

Availability of Micronutrients in Selected Saudi Soils

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ABSTRACT Micronutrients (Fe, Zn, Mn and Cu) contents in 102 soil samples selected from major agricultural areas (Al-Kharj, Al-Hasa, Qaşim, Taif and Wadi Dawasir) representing a wide range of soils cultivated for crop production in Saudi Arabia, were analyzed by the DTPA method. Values in parts per million in the surface soils of the 23 locations ranged from 1.10 to 11.70 for Fe, 0.12 to 3.20 for Zn, 0.40 to 26.0 for Mn and 0.20 to 3.20 for Cu. None of the surface soils showed Cu deficiency, and only 2% of the samples were deficient in Mn. Iron was deficient in 78% of the samples and Zn in 70% of the samples. Distribution of Zn and Cu throughout the profile below the surface layers was uniform with larger amounts in surface horizons. Contents of Fe and Mn generally decreased with depth.

Deficiencies of micronutrients are a serious problem in crop production on light-textured calcareous soils of arid regions (Lucas and Knezeck 1972). In Saudi Arabia, calcareous soils represent a very significant part of all the agricultural soils. These soils are likely to be poor in one or more of the micronutrients owing to the ability of free CaCO_3 to transform these nutrients to sparingly soluble compounds. Analyses of several thousands of soil samples from Saudi Arabia at our laboratory in the last three years revealed that they are generally coarse to medium in texture with low organic matter and usually have a pH between 7.5-8.5. Jones and Kelso (1977) studied the micronutrient status of Al-Hasa soils and reported iron and zinc deficiencies. Apart from this, little information is available on the status of micronutrients in Saudi soils and of their distribution in soil profiles. In recent years, many previously uncultivated areas are being intensively used for growing major field crops, fruits and vegetables. It has, therefore, become essential to know the status of micronutrients in the agricultural soils of the country. This study was attempted to assess the availability of Fe, Zn, Mn and Cu in some important

agricultural soils by extraction with Diethylenetriaminepentaacetic acid (DTPA) solution and determine the distribution of these micronutrients in the soil profiles under study.

Material and Methods

A total of 102 soil samples representing 23 profiles were collected from five major agricultural areas in the Kingdom; 8 from Al-Hasa, 4 from Qaṣīm, 7 from Taif, 2 from Wadi Dawasir and 2 from Al-Kharj (Fig. 1). The soils represented various types and cover important regions in the country. The total area of Saudi Arabia is about 2.2 million km² and represents 5% of the arid zones of the world. The environment of the present study areas (physiography, detailed morphological and physico-chemical properties) was described by Bashour *et al.* (1983). Soil samples collected from different areas were air dried, ground to pass through a 2 mm sieve and stored for subsequent analyses. Calcium carbonate percent, electrical conductivity (EC mmhos/cm) and pH were determined as outlined in USDA Salinity Laboratory Handbook 60 (Richards 1954). Texture was determined by the hydrometer method (Foth *et al.* 1976). The micronutrients were extracted by the

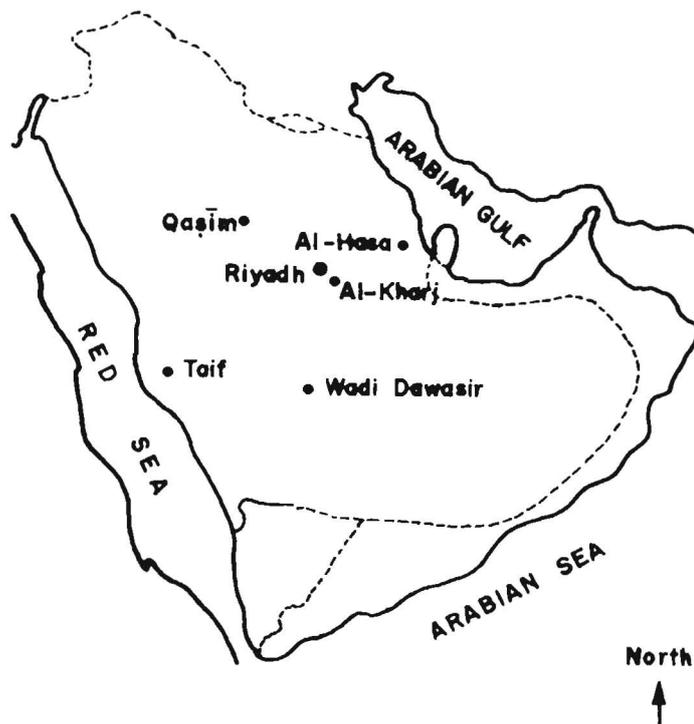


Fig. 1. Geographical map of Saudi Arabia showing study areas.

DTPA ($C_{14}H_{23}O_{10}N_3$) method which was advocated by Lindsay and Norwell (1978) to be the most efficient for simultaneous assessment of Fe, Zn, Mn and Cu in calcareous soils. The method consists of extracting 20 g soil with 40 ml of DTPA solution which was prepared to contain 0.005 M DTPA, 0.01 M $CaCl_2$, 0.1 M triethanolamine (TEA) and an adjusted pH of 7.30. After shaking for two hours the soil extracts were filtered through a Whatman No. 42 filter paper. Iron, zinc, manganese and copper were then determined in the filtrates using a 603 Perkin-Elmer atomic absorption spectrophotometer.

The DTPA-extractable critical levels of micronutrients as reported by Lindsay and Norwell (1978) for calcareous soils in greenhouse experiment were adapted to assess the status of micronutrients in the soils; 4.50 ppm for Fe, 0.80 ppm for Zn, 1.00 ppm for Mn and 0.20 ppm for Cu.

Results and Discussion

Table 1 summarizes some properties of all the studied soil samples and the DTPA-extractable Fe, Zn, Mn and Cu contents in them with minimum, maximum and mean values.

Table 2 records the DTPA-extractable Fe, Zn, Mn, and Cu contents and some important properties of surface soils of the 23 profiles. The DTPA-extractable Fe ranged from 1.10 to 11.70 ppm, Zn from 0.12 to 3.20 ppm, Mn from 0.40 to 26.00 ppm, and Cu from 0.20 to 3.20 ppm. Iron was deficient in 18 of the 23 samples and Zn in 16 of them when related to the critical levels reported by Lindsay and Norwell (1978). None of the surface soils were deficient in Cu, and only 2 samples in Mn. Calcareous soils, soils low in organic matter, soils with a pH higher than 7.0, leached sandy soils and very frequently newly levelled soils for furrow or flood irrigation have often been reported to be deficient in Zn (Viets 1966). These

Table 1. Ranges and means of some soil characteristics and DTPA-extractable micro-nutrient contents of 102 soil samples representing 23 profiles.

Characteristic	Range		Mean
	Minimum	Maximum	
pH	6.20	8.90	7.77
CaCO ₃ %	0.80	45.10	13.60
E.C. (mmhos/cm)	0.50	133.50	14.18
Fe - ppm	1.00	11.70	3.83
Zn - ppm	0.12	3.20	0.44
Mn - ppm	0.40	26.00	3.90
Cu - ppm	0.16	3.20	0.82

Table 2. Important soil properties and DTPA-extractable Fe, Zn, Mn and Cu contents of surface horizons in 23 locations sampled.

Sample Number	Location	pH	CaCO ₃ %	E.C. mmhos/cm	Fe	Zn	Mn	Cu
					ppm			
<i>Al-Hasa</i>								
1	HIDA* farm	8.0	16.8	16.3	0.50	0.30	3.00	0.50
2	Shuban	7.8	6.9	2.8	3.66	0.48	3.30	0.24
3	Hofuf-I	8.0	17.1	53.4	4.10	0.30	3.50	0.70
4	Hofuf-II	7.4	18.4	8.5	6.70	1.42	6.00	0.70
5	Hofuf-III	7.5	24.6	3.3	5.40	0.38	3.30	0.40
6	Hofuf-IV	7.0	2.5	32.0	2.20	0.32	3.40	0.56
7	Hofuf-V	7.5	19.6	133.5	2.20	0.86	4.30	0.70
8	Taraf	7.9	17.8	4.4	1.10	0.32	2.50	0.34
<i>Qasim</i>								
9	Al-Bassamiah	7.6	4.6	6.0	3.00	0.24	4.20	0.38
10	Al-Badaeh	7.5	14.0	7.5	7.50	0.48	20.00	1.10
11	Al-Qarzea	7.9	9.7	1.7	3.30	0.50	6.30	0.56
12	A.R.C.** farm	7.9	3.8	1.67	3.30	0.84	1.90	0.22
<i>Taif</i>								
13	Al-Mathana	8.1	7.4	2.3	4.30	1.80	20.00	1.90
14	Muzalala	7.7	11.5	3.3	3.50	0.86	7.80	1.14
15	Al-Hada	7.8	3.3	3.7	11.70	2.00	16.00	2.80
16	Rawdah	6.3	4.5	1.0	3.30	0.22	4.70	0.64
17	Liyah	7.7	12.5	1.2	3.66	0.44	7.60	1.48
18	Ashafa	7.5	3.8	1.5	9.10	3.20	26.00	1.82
19	Sail Kabir	7.4	5.1	5.8	3.80	1.96	4.40	0.74
<i>Wadi Dawqir</i>								
20	Kashm Al-Ashqar	7.3	8.2	115.7	1.10	0.32	0.60	0.30
21	Sulayyal	7.8	13.8	37.4	3.00	0.32	0.50	1.44
<i>Al-Kharj</i>								
22	Kharj-I	7.5	23.0	5.4	4.00	3.70	4.80	0.50
23	Kharj-II	7.7	21.2	2.7	2.80	0.20	1.70	0.36

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conditions, at least partially, appear to exist in most of the soils of the present study and could be responsible for the observed Zn deficiencies. About 78% of the samples tested were deficient in DTPA-extractable Fe. Generally, degree of calcareousness and/or pH may account for Fe deficiency in the soils. Preliminary mineralogical analyses of the soils (unpublished data) have shown the dominant component of the parent material to be quartz or calcite, and it is likely that the

lack of minerals containing iron is one of the most significant reasons for the iron deficiencies in those soils. Field observations by the authors have also suggested iron and zinc deficiencies symptoms to be common in the soils under discussion. This was further confirmed by the response to application of Fe and Zn by vegetables at Al-Kharj and Qaṣīm areas (unpublished data). Severe Fe and Zn deficiencies in the soils of the present study are in agreement with the works of Jones and Kelso (1977) and Loizides (1975). Data in Table 2 suggest that despite high pH values and calcium carbonate content, none of the soils was deficient in Cu and only 2 samples were deficient in DTPA-extractable Mn. Calcareous soils of Lebanon are also adequate in DTPA-extractable Mn (Khan and Ryan 1978). Fuehring (1973) similarly reported that Mn and Cu are much less apt to be deficient on calcareous soils than Fe and Zn. Manganese content is generally high in the soils and high concentration of Mn is reported to cause Fe deficiency in plants by competing with the absorption of Fe (Lingle *et al.* 1963).

Distribution of Fe, Zn, Mn and Cu Throughout Soil Profiles

The distribution of Fe, Zn, Mn and Cu in some profiles is shown in Table 3. A general conclusion emerging from the data is that the concentration of iron and zinc are low and that those of iron and manganese decreased with depth. However, there was no consistent trend in all the 23 profiles and this is probably due to the transported alluvial nature of some of the soils under study. Randhawa *et al.* (1961) and Kubota (1963) also reported similar trends in distribution of micronutrients in soil profiles and attributed this to clay content. The textural classes of the studied soils indicated the presence of high percentage of the sand fraction in them and this appeared to be associated with low contents of Fe, Zn and Mn along the profiles. Aubert and Pinta (1977) reported similar results in coarse textured soils. Low organic matter, variation in calcium carbonate content along the profile and, to some extent, texture may be the reasons for the observed distribution of iron and manganese in this study. However, no attempts were made to correlate these variables. Generally, Zn and Cu contents are higher in surface horizons (Table 3) and are distributed more or less uniformly throughout the depth of the profiles below. Many authors (e.g. Iyer and Satyanarayan 1963, Hodgson 1963) have reported uniform distribution of Zn and Cu in arid soil profiles. These reports and the results of the present study confirm the theory that a high degree of profile development or advanced stage of weathering is necessary for variation in micronutrient patterns in soil profiles.

In conclusion, this study has shown that the available Fe and Zn contents are low in most of the soils probably due to degree of calcareousness and/or pH, texture and low levels of organic matter. It is apparent from the results that, despite high pH and high CaCO₃ levels, many soils of Saudi Arabia contain adequate levels of available Mn and Cu as measured by the DTPA extraction

Table 3. Profile distribution of DTPA extractable Fe, Zn, Mn and Cu in some soils.

Location	Area	Depth cm	Fe	Zn	Mn	Cu
			ppm			
1. Shuban	Al-Hasa	0- 6	3.66	0.48	3.30	0.24
		6- 32	1.30	0.50	3.00	0.50
		32- 75	1.44	0.24	1.00	0.25
		75-100	1.44	0.24	0.90	0.34
		100-127	1.44	0.70	1.00	0.38
		127-150	1.10	0.22	1.00	0.24
2. Al-Qarzae	Qasim	0- 20	3.30	0.50	6.30	0.56
		20- 40	2.70	0.44	4.90	0.60
		40- 62	3.00	0.32	1.80	0.28
		62- 95	3.80	0.30	1.40	0.28
		95-135	1.90	0.36	0.90	0.34
3. Rawdah	Taif	0- 20	3.30	0.22	4.70	0.54
		20- 45	2.00	0.14	3.00	0.64
		45- 80	1.30	0.14	1.70	0.50
		80-105	2.00	0.14	2.60	0.65
		105-130	1.20	0.12	0.90	0.45
		130-155	1.80	0.28	1.30	0.50
4. Sulayyal	Wadi Dawasir	0- 23	3.00	0.32	0.50	1.44
		23- 59	3.00	0.16	0.40	0.30
		59- 90	3.00	0.14	0.40	0.20
		90-143	3.00	0.16	0.80	0.24
		143-173	1.60	0.14	0.70	0.26
5. Kharj-I	Al-Kharj	0- 20	4.00	0.70	4.80	0.50
		20- 35	3.00	0.50	4.10	0.60
		35- 50	2.80	0.50	3.30	0.60
		50- 65	2.80	0.35	4.20	0.90
		65- 80	2.80	0.30	3.50	0.65
		80- 95	2.60	0.25	2.30	0.65

procedure. The absence of Mn and Cu deficiencies can be attributed to initially high levels of soil Mn and Cu. Plans are underway for sampling a larger number of soils to find the relationships between soil properties and availability of micronutrients, particularly iron and zinc.

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توفر المغذيات الدقيقة في بعض الأراضي السعودية

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المركز الاقليمي لأبحاث الزراعة والمياه، وزارة الزراعة والمياه،

ص.ب. ١٧٢٨٥ - الرياض - المملكة العربية السعودية

تم تحليل ١٠٢ عينة تربة مجمعة من خمس مناطق زراعية هامة بالمملكة العربية السعودية وهي: الخرج، الأحساء، القصيم، الطائف ووادي الدواسر. حللت العينات بطريقة الاستخلاص بمحلول (DTPA) لتقدير محتواها من المغذيات الدقيقة الآتية: الحديد، الزنك، المنجنيز والنحاس. وقد جرى تقدير محتوى الطبقات السطحية للتربة من هذه العناصر وذلك في ٢٣ موقعا تحت الدراسة. وقد تراوحت محتوياتها بالأجزاء من المليون كالاتي: ١٠, ١ - ١١, ٧٠ للحديد، ١٢, ٠ - ٣, ٢٠ للزنك، ٤٠, ٠ - ٢٦, ٠ للمنجنيز و ٢٠, ٢٠ - ٣, ٢٠ للنحاس.

أشارت النتائج إلى عدم وجود نقص في محتوى العينات من النحاس، في حين أن نسبة العناصر الأخرى كانت: ٢٪ للمنجنيز، ٧٨٪ للحديد، ٧٠٪ للزنك. وقد كان توزيع كل من عنصرَي الزنك والنحاس متجانسا في قطاعات التربة التي أجريت عليها الدراسة، أما في حالة عنصرَي الحديد والمنجنيز فقد تناقص محتواهما عموما مع العمق.