation, Tahir (1978) analyzed 63 surface soil samples from Lahore, Shaikhupura, and Gujranwala and Faisalabad districts and found that DTPA extractable Zn of these soil ranges from 0.32-1.88 with an average of 0.69ppm.

In another study they collected soil samples from farmer's field in Faisalabad, Jhang, Sahiwal, Multan and Vehari districts and the DTPA extractable Zn ranged from 0.17-1.10 with an average of 0.35ppm. During the same period, Kausar *et al.* (1979) analyzed 152 soil samples collected from different soil series of the four province of the country using DTPA as an extractant and reported that 85% of the samples were with marginal to deficient concentration of available zinc, being 69% in Baluchistan, 55% in NWF, P 45% in Punjab and 17% in Sindh. Gough *et al.* (1980) reported that the soils of Northern Great plain contain 2 to 53mg kg^{-1} DTPA-Zinc. Later on, Bhatti *et al.* (1982) estimated the available zinc status of soils of main agricultural areas of Lebanese soils using $NH_4H_2PO_4$, $MgCL_2$ and DTPA as extractants. They reported that Zn availability in Lebanese soils was adequate. However, the ranged of DTPA extractable zinc was of 0.5ppm to 58.3ppm out of 162 samples while a further 28 samples 0.5-1.0ppm which might be considered marginal.

Similarly, Memon (1985) analyzed 125 surface soil samples in Hyderabad district and found that Zn content of these soils ranged from 0.49-7.35 ppm with and averaged of 1.78ppm. Rehmatullah *et al.* (1988) reported a severe deficiency of Zn in major rice growing areas of Punjab. Thirty soil and plant samples were collected form each Basmathi-370 and IRRI field at flowering stages from major rice growing areas of Gujranwala, Sheikhupura, Lahoure and Siallkot districts of Punjab. Results revealed 25% Zn deficiency in Basmathi-370 and 50% in IRRI variety of rice. Thereafter, Parveen *et al.* (1993) studied the micronutrient status of 30 agriculturally important soil series of NWFP and their relationship with various physic-chemical properties of the soil series, and found that DTPA extractable Zn of soil ranged from 0.36-1.84. It was noted that, Zn was found deficient in four, marginal in sixteen and adequate in ten soil series. Junejo (1997) reported that most of the soils in Taluka Khairpur Nathan Shah were heavy in texture, alkanline in reaction (pH ranged from 7.2-8.2) and free from salinity (EC 1.00 to 0.95dSm^{-1}). However, the soils were highly calcareous and the lime content ranged between 2.60-10.62%. The organic matter ranged from 0.14 to 1.86%. The content of Zn decreased with the increased soil depth but was sufficient (0.37 - 0.69mg kg^{-1}).

Khatri (1997) reported Zn deficiency in 50% soil samples at 0-15cm and 80% soil samples at 15-30cm depth of the soils of taluka Matli. Ali (2000) reported that the soils of Rice Research Institute Dokri were heavy in texture, non-saline, alkaline in reaction, moderately calcareous, poor to medium in organic matter content, deficient in available zinc. Ahmad (2003) also reported Zn deficiency in 60% soils of the growing areas (Kallar track). During last decade, many important researches are published on this subject. Siddiqui (2003) evaluated the status of rice soils in Deh Badaleah and Delawarpur of Jacobabad District involving 40 sites. Majority (97.5%) of soils were heavy in texture. The soils were slightly to moderately alkaline in reaction (pH: 7.4 to 8.5). The soils were non saline to strongly saline (EC: 1.3 to 30.6dS m^{-1}). The soils were poor in organic matter (0.45 to 1.3%). The ABDTPA-Zn was low (0.15 to 0.97mg kg^{-1}). Chachar (2007) studied that the micronutrient status of the soils of rice and cotton growing areas in Deh Surgo, taluka Pano Akil. Most of the soil samples were heavy in texture, alkaline in reaction, non-saline to slightly saline, medium to highly calcareous n nature and poor in organic matter. The Zn^{2+} concentration (0.25 to 1.09mg kg^{-1}) was low. Sajida (2010) classified soils of vegetable growing areas of Peshawar for their fertility status and found that ABDTPA extractable zinc was found deficient, medium and adequate in 33, 11 and 55% samples in surface soil while it was found deficient, medium and adequate in 44, 16 and 38% samples in sub surface soil.

Reference

Ahmad N, Abid M, Hussain K, Akram M, Yousaf M. 2003. Evaluation of nutrient status in the rice growing areas of Panjab. Asian. Journal of Plant Sciences **5,** 449-453.

Alloway BJ. 2004. Zinc in soils and crop nutrition. Brussels, Belgium: International Zinc.

Alloway BJ. 2008. Zinc in Soils and Crop Nutrition. 2nd ed. IZA. Brussels, Belgium.

Ankerman D, Richard L. 1989. Soil and plant analysis. Agronomy. Handbook. A & L Agricultural Laboratory. USA. p. 56.

Bhatti A, Berger KC, Ryan J. 1982. Available zinc status of Lebanese soils. Iranian Journal of Agricultural Research **1,** 41–47.

Bhatti HM, Rashid M. 1985. Micronutrient Research in Pakistan. Rice Production. Seminar, Larkana 67-72.

Chachar NA. 2007. Micronutrient status of rice and cotton growing areas indeh surgo taluka Pano Akil. MSc. Thesis, Department of Soil Science, Sindh Agriculture University, Tandojam.

Doberman A, Witt C, Dawe D. 2004. Increasing productivity of intensive rice systems through site-specific nutrient management. science publishers and international rice research institute (IRRI) pp. 410.

Fageria NK, Baligar VC, Clark RB. 2002. Micronutrients in Crop Production**.** Advances in Agronomy **77,** 185-268.

FAO. 1989. Sustainable agriculture production: Implication for international agriculture research. Research and technology paper 4. Rome: Food and Agriculture Organization of the United Nation.

Gandahi AW. 1995. Fertility status of the soils of taluka Kandiaro, District Nnushahro Feroze. MSc. Thesis Department of Soil Science, Sindh Agriculture University, Tandojam.

Jackson ML. 1962. Soil chemical analysis. Constable and co. Ltd. London. p. 244.

Junejo ZH. 1997. Status of micronutrients (Cu, Mn, Fe and Zn) in rice fields of taluka Khairpur Nathan Shah district Dadu. M.Sc. Thesis, Department of Soil Science, Sindh Agriculture University, Tandojam.

Kausar MA, Chaudhry FM, Rashid A, Latif A, Alam SM. 1976. Micronutrient availability to cereals from calcareous soils: Comparative Zn and Cu deficiency and their mutual interaction in rice and wheat. Plant Soil **45,** 397-410.

Kausar MA, lam SM, Sharif M, Pervez MI. 1979. Micronutrients status of Pakistan Soils. Pakistan J. Scientific and Industrial Research **22,** 156–61.

Khatri KM. 1997. Micronutirent status of rice soils of taluka Matli. M.Sc. Thesis, Department of Soil Science, Sindh Agriculture University, Tandojam.

Khattak RA, Hussain Z. 2007. Evaluation of soil fertility status and nutrition of orchards. Soil & Environment **26,** 22-32.

Lindsay W. 1972. Zinc in soil and plant nutrition. Advances in Agronomy **24,** 147-188.

Lindsay. 2000. Zinc: The Next Global Agenda. Malaysian journal of nutrition **6,** 189-195.

Marschner H. 1995. Mineral Nutrition of Higher Plants. 2nd ed. Academic Press, London.

Menghwar R. 1997. Available sulphur in relation to physico-chemical properties of rice soils. M.Sc. Thesis, Department of Soil Science, Sindh Agriculture University, Tandojam.

Mikkelsen DS, Shiou K. 1977. Zinc fertilisation and behaviour in flooded soils. Spec. Publ. No. 5 Comm. Agric. Bur., Farnham Royal.

Odhano PB. 1973. Phosphorus and potash status of rice soils of taluka Larkana. M.Sc. Thesis, Department of Soil Science, Sindh Agriculture University, Tandojam.

Rashid M. 1996. Effect of salinity, sodicity, Zn and Cu on concentration of micronutrients in rice. Pakistan. Journal of Soil Science **12,** 111-117.

Rehman H, Haq I. 2006. Diagnostic criteria of micronutrients for sweet orange. Soil Environment **25,** 119-127.

Ryan J, Estefan G, Rashid A. 2001. Soil and Plant Analysis Laboratory Manual. 2nd ed. pp. 172.

Sajida P, Malik Z, Nazif W. 2010. Fertility status of vegetable growing areas of Peshawer, Pakistan Pakistan Journal of Botany **42,** 1871-1880.

Sajwan KS, Lindsay WL. 1988. Effect of redox, zinc fertilisation and incubation time on DTPA-extractable zinc, iron and manganese. Communications in soil science and plant analysis **19,** 1-11.

Siddiqui MA. 2003. Fertility evaluation of rice soils of Jacobabad. M.Sc. Thesis, Department of Soil Science, Sindh Agriculture University, Tandojam.

Sillanpää M. 1990. Micronutrient Assessment at Country Level: An International Study.

Soltanpour PN, Schwab AP. 1977. A new soil test for simultaneous interaction of macro nutrients in Alkaline soils. Communications in soil science and plant analysis **8,** 195-207.

Timsina J, Connor DJ. 2001. Productivity and management of rice-wheat cropping systems: Issues and Challenges. Field Crops Research **69,** 93-132.

Wagan MR. 1972. Study of some of the micro-nutrient elements of the cultivated soils of warah taluka district Larkana. M.Sc. Thesis, Department of Soil Science, Sindh Agriculture University, Tandojam.

Wasiullah, Bhatti AU. 2006. Fertility status evaluation of soil of Kohat and Bannu districts. Sarhad Journal of Agriculture **22,** 459-463.