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ASSESSMENT OF TRACE ELEMENT CONCENTRATIONS IN FENUGREEK AND LUPIN PLANTED IN THE EXPERIMENTAL FARM, HIGH DAM LAKE DEVELOPMENT AUTHORITY, GERF HUSSEIN BEACH LOCALITY, EGYPT

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The trace elements Ag, Au, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr and Zn in fenugreek and lupin (leaves, stems, pods, pericarp, seeds, testa and cotyledon) as well as in soil samples taken from the immediate vicinity of crop roots at 10, 30 and 60 cm depths in the Gerf Hussein area were determined using flame atomic absorption spectrophotometer. Ca and Cl were estimated by EDTA and Cl by ion selective electrode. The results indicated that the trace elements are present in high concentrations in the soil samples collected from 60 cm depth. In fenugreek and lupin, most elements are concentrated in leaves and stems. The elements Ca, Cl, Co, Fe, Mg, Mn, K and Zn are present in higher concentrations in the crops as compared to the soil.

Key words: Spectrophotometer, Trace elements, Fenugreek and Lupin.

Introduction

Gerf Hussein Farm is located in the El-Dakka area of the lower Nubia plain. The El-Dakka beds are composed of variably coloured sandstones [2] and are characterized by the lack of polymiotic conglomerate accumulations. The soil has no diagnostic horizons. The soil texture is coarse rather than very fine loamy sands typical to a depth of one metre. The soil belongs to order Entisols and suborder Psamments.

Trace elements play a very important role in chemical, biological, biochemical and enzymatic reactions in the living cells of plants, animals and humans. A literature survey on trace elements in crops and soils revealed a lack of data. Therefore, the present work is devoted to determining the trace elements levels in lupin, fenugreek and in soil samples taken at different depths.

An atomic absorption spectrophotometer has been used to determine the trace elements in the blood of cattle [3], florida mares [4], serum and urine [5], whole blood [6], faeces [7], plants [8,9], vegetables [10], soil samples [11,12], water [13] and sediments in the Lake Nasser-Lake Nubia [13] area.

Also, the ion selective electrode method was used for the determination of chloride in plants [14], soils [15], fish cakes [16] and silicate rocks [17]. Inductively coupled plasma-atomic emission spectrophotometer has been utilised to determine the trace elements Be, Ca, Cr, Fe, Pb and Zn in raw agricultural crops (lettus, potatoes, spinach and wheat) [18] and As, Cd, Cu, Hg and Se in animal tissues [19]. Multielemental neutron activation analysis technique has been applied for determination of Al, As, Au, La, Mo and Zn in African tea, black pepper, tomatos and fenugreek [20,21].

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Experimental

Materials. All chemicals used were of Analar grades (BDH & Merck).

Plant crops. Fenugreek and lupin were planted on November 15, 1986. The total amount of fertilisers needed for feddan was 150-200 kg of superphosphate and 200 kg of nitro kima ($NH_4NO_3 + CaCO_3$). The rate of irrigation water applied was 180 m^3/feddan every two weeks.

Samples collection and preparation: Crop samples. Leaves, stems, pods, pericarp, seeds, testa and cotyledon of fenugreek and lupin samples were collected, washed with running tap water, followed by bidistilled and deionized water, then dried at 150°C for 48 hr. The dried samples were crushed, powdered and stored in bottles.

Soil samples. The soil samples collected at 10, 30 and 60 cm depths, dried at 105°C for 24 hr, powdered and stored.

Preparation of standard solutions. (a) For atomic absorption spectroscopy (AAS): Stock (500 ml solutions) 1000 ppm/ml of different metals used after dilution to the desired volume and (b) For the ion selective electrode method (ISE): A stock 1000 ppm/ml chloride solution was prepared from primary standard NaCl.

Sample preparation. (a) For AAS: (i) Ten grams of each of the dried crop samples were wet ashed using HNO_3 - $HClO_4$ acid (1:1) mixture followed by addition of a few drops of HF acid [22]. The mixture was heated on a sandbath until complete destruction of cellulose had occured. The residue was then made up to 100 ml using bidistilled water and (ii) One gram portions of dried soil samples were dissolved in 10 ml conc. HNO_3 and 10 ml conc. HCl, heated to dryness and another 10 ml HNO_3 + 10 ml HCl was added and reheated. The residue was extracted using 10 ml (2N) HCl and a solution made up to 100 ml using bidistilled water.

(b) For ISE: (i). One gram portions of standard solution 'b' dried finely ground crop subsamples were added to 50 ml of 1M $NaNO_3$, stirred and filtered, and (ii). Ten gram portions of powdered soil samples were shaken with 100 ml chloride free deionized water, then filtered.

Determination of elements by AAS. The concentration of trace elements in crop and soil samples were measured by a Pye Unicam SP 1900 atomic absorption spectrophotometer with hollow cathode lamps of elements at characteristic wavelengths. Atomic absorption data were acquired by aspiring aqueous single element standard solutions, blank and samples with two deionized water rinses between two each readings.

Determination of chloride by ISE. Chloride in crop and soil samples was measured using an Orion Ion Analyser, with an EA940 micro processor and an Orion 94-17 solid state chloride ion-selective electrode and double junction reference electrode. For soil samples, the double junction electrode filled with 10% KNO_3, and one ml of low level ionic strength adjustor (ISA, 1 M $NaNO_3$) was added to the sample and standard solutions. The chloride and reference electrodes were immersed in the sample solutions and concentrations were read out. For crop samples, a known volume of sample was used then 0.5 ml of ISA was added, followed by a known volume of expected standard concentration (single known addition technique) [23,24].

Results and Discussion

Representative data for the trace element concentration present in lupin and in its soil samples taken at 10, 30 and 60 cm depths are given in Tables 1 and 2 respectively. The relationships between the trace element concentration in lupin and fenugreek and in their soil samples are given in Figs. 1 and 2 respectively.

The results reveal that the elements Ag, Au, Co, Cr, Fe, Mn, Ni, Pb, Sr and Zn are present in high concentrations in the soil samples collected at 60 cm, Na, Ca and Cu at 30 cm and Cl at 10 cm depths. These differences may be related to the differences in mineralogical-chemical compositions and weathering effect as a result of geochemical and biogeochemical fractionation of the soil.

In fenugreek and lupin, most elements are concentrated in leaves and stems, while Au, Cr, Cu, Mn, Ni, Sr and Zn accumulate in the seeds, Ag, Ca, Cr, Fe, K, Mg, Mn and Na in pods. Ag, Au, Ca, Cl, Co, Cr, K, Mg, Mn, Na and Pb in pericarp. Co, Fe, Mn, Na, Ni, Sr and Zn in testa of lupin. Ca, Cu, Fe, Mn, Ni and Zn in cotyledon of lupin. The presence of Zn (0.164-0.870) and Co (0.016-0.056) ppm in high concentrations in lupin, particularly in the testa, recommend it as food for humans and animals. Zn is important as it stabilises the lysosomal membrance and resembles some co-factor enzymes such as carbonic anhydrase and dehydropeptidase which play a specific role in protein metabolism and synthesis of auxin [22,25]. Its deficiency causes rolling, chlorosis, shortening and finally death of the leaves [26]. Cobalt is an essential nutrient activator, involving vitamin B_{12} synthesis and nitrogen fixation [27]. Its deficiency results poor growth, break down of the healthy parts of the lamina and chlorosis [27].

The obtained results indicated that fenugreek contains

TABLE 1. RESULTS OF TRACE ELEMENTS CONCENTRATIONS IN LUPIN (GERF HUSSEIN AREA).

	Sample No. 1 (Depth in cm)							Sample No. 2 (Depth in cm)						
Element	a	b	c	d	e	f	g	a	b	c	d	e	f	g
Ag (ppm)	0.005	0.005	0.017	0.002	0.005	0.010	0.005	0.005	0.010	0.002	0.005	0.010	0.005	0.005
Au (ppm)	0.012	0.017	0.005	0.002	0.005	0.00	0.005	0.010	0.015	0.007	0.002	0.005	0.005	0.005
Ca (%)	1.50	1.40	0.45	0.47	0.47	0.38	0.85	1.70	1.42	0.54	0.48	0.52	0.43	0.85
Cl (ppm)	40.5	26.1	19.1	12.3	20.9	46.7	7.5	45.9	31.5	18.8	16.1	16.6	41.6	8.2
Cl^* (ppm)	39.7	25.3	17.5	11.5	19.5	45.9	6.8	45.5	30.6	18.0	15.3	15.5	40.5	7.2
Co (ppm)	0.040	0.027	0.045	0.012	0.02	0.06	0.025	0.030	0.035	0.047	0.017	0.015	0.045	0.01
Cr (ppm)	0.195	0.072	0.070	0.147	0.09	0.015	0.195	0.197	0.102	0.072	0.157	0.115	0.010	0.245
Cu (ppm)	0.100	0.011	0.022	0.011	0.090	0.052	0.092	0.102	0.015	0.023	0.008	0.097	0.035	0.100
Fe (ppm)	145	33	41.2	30.2	29.5	49	39	138	29	44.5	29	31	50	40
K (ppm)	120	300	320	337	137	245	107	150	375	345	400	145	280	127
Mg (ppm)	60	90	52.5	47.5	47.5	55	45	57.5	65	55	70	45	47.5	55
Mn (ppm)	22.5	18.7	5.6	4.0	6.2	3.2	5.0	21.7	10.6	6.3	4.7	6.0	2.6	3.7
Na (ppm)	11.2	36.2	11.8	15.1	8.85	19.1	8.85	11.5	49.5	14.5	16.6	9.6	16.5	8.5
Ni (ppm)	0.125	0.050	0.072	0.080	0.155	0.125	0.190	0.130	0.060	0.095	0.067	0.155	0.095	0.205
Pb (ppm)	0.00	0.003	0.00	0.00	0.00	0.00	0.00	0.005	0.005	0.00	0.00	0.00	0.00	0.00
Sr (ppm)	0.650	0.637	0.175	0.170	0.180	0.405	0.100	0.815	0.997	0.162	0.235	0.160	0.300	0.125
Zn (ppm)	0.480	0.192	0.350	0.150	0.815	0.585	0.955	0.545	0.175	0.420	0.200	0.895	0.740	1.00

(Continued)

(Table 1, continued)

Element	Sample No. 3 (Depth in cm)							Sample No. 4 (Depth in cm)						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
Ag (ppm)	0.005	0.005	0.017	0.002	0.005	0.030	0.010	0.005	0.005	0.005	0.002	0.005	0.010	0.010
Au (ppm)	0.015	0.022	0.012	0.00	0.015	0.00	0.005	0.012	0.017	0.012	0.005	0.015	0.010	0.010
Ca (%)	1.45	1.40	0.54	0.47	0.40	0.45	0.83	1.15	1.40	0.33	0.45	0.56	0.45	1.00
Cl (ppm)	42.0	21.0	19.2	14.2	14.0	43.0	8.6	51.9	18.8	21.0	18.0	21.2	41.3	9.6
Cl* (ppm)	40.5	19.2	18.5	13.4	13.4	42.3	4.8	51.5	18.1	20.0	17.2	20.5	40.5	9.2
Co (ppm)	0.035	0.003	0.025	0.012	0.025	0.04	0.035	0.015	0.030	0.027	0.020	0.030	0.065	0.010
Cr (ppm)	0.220	0.077	0.085	0.172	0.095	0.020	0.275	0.137	0.087	0.105	0.167	0.095	0.25	0.380
Cu (ppm)	0.095	0.010	0.018	0.007	0.082	0.032	0.077	0.105	0.012	0.018	0.016	0.082	0.045	0.087
Fe (ppm)	130	30.5	35	25	30	51.5	36.5	129	28.5	44.0	51	34	45.5	74.0
K (ppm)	107	322	337	302	172	247	147	105	405	327	495	112	287	85
Mg (ppm)	67.5	87	57	40	52.5	52.5	65	90	67	47	70	40	60	60
Mn (ppm)	30.0	15.0	5.2	5.3	6.7	3.5	5.0	40.5	22.2	5.1	6.1	5.7	2.7	3.3
Na (ppm)	12.1	51.0	11.7	13.2	6.8	20.6	9.5	10.7	46	15.8	19.2	9.0	23	9.6
Ni (ppm)	0.095	0.057	0.060	0.070	0.125	0.105	0.180	0.100	0.047	0.090	0.080	0.185	0.140	0.320
Pb (ppm)	0.00	0.003	0.00	0.00	0.00	0.00	0.00	0.00	0.003	0.00	0.00	0.00	0.00	0.00
Sr (ppm)	0.775	0.602	0.305	0.330	0.270	0.835	0.150	0.185	0.527	0.170	0.225	0.220	0.390	0.085
Zn (ppm)	0.390	0.207	0.327	0.120	1.09	0.800	0.870	0.185	0.170	0.315	0.222	0.560	0.680	0.940

Element	Sample No. 5 (Depth in cm)							Sample No. 6 (Depth in cm)						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
Ag (ppm)	0.005	0.005	0.010	0.002	0.005	0.010	0.010	0.005	0.005	0.017	0.002	0.005	0.010	0.010
Au (ppm)	0.010	0.015	0.007	0.002	0.010	0.00	0.005	0.012	0.017	0.005	0.002	0.025	0.015	0.010
Ca (%)	1.65	1.42	0.45	0.47	0.47	0.45	0.85	1.99	1.40	0.39	0.51	0.48	0.38	0.85
Cl (ppm)	62.0	22.0	20.0	12.0	15.2	46.2	9.2	40.2	20.0	17.1	13.3	21.0	49.1	8.0
Cl* (ppm)	60.0	21.5	19.0	18.5	14.5	45.5	8.9	39.5	19.3	16.5	12.5	20.3	48.5	7.8
Co (ppm)	0.040	0.040	0.037	0.012	0.015	0.045	0.025	0.045	0.027	0.045	0.012	0.025	0.060	0.015
Cr (ppm)	0.218	0.100	0.075	0.125	0.100	0.010	0.200	0.200	0.097	0.112	0.145	0.105	0.090	0.265
Cu (ppm)	0.095	0.011	0.023	0.012	0.095	0.055	0.102	0.102	0.010	0.022	0.008	0.082	0.036	0.082
Fe (ppm)	114	37.5	37.5	29.5	28	35.5	35	181	25.5	40.0	22.0	25.0	60.0	46.5
K (ppm)	120	375	317	352	142	272	120	162	295	375	222	167	282	142
Mg (ppm)	62.5	65	55	52	45	47.5	47.5	80	72	50	35	48.5	42.5	65
Mn (ppm)	19	19.1	7.3	5.2	6.7	3.2	3.5	34	11.7	10.2	4.6	6.8	3.6	3.5
Na (ppm)	12.7	48.5	17.3	9.6	8.3	14.2	8.5	13.3	30	12.5	9.5	9.5	18.2	9.2
Ni (ppm)	0.130	0.060	0.077	0.075	0.145	0.095	0.225	0.125	0.050	0.087	0.077	0.155	0.090	0.205
Pb (ppm)	0.012	0.007	0.00	0.00	0.00	0.00	0.00	0.07	0.010	0.00	0.00	0.00	0.00	0.00
Sr (ppm)	0.675	0.470	0.237	0.205	0.175	0.325	0.105	0.765	0.582	0.225	0.222	0.190	0.765	0.120
Zn (ppm)	0.200	0.210	0.402	0.172	0.920	0.490	1.14	0.500	0.160	0.252	0.102	0.785	0.500	1.06

Element	Sample No. 7 (Depth in cm)							Sample No. 8 (Depth in cm)						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
Ag (ppm)	0.005	0.005	0.007	0.002	0.005	0.010	0.010	0.005	0.005	0.002	0.007	0.005	0.010	0.010
Au (ppm)	0.015	0.020	0.007	0.005	0.020	0.00	0.005	0.017	0.017	0.012	0.007	0.010	0.00	0.00
Ca (%)	2.00	1.40	0.50	0.48	0.48	0.45	2.85	2.23	1.42	0.54	0.40	0.52	0.45	1.00
Cl (ppm)	40.5	22.5	20.0	20.0	25.9	41.6	5.9	52.1	30.3	19.8	20.9	16.0	51.0	8.9
Cl* (ppm)	39.7	21.5	19.5	19.4	25.2	40.3	5.2	51.5	25.5	10.0	20.0	15.3	20.0	8.3
Co (ppm)	0.040	0.027	0.030	0.015	0.020	0.060	0.005	0.050	0.025	0.025	0.012	0.050	0.060	0.035
Cr (ppm)	0.205	0.122	0.175	0.152	0.90	0.015	0.245	0.202	0.082	0.085	0.127	0.080	0.005	0.210
Cu (ppm)	0.107	0.015	0.021	0.011	0.092	0.055	0.90	0.107	0.013	0.025	0.009	0.095	0.050	0.102
Fe (ppm)	230	35	36	30.5	21.5	25.5	29.5	146	25	32	13.5	19	23.5	40
K (ppm)	307	245	327	385	187	280	112	117	212	350	190	137	290	145

(Continued)

(Table 1, continued)

Mg (ppm)	67.5	90	45	55	52.5	55	45	95	75	55	27	40	47.5	62.5
Mn (ppm)	26	9.7	9.0	5.6	6.0	4.2	2.0	35.5	24.2	10.2	5.2	7.7	5.2	4.6
Na (ppm)	11.1	59.5	18.2	13.5	10.0	13.1	8.1	13.6	45	12.5	5.2	7.6	15.8	5.3
Ni (ppm)	0.145	0.047	0.080	0.080	0.190	0.090	0.280	0.130	0.062	0.092	0.095	0.225	0.105	0.305
Pb (ppm)	0.002	0.005	0.00	0.002	0.00	0.00	0.00	0.00	0.008	0.005	0.00	0.00	0.00	0.00
Sr (ppm)	0.805	1.0	0.152	0.180	0.170	0.270	0.095	0.815	1.030	0.142	0.165	0.140	0.430	0.065
Zn (ppm)	1.34	0.187	0.440	0.232	0.925	0.680	1.19	0.600	0.170	0.440	0.160	1.06	0.495	1.41

	Sample No. 9 (Depth in cm)							Sample No. 10 (Depth in cm)						
Element	a	b	c	d	e	f	g	a	b	c	d	e	f	g
Ag (ppm)	0.005	0.005	0.002	0.002	0.005	0.010	0.010	0.005	0.005	0.030	0.002	0.005	0.010	0.005
Au (ppm)	0.017	0.010	0.012	0.002	0.025	0.010	0.00	0.012	0.022	0.00	0.002	0.015	0.005	0.005
Ca (%)	1.92	1.42	0.45	0.45	0.47	0.38	0.90	1.69	1.40	0.45	0.45	0.50	0.45	1.00
Cl (ppm)	56.2	11.0	20.0	19.8	21.0	48.0	7.2	61.0	20.2	21.0	18.1	26.3	50.2	5.8
Cl* (ppm)	55.8	10.3	19.3	19.0	20.2	47.3	6.8	60.2	19.6	20.2	17.5	25.6	49.4	5.2
Co (ppm)	0.015	0.015	0.027	0.015	0.015	0.050	0.015	0.045	0.030	0.030	0.012	0.030	0.055	0.035
Cr (ppm)	0.230	0.075	0.067	0.122	0.070	0.015	0.180	0.237	0.145	0.075	0.137	0.095	0.005	0.245
Cu (ppm)	0.105	0.012	0.018	0.010	0.087	0.032	0.112	0.095	0.016	0.022	0.012	0.092	0.050	0.095
Fe (ppm)	181	30.5	44	17	21	39	30.5	121	41	50	25	18	32	36.5
K (ppm)	210	420	305	295	170	252	135	155	390	370	250	190	282	140
Mg (ppm)	65	95	67	47	45	57.5	47.5	75	87	62	37	47.5	52.5	45
Mn (ppm)	19.0	16.3	11.3	4.0	7.0	3.1	5.0	30.5	12.1	5.2	4.8	6.2	2.2	5.8
Na (ppm)	16.5	58	14.5	15.6	9.3	15.3	6.1	12.5	43	14.1	10.5	8.8	17.1	7.3
Ni (ppm)	0.125	0.060	0.080	0.085	0.180	0.135	0.205	0.195	0.050	0.057	0.090	0.165	0.130	0.210
Pb (ppm)	0.00	0.003	0.00	0.00	0.00	0.00	0.00	0.008	0.007	0.005	0.00	0.00	0.00	0.00
Sr (ppm)	0.920	0.487	0.165	0.195	0.170	0.420	0.050	0.650	0.660	0.232	0.225	0.180	0.360	0.100
Zn (ppm)	0.440	0.185	0.417	0.200	0.915	0.530	1.37	0.490	0.197	0.215	0.127	0.765	0.535	1.23

	Sample No. 11 (Depth in cm)							Sample No. 12 (Depth in cm)						
Element	a	b	c	d	e	f	g	a	b	c	d	e	f	g
Ag (ppm)	0.005	0.005	0.037	0.002	0.005	0.001	0.010	0.005	0.005	0.020	0.002	0.005	0.010	0.010
Au (ppm)	0.012	0.017	0.005	0.002	0.015	0.015	0.010	0.017	0.022	0.007	0.005	0.020	0.005	0.015
Ca (%)	1.44	1.45	0.54	0.48	0.47	0.29	0.76	1.62	1.42	0.54	0.56	0.47	0.40	0.85
Cl (ppm)	54.0	40.1	21.8	15.5	28.9	52.9	10.1	71.0	31.1	23.2	15.9	26.0	55.8	12.0
Cl* (ppm)	53.3	39.3	21.0	15.0	28.3	52.0	9.9	70.2	30.2	22.5	15.0	25.0	55.0	11.5
Co (ppm)	0.080	0.027	0.040	0.022	0.055	0.055	0.025	0.045	0.035	0.032	0.015	0.010	0.060	0.030
Cr (ppm)	0.205	0.097	0.105	0.147	0.060	0.085	0.220	0.195	0.055	0.215	0.150	0.070	0.010	0.230
Cu (ppm)	0.090	0.010	0.023	0.009	0.082	0.035	0.072	0.092	0.012	0.021	0.010	0.090	0.045	0.087
Fe (ppm)	187	31	45.5	19	11.5	46	23.5	148	40.0	59	36.5	14.5	22	22
K (ppm)	235	302	380	230	152	240	142	365	452	337	257	165	270	107
Mg (ppm)	67.5	67	75	47	47.5	62.5	52.5	52.5	105	52	32	42.5	52.5	45
Mn (ppm)	22.5	9.6	12.2	5.0	5.2	4.2	7.0	20.5	5.7	6.6	4.8	5.7	3.7	3.5
Na (ppm)	17.7	66.0	14.2	9.7	10.6	19.8	6.3	23.1	50.5	14.0	9.0	6.7	16.0	9.5
Ni (ppm)	0.110	0.040	0.090	0.082	0.175	0.095	0.275	0.105	0.057	0.082	0.077	0.165	0.140	0.290
Pb (ppm)	0.010	0.010	0.022	0.020	0.00	0.00	0.00	0.010	0.015	0.003	0.003	0.00	0.00	0.00
Sr (ppm)	0.840	0.472	0.205	0.187	0.1800.565		0.140	0.795	1.05	0.185	0.200	0.160	0.333	0.115
Zn (ppm)	0.420	0.165	0.375	0.155	0.855	0.480	0.710	0.410	0.385	0.747	0.172	0.825	0.595	1.29

	Sample No. 13 (Depth in cm)							Sample No. 14 (Depth in cm)						
Element	a	b	c	d	e	f	g	a	b	c	d	e	f	g
Ag (ppm)	0.005	0.005	0.002	0.002	0.005	0.010	0.010	0.005	0.005	0.005	0.007	0.005	0.010	0.010
Au (ppm)	0.015	0.025	0.010	0.002	0.020	0.015	0.010	0.010	0.022	0.010	0.002	0.015	0.010	0.005
Ca (%)	1.02	1.40	0.33	0.48	0.48	0.45	0.74	1.52	1.35	0.43	0.58	0.49	0.45	1.29

(Continued)

(Table 1, continued)

Cl (ppm)	61.0	25.1	26.2	14.0	30.0	45.1	13.9	72.0	33.2	29.0	19.6	31.0	56.0	13.5
Cl* (ppm)	60.3	24.4	25.5	13.4	28.4	53.3	13.4	71.2	32.5	28.4	19.0	30.2	55.5	12.8
Co (ppm)	0.050	0.030	0.035	0.022	0.015	0.060	0.025	0.075	0.032	0.030	0.027	0.030	0.055	0.030
Cr (ppm)	0.232	0.082	0.172	0.115	0.080	0.025	0.215	0.185	0.112	0.125	0.150	0.140	0.015	0.205
Cu (ppm)	0.085	0.010	0.017	0.007	0.077	0.035	0.080	0.092	0.011	0.016	0.009	0.009	0.040	0.085
Fe (ppm)	114	48	31	16.5	11	26.5	23.5	182	50.5	50.5	25.5	13	30	30
K (ppm)	142	370	292	247	197	225	152	130	327	337	250	172	282	115
Mg (ppm)	62.5	92	27	32	45	40	60	72.5	87	50	40	47.5	57.5	50
Mn (ppm)	15	5	5.3	4.8	6.2	2.7	3	25	19.7	10.1	6.1	6.7	4.5	3.6
Na (ppm)	10.6	33.5	13.6	7.0	10.2	13.6	7.8	19.7	36	13.8	8.1	9.6	11.8	10.0
Ni (ppm)	0.100	0.047	0.067	0.090	0.210	0.130	0.240	0.045	0.065	0.092	0.097	0.180	0.120	0.255
Pb (ppm)	0.007	0.010	0.002	0.002	0.00	0.00	0.00	0.010	0.007	0.003	0.002	0.00	0.00	0.00
Sr (ppm)	0.530	0.620	0.200	0.272	0.170	0.435	0.110	0.715	0.987	0.152	0.175	0.145	0.305	0.070
Zn (ppm)	0.335	0.110	0.307	0.140	0.785	0.455	1.41	0.360	0.197	0.250	0.160	0.940	0.610	1.36

	Sample No. 15 (Depth in cm)							Sample No. 16 (Depth in cm)						
Element	a	b	c	d	e	f	g	a	b	c	d	e	f	g
Ag (ppm)	0.005	0.005	0.012	0.002	0.005	0.010	0.010	0.005	0.005	0.007	0.002	0.005	0.010	0.010
Au (ppm)	0.012	0.010	0.007	0.002	0.010	0.005	0.010	0.007	0.015	0.005	0.002	0.005	0.000	0.005
Ca (%)	1.92	1.40	0.45	0.55	0.50	0.47	1.00	1.65	0.90	0.45	0.50	0.49	0.47	0.85
Cl (ppm)	74.0	40.5	28.9	21.8	28.5	50.0	13.5	64.0	40.5	26.0	18.2	30.0	52.0	12.9
Cl* (ppm)	73.3	36.9	28.3	21.0	27.9	49.5	13.2	63.5	39.1	25.5	17.5	29.3	51.2	12.3
Co (ppm)	0.065	0.027	0.027	0.017	0.025	0.070	0.025	0.055	0.030	0.030	0.022	0.025	0.065	0.030
Cr (ppm)	0.205	0.050	0.137	0.122	0.120	0.020	0.195	0.228	0.072	0.147	0.150	0.100	0.040	0.200
Cu (ppm)	0.100	0.009	0.021	0.011	0.085	0.040	0.090	0.095	0.010	0.023	0.008	0.080	0.040	0.085
Fe (ppm)	188	48.7	46.7	32.5	15	37.5	31.5	173	44.7	50	29.5	11	33	29.5
K (ppm)	167	337	362	287	200	277	135	185	387	297	352	162	297	140
Mg (ppm)	92.5	75	47	37	42.5	45	47.5	57.5	92	62	35	45	52.5	47.5
Mn (ppm)	18	12.7	9.3	4.8	6.2	4	5	18	18.2	7.7	5.6	7.0	3.7	4.1
Na (ppm)	14.6	45	14.1	9.8	7.8	19	9.3	17.7	43.5	13.5	7.3	11.6	15.1	9.3
Ni (ppm)	0.170	0.035	0.087	0.090	0.200	0.130	0.225	0.075	0.052	0.080	0.097	0.195	0.125	0.240
Pb (ppm)	0.010	0.002	0.004	0.002	0.00	0.00	0.00	0.010	0.007	0.002	0.002	0.00	0.00	0.00
Sr (ppm)	0.935	0.472	0.162	0.222	0.160	0.555	0.050	0.790	1.00	0.150	0.172	0.150	0.370	0.95
Zn (ppm)	0.410	0.287	0.540	0.160	0.860	0.525	0.990	0.445	0.120	0.400	0.160	0.945	0.690	0.930

	Mean (Depth in cm)							S.D. (Depth in cm)						
Element	a	b	c	d	e	f	g	a	b	c	d	e	f	g
Ag (ppm)	0.005	0.005	0.012	0.002	0.005	0.010	0.009	0.000	0.000	0.010	0.002	0.000	0.000	0.002
Au (ppm)	0.012	0.017	0.008	0.003	0.014	0.009	0.007	0.002	0.004	0.002	0.001	0.006	0.004	0.002
Ca (%)	1.65	1.37	0.46	0.48	0.48	0.42	0.90	0.31	0.12	0.07	0.04	0.03	0.04	0.13
Cl (ppm)	55.5	27.1	21.9	17.2	23.2	48.7	12.3	11.5	8.6	3.6	2.8	5.7	4.9	11.9
Cl* (ppm)	54.7	25.8	21.1	16.5	22.4	47.9	9.1	11.5	8.2	3.7	2.8	5.7	5.0	2.7
Co (ppm)	0.047	0.029	0.033	0.016	0.025	0.056	0.023	0.005	0.016	0.007	0.004	0.012	0.008	0.009
Cr (ppm)	0.205	0.089	0.113	0.142	0.094	0.025	0.231	0.023	0.024	0.044	0.016	0.020	0.025	0.047
Cu (ppm)	0.097	0.011	0.020	0.009	0.087	0.042	0.089	0.006	0.002	0.002	0.002	0.006	0.008	0.010
Fe (ppm)	156.6	36.1	43.3	27	20.8	38.2	35.4	33	8.4	7.4	9.0	7.8	11	12.3
K (ppm)	173.5	344	336	303	162	269	128	73	64	26	79	24	20	18
Mg (ppm)	70.3	81.9	55.5	43.9	45.4	51.7	52.5	13	12.4	7.9	12.7	3.6	6.3	7.5
Mn (ppm)	24.8	14.4	7.9	5.0	6.4	3.35	4.2	7.3	5.6	2.4	0.61	0.61	0.65	1.2
Na (ppm)	13.4	46.3	14.1	11.1	9.0	16.7	8.5	4.1	9.7	1.7	3.9	1.3	3.0	1.2
Ni (ppm)	0.119	0.052	0.080	0.083	0.175	0.115	0.240	0.035	0.008	0.011	0.009	0.025	0.018	0.042
Pb (ppm)	0.008	0.006	0.003	0.002	0.00	0.00	0.00	0.002	0.003	0.007	0.004	0.00	0.00	0.00
Sr (ppm)	0.726	0.724	0.188	0.211	0.176	0.442	0.098	0.177	0.237	0.043	0.042	0.031	0.162	0.029
Zn (ppm)	0.471	0.194	0.381	0.164	0.871	0.586	1.11	0.250	0.064	0.122	0.035	0.123	0.103	0.115

(Continued)

(Table 1, continued)

RESULTS OF TRACE ELEMENT CONCENTRATIONS IN LUPIN (GERF HUSSEIN AREA)

Element	Sample No. R.E. (Depth in cm) a	b	c	d	e	f	g
Ag (ppm)	0.000	0.000	0.025	0.011	0.000	0.000	0.011
Au (ppm)	0.011	0.15	0.011	0.008	0.019	0.020	0.012
Ca (%)	0.13	0.08	0.06	0.05	0.04	0.05	0.09
Cl (ppm)	0.84	0.73	0.47	0.41	0.59	0.55	0.86
Cl* (ppm)	0.84	0.70	0.48	0.41	0.59	0.55	0.41
Co (ppm)	0.017	0.031	0.020	0.015	0.027	0.022	0.023
Cr (ppm)	0.037	0.038	0.052	0.031	0.035	0.039	0.054
Cu (ppm)	0.019	0.011	0.011	0.011	0.019	0.022	0.025
Fe (ppm)	1.43	0.72	0.68	0.75	0.69	0.82	0.87
K (ppm)	2.13	2.0	1.27	2.22	1.22	1.11	1.06
Mg (ppm)	0.90	0.88	0.70	0.89	0.47	0.62	0.68
Mn (ppm)	0.67	0.59	0.38	0.19	0.19	0.20	0.27
Na (ppm)	0.50	0.77	0.32	0.49	0.28	0.43	0.27
Ni (ppm)	0.046	0.022	0.026	0.023	0.039	0.033	0.051
Pb (ppm)	0.012	0.013	0.031	0.023	0.00	0.00	0.00
Sr (ppm)	0.105	0.121	0.051	0.051	0.44	0.100	0.042
Zn (ppm)	0.125	0.063	0.087	0.046	0.087	0.080	0.115

* Determined by ion selective electrode a = leaves, b = stem, c = pods, d = pericarp, e = seeds, f = testa, g = cotyledon

TABLE 2. RESULTS OF TRACE ELEMENT CONCENTRATIONS IN SOIL SAMPLES OF LUPIN (GERF HUSSEIN AREA).

	Sample No. (Depth in cm)											
	1			2			3			4		
Element	10	30	60	10	30	60	10	30	60	10	30	60
Ag (ppm)	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Au (ppm)	0.00	0.00	0.02	0.00	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.00
Ca (%)	1.80	2.25	2.43	2.16	1.08	1.72	1.89	2.07	2.52	1.62	2.25	1.53
Cl (ppm)	1.29	1.16	1.07	1.36	1.08	1.49	1.30	1.12	1.59	1.39	0.92	1.47
Cl* (ppm)	1.22	1.11	0.99	1.35	1.00	1.45	1.26	1.08	1.58	1.32	0.89	1.45
Co (ppm)	0.04	0.03	0.05	0.07	0.03	0.05	0.04	0.09	0.03	0.06	0.05	0.08
Cr (ppm)	0.47	0.37	0.45	0.29	0.42	0.45	0.48	0.34	0.46	0.38	0.80	0.62
Cu (ppm)	0.10	0.09	0.10	0.09	0.09	0.10	0.10	0.10	0.12	0.10	0.11	0.12
Fe (ppm)	346	478	477	299	333	461	287	338	443	292	466	478
K (ppm)	31.5	64.0	51.5	38.5	46.0	63.5	38.5	52.0	54.5	23.0	53.0	52.5
Mg (ppm)	68.0	55.5	103	58.5	47.0	64.0	73.0	52.5	48.0	55.5	105	92.5
Mn (ppm)	1.95	2.11	2.53	1.77	1.83	2.20	1.91	2.29	2.15	1.51	2.92	2.17
Na (ppm)	20.5	19.0	18.0	22.5	19.5	20.5	12.5	8.5	9.5	21.0	19.0	18.5
Ni (ppm)	0.27	0.30	0.36	0.31	0.35	0.39	0.38	0.31	0.36	0.30	0.41	0.44
Pb (ppm)	0.11	0.00	0.04	0.02	0.01	0.02	0.01	0.04	0.05	0.05	0.08	0.05
Sr (ppm)	0.13	0.06	0.07	0.10	0.07	0.08	0.13	0.12	0.17	0.15	0.13	0.11
Zn (ppm)	0.18	0.21	0.22	0.15	0.12	0.20	0.15	0.24	0.22	0.14	0.20	0.15

	Sample No. (Depth in cm)											
	5			6			7			8		
Element	10	30	60	10	30	60	10	30	60	10	30	60
Ag (ppm)	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.00
Au (ppm)	0.01	0.00	0.00	0.02	0.00	0.01	0.00	0.02	0.06	0.00	0.02	0.03
Ca (%)	2.13	0.63	1.08	2.07	0.99	1.44	2.25	1.08	1.71	2.25	1.17	0.72
Cl (ppm)	1.41	1.08	1.49	0.98	0.91	0.85	1.20	1.08	1.31	1.01	0.89	1.19
Cl* (ppm)	1.37	0.99	1.42	0.92	0.85	0.79	1.15	0.99	1.24	0.95	0.83	1.13

(Continued)

(Table 2, continued)

Co (ppm)	0.09	0.06	0.09	0.12	0.13	0.06	0.06	0.08	0.11	0.09	0.07	0.08
Cr (ppm)	0.35	0.20	0.44	0.64	0.13	0.20	0.12	0.21	0.25	0.07	0.16	0.13
Cu (ppm)	0.10	0.10	0.09	0.14	0.10	0.09	0.09	0.15	0.16	0.11	0.08	0.10
Fe (ppm)	282	331	444	343	304	458	373	292	257	257	286	323
K (ppm)	26.0	41.0	46.0	23.0	52.5	54.5	37.5	45.5	62.0	40.5	45.5	52.5
Mg (ppm)	61.0	42.5	81.0	57.5	48.0	65.5	70.0	48.5	47.5	53.0	46.0	48.0
Mn (ppm)	1.88	1.11	1.28	1.80	2.02	2.19	1.98	1.83	3.21	1.49	1.70	1.97
Na (ppm)	17.5	15.5	13.5	12.5	11.0	11.5	10.5	8.5	11.0	10.0	3.5	4.0
Ni (ppm)	0.32	0.26	0.31	0.32	0.16	0.26	0.22	0.20	0.23	0.17	0.19	0.21
Pb (ppm)	0.08	0.05	0.09	0.08	0.08	0.14	0.14	0.07	0.06	0.05	0.07	0.06
Sr (ppm)	0.17	0.06	0.12	0.16	0.19	0.17	0.11	0.07	0.17	0.16	0.12	0.08
Zn (ppm)	0.14	0.08	0.12	0.15	0.13	0.16	0.15	0.18	0.26	0.13	0.11	0.05

	Sample No. (Depth in cm)											
	9			10			11			12		
Element	10	30	60	10	30	60	10	30	60	10	30	60
Ag (ppm)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.02	0.00	0.02	0.03
Au (ppm)	0.00	0.01	0.01	0.00	0.03	0.03	0.02	0.00	0.00	0.01	0.02	0.00
Ca (%)	2.43	1.26	0.90	1.26	1.53	2.61	0.90	1.62	2.43	1.80	0.45	2.43
Cl (ppm)	1.08	0.91	0.88	1.29	1.08	1.39	0.75	0.92	0.82	0.92	0.80	1.31
Cl* (ppm)	0.99	0.85	0.80	1.21	1.00	1.35	0.67	0.85	0.75	0.89	0.72	1.25
Co (ppm)	0.03	0.04	0.02	0.05	0.03	0.06	0.03	0.04	0.03	0.03	0.05	0.06
Cr (ppm)	0.08	0.11	0.06	0.18	0.11	0.16	0.08	0.11	0.26	0.10	0.06	0.30
Cu (ppm)	0.10	0.10	0.08	0.11	0.10	0.09	0.09	0.09	0.11	0.11	0.10	0.11
Fe (ppm)	275	287	404	292	303	394	289	296	390	291	251	413
K (ppm)	33.5	12.0	43.5	26.5	56.0	46.5	55.5	38.5	44.5	30.0	17.5	40.5
Mg (ppm)	58.5	103	92.5	55.5	46.5	48.0	54.5	52.0	79.0	59.0	42.5	92.0
Mn (ppm)	1.33	1.21	1.27	2.17	1.69	1.65	1.62	1.83	2.05	1.74	1.46	1.93
Na (ppm)	12.0	10.5	8.0	15.0	13.0	12.0	7.5	5.5	5.0	7.0	3.5	6.5
Ni (ppm)	0.18	0.22	0.20	0.22	0.24	0.18	0.20	0.20	0.26	0.22	0.20	0.26
Pb (ppm)	0.08	0.07	0.05	0.06	0.08	0.10	0.15	0.08	0.07	0.08	0.14	0.14
Sr (ppm)	0.10	0.12	0.08	0.09	0.11	0.16	0.13	0.11	0.14	0.12	0.06	0.17
Zn (ppm)	0.14	0.09	0.08	0.08	0.08	0.07	0.07	0.05	0.09	0.24	0.05	0.17

	Sample No. (Depth in cm)											
	13			14			15			16		
Element	10	30	60	10	30	60	10	30	60	10	30	60
Ag (ppm)	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Au (ppm)	0.01	0.00	0.03	0.02	0.06	0.04	0.03	0.06	0.02	0.04	0.03	0.02
Ca (%)	1.26	1.62	2.70	1.44	1.98	0.72	0.90	1.08	2.16	0.45	0.81	1.98
Cl (ppm)	0.91	1.38	1.19	0.99	1.29	1.19	1.30	1.19	1.53	1.36	1.15	1.45
Cl* (ppm)	0.85	1.32	1.13	0.90	1.25	1.16	1.25	1.12	1.55	1.30	1.09	1.41
Co (ppm)	0.01	0.03	0.02	0.07	0.08	0.06	0.05	0.04	0.08	0.03	0.08	0.06
Cr (ppm)	0.19	0.15	0.18	0.14	0.10	0.12	0.12	0.22	0.19	0.12	0.10	0.13
Cu (ppm)	0.13	0.07	0.11	0.09	0.10	0.12	0.10	0.12	0.11	0.10	0.10	0.08
Fe (ppm)	317	159	289	294	281	395	324	297	387	288	243	394
K (ppm)	31.5	10.0	26.5	37.5	21.5	32.5	26.0	51.5	56.0	44.0	21.5	31.0
Mg (ppm)	53.9	29.0	61.0	56.3	43.0	73.0	61.0	103	87.0	51.0	41.0	57.5
Mn (ppm)	1.53	0.86	1.57	1.29	1.51	1.98	1.62	2.46	1.76	1.74	1.54	1.33
Na (ppm)	7.5	6.5	8.5	7.0	4.5	4.0	7.5	5.5	3.5	8.5	6.0	8.0
Ni (ppm)	0.22	0.16	0.23	0.20	0.18	0.22	0.19	0.24	0.18	0.20	0.21	0.22
Pb (ppm)	0.08	0.05	0.11	0.07	0.03	0.07	0.09	0.06	0.07	0.12	0.06	0.07
Sr (ppm)	0.12	0.10	0.19	0.13	0.14	0.18	0.11	0.13	0.11	0.09	0.07	0.13
Zn (ppm)	0.24	0.02	0.14	0.04	0.06	0.14	0.16	0.26	0.29	0.19	0.08	0.04

(Continued)

(Table 2, continued)

	Sample No. (Depth in cm)								
	Mean			S.D.			R.E.		
Element	10	30	60	10	30	60	10	30	60
Ag (ppm)	0.026	0.025	0.026	0.006	0.006	0.005	0.02	0.02	0.018
Au (ppm)	0.018	0.026	0.025	0.010	0.018	0.015	0.03	0.04	0.03
Ca (%)	1.67	1.36	1.81	0.59	0.56	0.69	0.25	0.19	0.25
Cl (ppm)	1.15	1.06	1.26	0.20	0.15	0.25	0.11	0.07	0.19
Cl* (ppm)	1.10	1.10	1.21	0.21	0.16	0.26	0.10	0.08	0.10
Co (ppm)	0.054	0.058	0.058	0.028	0.028	0.025	0.041	0.041	0.039
Cr (ppm)	0.24	0.22	0.27	0.17	0.18	0.16	0.103	0.106	0.100
Cu (ppm)	0.103	0.103	0.106	0.014	0.017	0.019	0.026	0.032	0.034
Fe (ppm)	303	309	398	29.9	76.5	62.4	1.36	2.18	1.28
K (ppm)	34.4	39.2	47.9	11.8	17.1	10.8	0.85	1.03	0.82
Mg (ppm)	59.1	56.5	71.2	6.2	24.1	18.8	0.62	1.22	1.08
Mn (ppm)	1.71	1.77	1.95	0.24	0.52	0.49	0.12	0.18	0.17
Na (ppm)	12.4	9.9	10.1	5.3	5.6	5.3	0.57	0.59	0.57
Ni (ppm)	0.24	0.23	0.26	0.06	0.07	0.07	0.06	0.066	0.066
Pb (ppm)	0.079	0.064	0.074	0.038	0.029	0.033	0.048	0.043	0.045
Sr (ppm)	0.125	0.103	0.233	0.025	0.036	0.040	0.039	0.047	0.050
Zn (ppm)	0.15	0.12	0.14	0.05	0.07	0.07	0.055	0.066	0.066

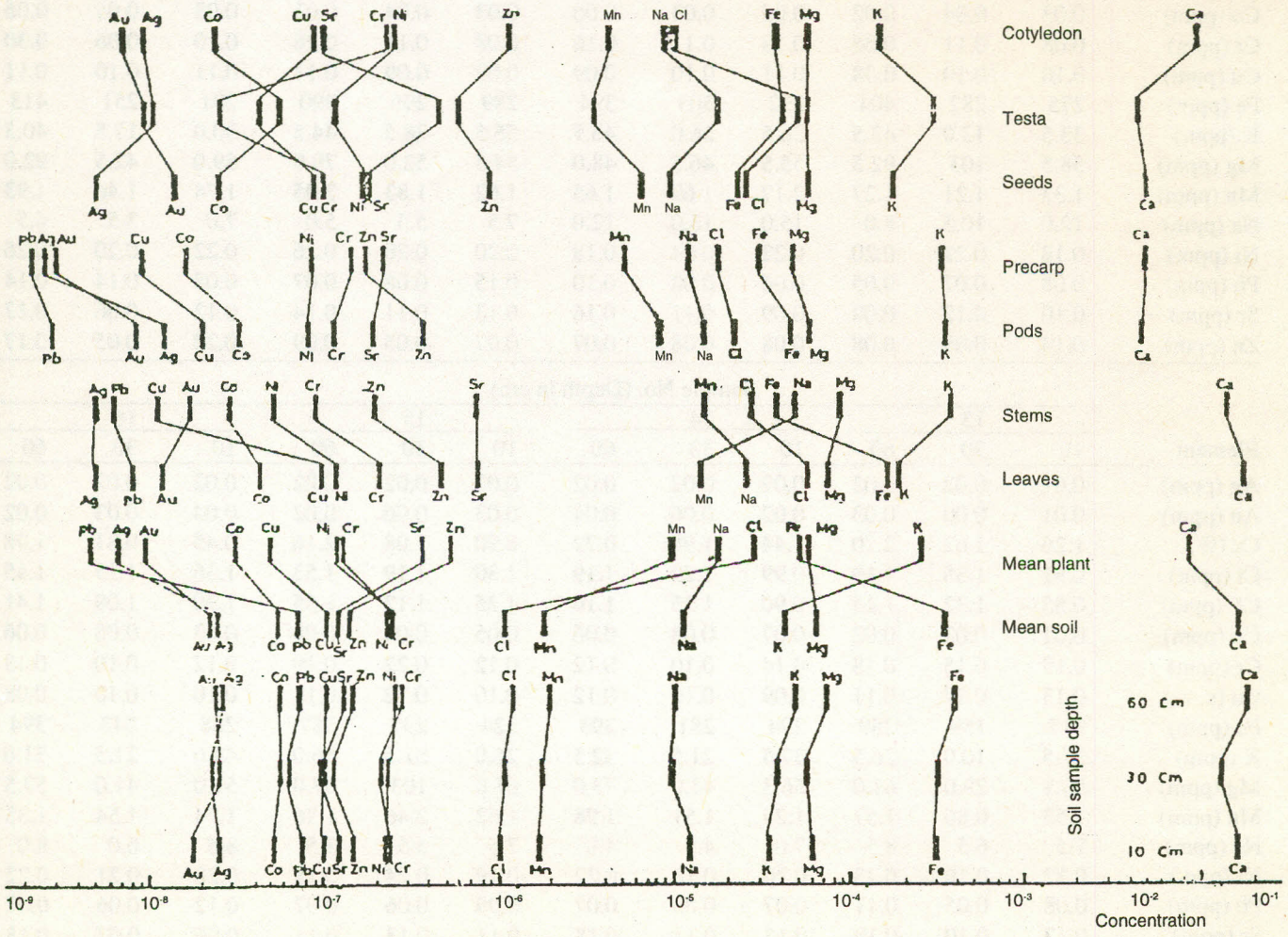

Fig. 1. Relationship between trace elements concentration in lupin (leaves, stems, pods, pericarp, seeds, testa and cotyledon) planted in Gerf Hussein and in Gerf Hussein soil samples.

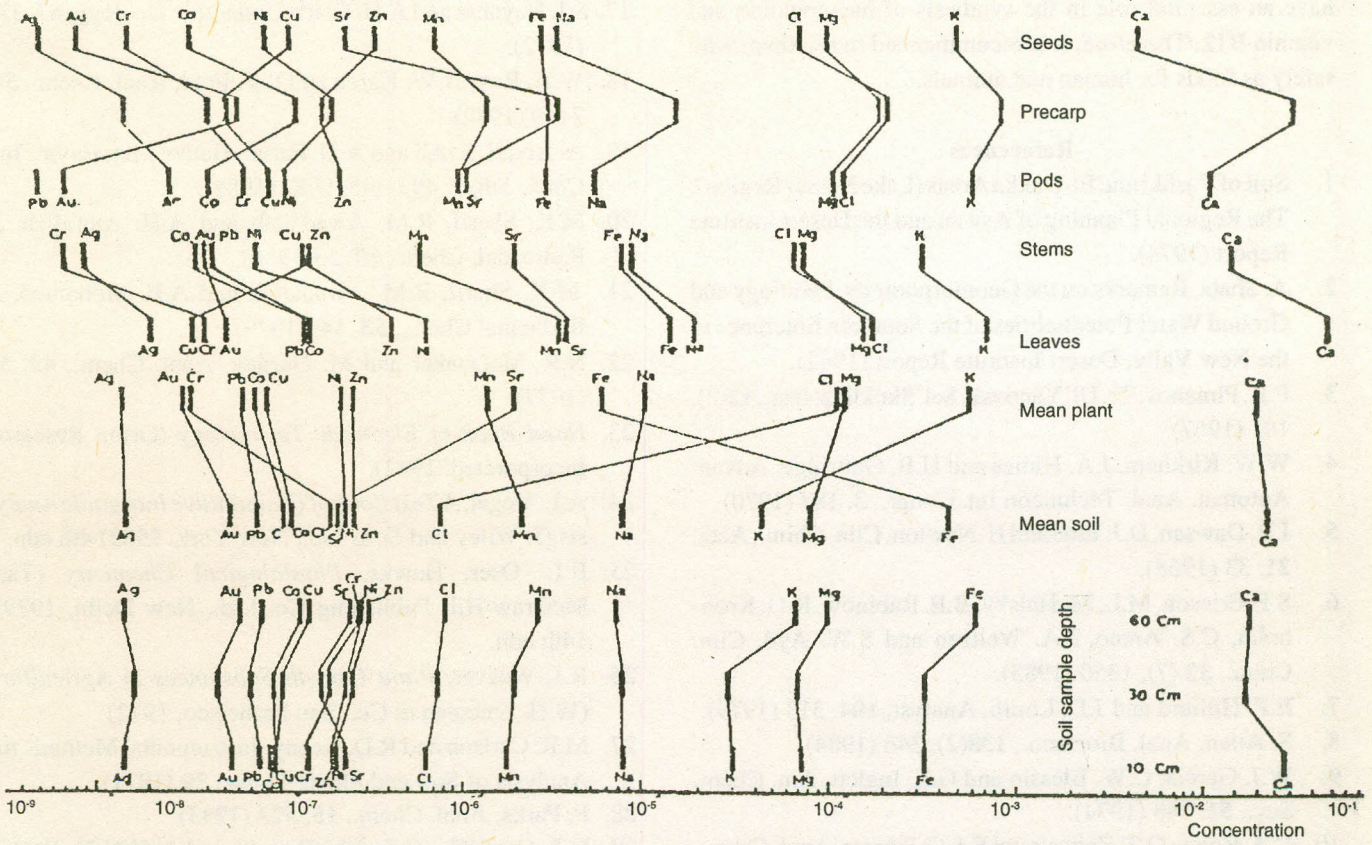

Fig. 2. The relationship between trace elements concentration in fenugreek (leaves, stems, pod, pericarp and seeds) planted in Gerf Hussein and in Gerf Hussein soil samples.

higher concentrations of K (260-1027), Cl(59-157), Ca (0,39-4.14), Mg(63-163), Cu(0.035-0.136), Ni (0.052-0.242) and Ag (0.005-0.025) ppm than lupin. This may be attributed to the variable rate of preferential selective uptake of external soil solutions and to differentiation in botanic textures and structures of the crops. K is an essential nutrient element and has an important role in the synthesis of amino acids and proteins from ammonium ions [22] as it activates the enzymatic reactions of carbohydrates metabolism. The observed high chloride concentration may be ascribed to the ability of fenugreek to exchange chloride for the anions such as bicarbonate. Chloride is an essential element for plant growth, root formation and photosynthesis [28]. The observed high calcium concentration is in agreement with the results for K, Mg and Cl. Calcium is an essential constituent of the middle lamellae of the cell walls and it activates a number of enzymes [22]. Its deficiency results in the accumulation of starch in leaves, destruction of meristematic regions and hookening of young leaves [29]. Magnesium plays a significant role in nucleic acids synthesis and acts as a binding agent in the ribosomal particles [22,26]. The high percentage of copper and nickel in fenugreek as compared to lupin may be due to the differences in chemical and biological compositions of these plants. Copper is a constituent of ascorbic acid oxidase, lactose and tyrosinose [30,31]. Nickel is a co-activator element and plays a role in pigmentation and colouration of plants [30]. Silver is known to be essential for plants and scattered in trace amounts through various tissues and it has a unique metabolism, probably binding to SH groups in proteins [25].

High concentrations of Na (8.5 - 46.8), Mn (3.35 - 24.8), Fe (20.8 - 156.6) and Cr (0.025 - 0.321) ppm in lupin were detected. This may be due to a high requirement of Na for daily lupin physiological functions. Sodium has a catalytic effect on enzyme activity and is necessary for glycolysis [22,27]. Increase of Mn in lupin as compared to fenugreek may be related to its preferential and selective absorption where the colour, taste and smell are attributed to the presence of Mn [32,33]. Moreover, Mn serves as a metal co-factor and enzyme activator [22,29,34]. Its deficiency causes a disorganisation and disintegration of lamellae [22]. Iron is important for erythrocytes as haemoglobin and haemation in blood and for ferrodoxin nitrate reductase [27,30]. The higher accumulation of chromium in lupin than in fenugreek is related to their different macromolecular weights, chemical and biological compositions. Cr increases glucose tolerance and has a vital function for lipid and co-factor and activates several enzymes [35].

The conclusion is that Gref Hussein soil is suitable for cultivation. The detected trace elements in fenugreek and lupin

have an essential role in the synthesis of haemoglobin and vitamin B12. Therefore, it is recommended to use them with safety as foods for human and animals.

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