Journal of Agri-Food and Applied Sciences
Available online at jaas.blue-ap.org
©2014 JAAS Journal. Vol. 2(3), pp. 60-66, 31 March, 2014
E-ISSN: 2311-6730

Combined effect of iron and wheat genotype on seedling tissue concentration of Fe, Zn, Cu and Mn

Sadullah N AL-NIEMI[1*] Mohammed Sedqi S DOHUKI[2] AND Suzan Salih BARWARY[2]

1-University of Mosul, College of Agriculture and Forestry, Department of Soil and Water Sciences, MOSUL, Iraq
2-University of Dohuk, College of Agriculture, Department of Soil Sciences and Water, DOHUK, Iraq

Corresponding Author: Sadullah N. AL-NIEMI

Received: 25 February, 2014 *Accepted: 10 March, 2014* *Published: 31 March, 2014*

ABSTRACT

Seeds of 15 wheat genotypes were sieved and separated to two seed size groups (seed retained on 4 mm mesh and retained on 2.8 mm mesh). In the lathhouse study the seeds of the 15 wheat genotypes were grown under factorial combination of four levels of Fe treatment and two seed size groups in order to investigate the combined effect of iron and wheat (*Triticum aestivum* L.)genotype on Fe, Zn, Cu and Mn by measuring the concentration of these micronutrients in wheat seedling plants grown in calcareous soil containing different amount of Fe under lathhouse conditions. Our finding revealed that the application of Fe increased the concentration of Fe in root and shoot of wheat seedling, and generally decreased the concentrations of Zn, Cu and Mn especially with the higher level of Fe applied.

Keywords: *seedling, variety, wheat, micronutrient, concentration iron*.

INTRODUCTION

Many of the micronutrients are required in exceedingly small amounts, but this does not reflect in any way the importance of the element to growth, survival and reproductive success of the plant (Reid, 2001). They are largely function in plant–enzyme systems. The factors that determine the amounts of micronutrients available to plants are closely related to soil conditions and plant species and varieties (Mengel and Kirkby,2001). Changing the level of one nutrient in the soil will often affect the uptake or transport within the plant of another nutrient. Assessment of nutrient interactions should include the relationship between nutrient supply in the soil and nutrient concentrations in plant tissue (Bierman and Rosen, 2005). The Fe-deficient tolerant plant genotypes have the ability to uptake sufficient Fe from calcareous soils and thus less reduction in their growth will happen under Fe deficient condition compared with Fe-deficient sensitive genotypes. (Gourley, 1994; Marschner, 1995). In cereal, particularly bread wheat, a wide range of genotypic variation in response to Fe deficiency has been reported (Khoshgoftarmanesh, 2010; Marschner, 1995).

Competition between ions can develop especially for those with the same physical (electrical charge and ion diameter) and chemical properties (chemical valance). The relations can be antagonistic where one ion decreasing the availability of another ion or synergistic where one ion is increasing the availability of another ion. High levels of iron compounds in soil are known to greatly decrease trace metal uptake (Mengel and Kirkby,2001). Most micronutrient research has focused on dicotyledonous crops, such as soybean and the information about the effect of Fe and Zn on monocotyledonous crops, especially wheat, is limited (Ai-Qing, 2011). This experiment investigated the combined effect of iron and wheat (Triticum aestivum L.) genotype on Fe, Zn, Cu and Mn concentration in wheat seedling grown in calcareous soil containing different amount of Fe under lathhouse conditions.

MATERIALS AND METHODS

Soil collection and analysis

Soil was collected from the surface 15 cm. of the field experiment station soil at the College of Agriculture of Dohuk University, Northern Iraq. The soil was air-dried, passed through a 4-mm sieve and was analyzed for pH, $CaCO_3$, Organic matter, and soil texture using standard procedures (Page,1982). Plant available concentration of Fe in soil was determined also according to the method stated by (Tandon,1999), by extraction with DTPA (diethylene triamine penta acetic acid) using a soil: solution ratio of 1:2 and shaking time of two hours. Micronutrient extracted was determined by atomic absorption spectrophotometer. Seed of each of 15 wheat genotypes which brought from Syria – ICARDA was sieved and separated to two seed size groups [retained on 4.0 mm mesh (group I), passed through a 4.0 mm mesh and retained on 2.8 mm mesh (group II)].

Sowing and Watering

PVC pots (length=10.5cm, width= 12 cm) were filled with 500g air – dry soil and fertilized with 0.0, 0.2, 0.4, 0,8 mg Fe kg^{-1} air- dried soil applied as $FeSO_4$ $7H_2O$. Eight seeds from each group size were sown in each pot and distilled water was added in amounts sufficient to bring soil water content to 75% of soil field capacity. Soil moisture content were kept at 75% of field capacity during the period of the experiment . Time of watering plants was determined by weighing the pots daily and adding water to obtain the original wet weight (75% of field capacity). After germination plants were thinned to 4 plants per pot, and after 45 days from sowing plants were harvested.

Plant harvest

At harvest time the soil was washed off root under running tap water. Both roots and shoots were separated gently and immediately weighted to obtain fresh weights of roots and shoots of plants in each pot. Plant samples were placed in paper bags and dried at 70 ˚C for 48 hours. The dry weights of both roots and shoots were then obtained.

Statistical analysis

A factorial experiment with three factors (15 genotypes X4 Fe fertilization rates X 2 seed sizes) and 3 replicates were used. The data were analyzed by analysis of variance and significance of differences between means was evaluated by the adjusted least significant difference test (Adj. LSD).

RESULTS AND DISCUSSION

Physicochemical characteristic of soil

Various physical and chemical properties of soil are presented in table 1. Soil had high pH (8.06) and was calcareous, which contain more than 20% $CaCO_3$. The organic matter content was 1.60%. Soil had a clay texture, where the clay fraction was higher than the sum of both sand and clay fractions. In soil sample concentration of DTPA-extractable Fe was 2.80 mg kg^{-1} which was less than the adequate amount of Fe in calcareous soils (4 mg kg^{-1}) as stated by Soltanpour and Schwab (1977), and it was marginal with the critical level for calcareous soils (2.5 mg kg^{-1}) obtained by (Sims and Johnson, 1991). The high pH and the high concentrations of $CaCO_3$ and clay in soil together with low annual precipitation can be considered to be the major factors causing Fe deficiency in plant grown in the north part of Iraq. Fe moves to plant root in soils is limited largely by diffusion in the soil solution (O'Connor, 1971, Chaney, 1984, Marschner, 1993), and thus absorption is highly dependent on soil water status and root growth (Mengel and Kirkby, 2001). Iron nutrition of plants is often threatened in arid soils having low plant available concentration of Fe. Diffusion of micronutrients in soil is also greatly affected by soil pH. In calcareous soils, diffusion coefficient for micronutrients is lower than in acid soils (Melton, 1973). O'Connor, (1971) stated that at neutral to basic soil pH, inorganic Fe levels available for transport to the plant roots by both mass flow and diffusion are below plant requirements. Fe^{2+} decreases in solubility 100-fold for every unit increase in pH (Crowley, 1987).

Table 1. Physicochemical properties of top soil sample (0-30) cm

pH	8.06
Total $CaCO_3$ (%)	20.20
Organic matter (%)	1.6
Available Fe (ppm)	2.80
Sand (g kg^{-1})	149.0
Silt (g kg^{-1})	155.0
Clay (g kg^{-1})	596.0
Soil texture	clay
Moisture at Field capacity	31.68

Micronutrients uptake and interaction

As expected, Fe supply increased Fe concentration in wheat seedling. Root –Fe concentrations were 40.99, 29.92 and 25.69% higher (Table 2) and shoot concentrations were 49.14, 28.84 and 19.03% higher (Table 3) in the Fe 0.8 treatments compared to Fe 0.0, 0.2, 0.4 treatments respectively. Iron was supplied directly to the soil as $FeSO_4.7H_2O$ to set up different Fe levels. The concentration in roots and shoots of wheat seedling seemed to reflect total supply of iron more than any other factor (Langdale, 1973, Al-Ali 1996; Chany, 1982).

Iron supply generally decreased Zn, Cu and Mn concentrations in both roots and shoots of wheat seedling (Tables 4-9). Iron supply significantly decreased wheat Zn concentrations. Root Zn concentrations were 3.46, 15.88 and 15.71 lower (Table 4) and shoot concentrations were 0.0, 0.0 and 7.92% lower (Table 5) in the Fe 0.2, 0.4, 0.8 treatments as compared to Fe 0.0 treatments. Our results showed that Fe interfered with Zn uptake and translocation (but only when Fe concentration was high). The possible mechanisms for this antagonism could be competition between Fe and Zn during uptake (Kabata-Pendias, 2001) and translocation (Alloway, 2008). This results is not in accordance completely with the report of Alloway (2008) who found that Fe interfered with Zn translocation only.

The application of high levels of Fe to soil (0.4 and 0.8 treatments) reduced the Cu concentrations in roots of wheat seedling (Table 6) and the magnitude of reduction was 1.88 % with the application of 0.4 mg kg^{-1} of Fe and was 15.39% with the application of 0.8 mg kg^{-1} of Fe to soil. Shoot- Cu concentrations (Table 7) were 27.40, 33.56 and 17.82% lower in the Fe 0.8, 0.4, 0.2 treatments compared to the Fe0.0 treatments. High levels of iron in soil are known to greatly decrease Cu uptake (Kabata–Pendias, 2001).

The concentration of Mn in root and shoot was higher at 0.0 level of Fe and decreased with increasing the amount of Fe applied to the soil (Table 8, 9). Root–Mn concentrations were 18.60, 5.74 and 4.37% lower in the Fe 0.8, 0.4, 0.2 treatments compared to the Fe 0.0 treatments (Table 8) and Shoot–Mn concentrations were 16.48, 6.74 and 7.30% lower in the Fe 0.8, 0.4, 0.2 treatments compared to the Fe 0.0 treatments (Table 9). Similar results were found by Ai-Qing, (2011), who stated that iron supply generally reduced wheat Mn concentrations especially in leaves, and Mn concentrations were negatively correlated with root and leaf–Fe concentrations.

The results of our study revealed that the effect of Fe supply on wheat tissue Fe, Zn, Cu and Mn concentrations varied in their distribution within seedling parts. Root – Fe, Zn and Mn concentration generally were about as much as their concentrations in shoots of wheat seedling (Tables 2, 4 and 8), where as the root – Cu concentrations were 9.3, 13.3, 13.8 and 10.9 times greater than its concentration in shoots under the effect of Fe 0.0, 0.2, 0.4, 0.8 treatments respectively.

Our finding opined that roots of the 15 genotypes contained higher concentration of Cu as compared to shoots. These results could be related to strongly bounded divalent copper ion to plant roots which are the sites of preferential copper accumulation, and Cu is easily replace other ions at root cation exchange sites, also Cu tends to accumulate in the root tissue with little translocated to shoots (Marschner, 1995). Our results support the findings of Al – Niemi and Al – Ali (2010).

Table 2. Iron concentration in the roots of the 15 wheat genotypes

Genotypes		Abo-Ghrab	IPA99	Doma/1	Sham/8	Bohath/4	Bohath/6	Bohath/7	Acsad/65	Sham/3	Tikrafar/3	Karoukh	Zebra/5	Haama/14	Adil/3	Pasha/29	Interaction effect between (Fe &seed size)	Effect of seed size	Effect of Fe
seed size	Fe level																		
large	0	274.27	475.67	207.27	209.00	445.83	392.67	233.27	338.77	414.50	313.00	193.00	415.00	696.27	431.50	218.27	350.55		
	0.2	716.00	191.27	377.50	379.50	263.83	374.33	260.00	341.17	315.00	771.17	521.00	328.50	334.50	453.33	272.00	393.27		
	0.4	360.17	278.00	277.50	357.50	348.00	335.83	449.77	653.67	457.33	294.33	276.00	358.83	517.83	417.00	282.83	377.64		
	0.8	550.67	318.83	370.50	260.83	379.50	466.00	536.83	856.50	464.67	452.33	468.00	458.67	576.17	350.50	220.83	448.72		
Small	0	446.766	324.33	451.50	285.77	436.27	381.00	361.50	334.50	385.00	223.00	191.00	540.33	391.00	267.50	461.50	365.40		
	0.2	271.00	417.67	250.50	424.00	709.83	210.83	408.27	341.00	596.83	254.77	500.83	292.67	567.67	223.50	285.33	383.65		
	0.4	211.77	255.00	321.27	240.50	543.33	611.67	371.50	652.00	247.33	412.77	483.83	697.50	341.33	614.00	378.00	425.45		
	0.8	375.00	507.67	578.00	489.17	508.67	631.67	469.17	833.50	456.77	563.17	567.17	678.50	513.50	616.50	621.67	560.67		
Interaction effect between Genotype, &seed size	large	475.28	315.94	308.19	301.71	359.29	392.21	369.97	547.53	412.88	457.71	364.50	390.25	531.19	413.08	248.48		392.55	
	Small	326.13	376.17	400.32	359.86	549.53	458.79	402.61	540.25	421.48	363.43	435.71	552.25	453.38	430.38	436.63		433.79	
Interaction effect between Genotype& Fe	0	360.52	400.00	329.38	247.38	441.05	386.83	297.38	336.63	399.75	268.00	192.00	477.67	543.63	349.50	339.88			357.97
	0.2	493.50	304.47	314.00	401.75	486.83	292.58	334.13	341.08	455.92	512.97	510.92	310.58	451.08	338.42	278.67			388.46
	0.4	285.97	266.50	299.38	299.00	445.67	473.75	410.63	652.83	352.33	353.55	379.92	528.17	429.58	515.50	330.42			401.55
	0.8	462.83	413.25	474.25	375.00	444.08	548.83	503.00	845.00	460.72	507.75	517.58	568.58	544.83	483.50	421.25			504.70
Effect of Genotype		400.70	346.05	354.25	330.78	454.41	425.50	386.29	543.89	417.18	410.57	400.10	471.25	492.28	421.73	342.55			

LSD for Gen. = 116.39 Seed size= 42.5 Fe=60.105 Gen. x Seed size=164.6 Gen. x Fe= 232.78 Seed size x Fe= 85.001 Gen. x Seed size x Fe=329.21

Table 3. Iron concentration in the shoot of the 15 wheat genotypes

Genotypes		Abo-Ghraib	IPA/99	Doma/1	Sham/8	Bohuth/4	Bohuth/6	Bohuth/7	Acsad/65	Sham/3	Tikrafar/3	Karoniah	Zebba/5	Haama/14	Adil/3	Paska/29	Interaction effect between (Fe &seed size)	Effect of seed size	Effect of Fe
seed size	Fe level																		
large	0	106.00	138.00	220.77	130.33	307.50	125.77	357.67	130.77	396.00	167.00	320.27	203.77	242.27	122.00	223.27	212.76		
	0.2	195.27	266.17	212.67	128.77	214.00	222.17	219.00	104.77	308.50	268.50	291.27	204.77	238.33	161.50	555.17	239.39		
	0.4	329.00	272.67	305.00	185.67	229.50	154.17	242.50	390.50	152.17	166.00	422.17	172.50	168.67	155.33	543.00	259.26		
	0.8	336.33	327.50	144.50	303.17	903.17	260.50	552.00	198.33	377.77	236.17	437.50	218.67	141.33	249.17	698.00	358.94		
Small	0	93.67	111.77	174.27	117.77	162.50	108.50	112.00	177.27	324.00	333.33	573.77	110.50	166.27	188.00	456.27	213.99		
	0.2	309.00	113.83	613.00	215.83	274.00	123.50	401.00	175.00	157.50	214.33	258.33	462.77	131.00	110.17	376.17	262.36		
	0.4	197.00	235.00	208.33	332.00	218.50	223.67	251.00	108.50	508.10	448.33	140.00	461.17	149.50	239.83	410.33	275.42		
	0.8	303.50	323.50	174.83	161.67	227.50	145.83	208.50	219.17	313.50	478.83	352.83	473.50	177.00	180.00	422.00	277.48		
Interaction effect between Genotype, &seed size	large	241.65	251.08	220.73	186.98	413.54	190.65	342.79	206.09	308.61	209.42	367.80	199.93	197.65	172.00	504.86		267.59	
	Small	225.79	196.03	292.61	206.82	220.63	150.38	243.13	169.98	325.78	368.71	331.23	376.98	155.94	179.50	416.19		257.31	
Interaction effect between Genotype& Fe	0	99.83	124.88	197.52	124.05	235.00	117.13	234.83	154.02	360.00	250.17	447.02	157.13	204.27	155.00	339.77			213.37
	0.2	252.13	190.00	412.83	172.30	244.00	172.83	310.00	139.88	233.00	241.42	274.80	333.77	184.67	135.83	465.67			250.88
	0.4	263.00	253.83	256.67	258.83	224.00	188.92	246.75	249.50	330.13	307.17	281.08	316.83	159.08	197.58	476.67			267.34
	0.8	319.92	325.50	159.67	232.42	565.33	203.17	380.25	208.75	345.63	357.50	395.17	346.08	159.17	214.58	560.00			318.21
Effect of Genotype		233.72	223.55	256.67	196.90	317.08	170.51	292.96	188.04	317.19	289.06	349.52	288.45	176.80	175.75	460.53			

LSD for Gen. =99.86 Seed size=36.464 Fe=51.567 Gen. x Seed size=141.22 Gen. x Fe=199.72 Seed size x Fe=72.927 Gen. x Seed size x Fe=282.45

Table 4. Zinc concentration in the roots of the 15 wheat genotypes

Genotypes		Abo-Ghraib	IPA/99	Doma/1	Sham/8	Bohuth/4	Bohuth/6	Bohuth/7	Acsad/65	Sham/3	Tikrafar/3	Karoniah	Zebba/5	Haama/14	Adil/3	Paska/29	Interaction effect between (Fe &seed size)	Effect of seed size	Effect of Fe
seed size	Fe level																		
large	0	102.83	151.00	137.00	96.17	145.00	229.67	128.83	97.33	173.67	115.83	83.50	120.33	132.50	160.83	202.33	138.46		
	0.2	130.33	70.50	114.25	217.33	72.67	90.17	151.00	126.00	153.83	130.17	115.83	112.83	105.83	223.50	98.33	127.51		
	0.4	197.00	107.50	43.50	189.50	159.17	107.33	85.25	124.83	109.00	219.50	46.83	87.77	178.50	101.50	55.00	120.81		
	0.8	91.33	138.00	91.83	92.00	212.50	122.83	85.33	37.00	89.67	98.33	77.17	99.83	76.00	99.17	68.00	98.60		
Small	0	157.33	124.83	112.33	175.50	105.67	110.67	126.33	120.50	115.67	121.17	76.50	82.83	133.17	109.00	137.67	120.61		
	0.2	67.83	185.00	132.67	142.83	180.17	96.33	155.17	67.83	109.67	91.50	126.50	185.00	85.33	108.17	105.00	122.60		
	0.4	115.00	56.00	99.83	84.00	74.00	81.83	60.50	76.00	127.00	69.17	197.00	88.50	57.77	105.77	184.83	98.48		
	0.8	133.67	226.00	102.00	191.83	96.00	97.17	79.00	105.00	85.50	136.50	70.00	139.33	112.50	115.67	115.33	120.37		
Interaction effect between Genotype, &seed size	large	130.38	116.75	96.65	148.75	147.33	137.50	112.60	96.29	131.54	140.96	80.83	105.19	123.21	146.25	105.92		121.34	
	Small	118.46	147.96	111.71	148.54	113.96	96.50	105.25	92.33	109.46	104.58	117.50	123.92	97.19	109.65	135.71		115.51	
Interaction effect between Genotype& Fe	0	130.08	137.92	124.67	135.83	125.33	170.17	127.58	108.92	144.67	118.50	80.00	101.58	132.83	134.92	170.00			129.53
	0.2	99.08	127.75	123.46	180.08	126.42	93.25	153.08	96.92	131.75	110.83	121.17	148.92	95.58	165.83	101.67			125.05
	0.4	156.00	81.75	71.67	136.75	116.58	94.58	72.88	100.42	118.00	144.33	121.92	88.13	118.13	103.63	119.92			109.65
	0.8	112.50	182.00	96.92	141.92	154.25	110.00	82.17	71.00	87.58	117.42	73.58	119.58	94.25	107.42	91.67			109.48
Effect of Genotype		124.42	132.35	104.18	148.65	130.65	117.00	108.93	94.31	120.50	122.77	99.17	114.55	110.20	127.95	120.81			

LSD for Gen. =30.906 Seed size=11.285 Fe=15.960 Gen. x Seed size=43.707 Gen. x Fe=61.811 Seed size x Fe=22.570 Gen. x Seed size x Fe=87.414

Table 5. Zinc concentration in the Shoot of the 15 wheat genotypes

Genotypes		Abo-Ghraib	IPA/99	Doma/1	Sham/8	Bohuth/4	Bohuth/6	Bohuth/7	Acsad/65	Sham/3	Tikadar/3	Karoniah	Zebba/5	Haamra/14	Adil/3	Parka/29	Interaction effect between (Fe &seed size)	Effect of seed size	Effect of Fe
seed size	Fe level																		
large	0	121.83	101.33	142.77	114.43	73.33	207.33	119.00	75.17	120.50	109.67	102.67	133.67	79.27	126.50	185.00	120.83		
	0.2	110.17	135.50	101.33	126.00	140.83	167.50	110.83	131.33	126.00	65.67	82.67	133.00	139.50	220.33	74.83	124.37		
	0.4	94.17	117.67	65.33	137.00	109.17	163.67	162.67	117.83	177.67	113.50	77.33	83.17	135.00	158.83	112.83	121.72		
	0.8	56.17	109.17	164.83	70.83	96.17	43.83	97.83	165.83	82.33	103.33	44.83	93.50	188.50	77.17	103.33	99.84		
Small	0	179.77	168.33	142.00	74.50	108.00	109.17	302.77	135.50	95.83	78.50	106.00	107.33	126.00	77.67	79.33	126.05		
	0.2	130.33	189.33	132.33	92.50	200.33	168.17	84.50	87.67	144.17	119.17	130.83	231.50	96.50	86.50	84.00	131.86		
	0.4	162.00	103.67	154.33	118.50	128.00	92.83	136.00	115.17	111.67	127.50	125.33	163.67	92.67	78.17	173.33	125.52		
	0.8	129.00	84.33	75.33	162.33	78.83	170.50	122.17	116.17	168.83	124.33	102.50	146.83	206.33	121.50	103.50	127.50		
Interaction effect between Genotype, &seed size	large	95.58	115.92	118.57	112.07	104.88	145.58	122.58	122.54	126.63	98.04	76.88	110.83	135.57	145.71	119.00		116.69	
	Small	150.28	136.42	126.00	111.96	128.79	135.17	161.36	113.63	130.13	112.38	116.17	162.33	130.38	90.96	110.04		127.73	
Interaction effect between Genotype& Fe	0	150.80	134.83	142.38	94.47	90.67	158.25	210.88	105.33	108.17	94.08	104.33	120.50	102.63	102.08	132.17			123.44
	0.2	120.25	162.42	116.83	109.25	170.58	167.83	97.67	109.50	135.08	92.42	106.75	182.25	118.00	153.42	79.42			128.11
	0.4	128.08	110.67	109.83	127.75	118.58	128.25	149.33	116.50	144.67	120.50	101.33	123.42	113.83	118.50	143.08			123.62
	0.8	92.58	96.75	120.08	116.58	87.50	107.17	110.00	141.00	125.58	113.83	73.67	120.17	197.42	99.33	103.42			113.67
Effect of Genotype		122.93	126.17	122.28	112.01	116.83	140.38	141.97	118.08	128.38	105.21	96.52	136.58	132.97	118.33	114.52			

LSD for Gen. =34.304 Seed size=12.526 Fe=17.715 Gen. x Seed size=48.514 Gen. x Fe=68.609 Seed size x Fe=25.052 Gen. x Seed size x Fe=97.027

Table 6. Copper concentration in the roots of the 15 wheat genotypes

Genotypes		Abo-Ghraib	IPA/99	Doma/1	Sham/8	Bohuth/4	Bohuth/6	Bohuth/7	Acsad/65	Sham/3	Tikadar/3	Karoniah	Zebba/5	Haamra/14	Adil/3	Parka/29	Interaction effect between (Fe &seed size)	Effect of seed size	Effect of Fe
seed size	Fe level																		
large	0	593.33	383.33	565.00	445.00	760.00	396.67	511.67	350.00	240.00	583.33	983.33	986.67	160.00	478.33	342.50	518.61		
	0.2	401.67	888.33	565.00	371.67	391.67	695.00	487.50	833.33	321.67	393.33	326.67	1223.33	368.33	471.67	1218.33	597.17		
	0.4	693.33	616.67	332.50	241.67	358.33	266.67	440.00	300.00	346.67	261.67	222.50	940.00	308.33	331.67	627.50	419.17		
	0.8	245.00	305.00	355.00	377.50	460.00	280.00	603.33	290.00	365.00	628.33	513.33	496.67	685.00	285.00	320.00	413.94		
Small	0	493.33	708.33	502.50	247.67	408.33	362.50	402.50	310.00	302.50	595.00	498.33	707.50	448.33	300.00	735.00	468.12		
	0.2	713.33	445.00	575.00	490.00	246.67	585.00	373.33	575.00	450.00	330.00	271.67	1095.00	1085.00	685.00	873.33	586.22		
	0.4	821.67	945.00	205.00	592.50	771.67	293.33	592.50	771.67	715.00	743.33	260.00	705.00	640.00	190.00	306.67	570.22		
	0.8	605.00	262.50	243.33	240.00	372.50	593.33	1026.67	286.67	162.50	593.33	225.00	580.00	302.50	455.00	640.00	439.22		
Interaction effect between Genotype, &seed size	large	483.33	548.33	454.38	358.96	492.50	409.58	510.63	443.33	318.33	466.67	511.46	911.67	380.42	391.67	627.08		487.22	
	Small	658.33	590.21	381.46	392.54	449.79	458.54	598.75	485.83	407.50	565.42	313.75	771.88	618.96	407.50	638.75		515.95	
Interaction effect between Genotype& Fe	0	543.33	545.83	533.75	346.33	584.17	379.58	457.08	330.00	271.25	589.17	740.83	847.08	304.17	389.17	538.75			493.37
	0.2	557.50	666.67	570.00	430.83	319.17	640.00	430.42	704.17	385.83	361.67	299.17	1159.17	726.67	578.33	1045.83			591.69
	0.4	757.50	780.83	268.75	417.08	565.00	280.00	516.25	535.83	530.83	502.50	241.25	822.50	474.17	260.83	467.08			494.69
	0.8	425.00	283.75	299.17	308.75	416.25	436.67	815.00	288.33	263.75	610.83	369.17	538.33	493.75	370.00	480.00			426.58
Effect of Genotype		570.83	569.27	417.92	375.75	471.15	434.06	554.69	464.58	362.92	516.04	412.60	841.77	499.69	399.58	632.92			

LSD for Gen. = 158.000 Seed size=57.693 Fe=81.590 Gen. x Seed size= 223.440 Gen. x Fe=316.000 Seed size x Fe=115.390 Gen. x Seed size x Fe=446.890

Table 7. Copper concentration in the Shoot of the 15 wheat genotypes

Genotypes		Abo-Ghraib	IPA/99	Doma/1	Sham8	Bohuth/4	Bohuth/6	Bohuth/7	Acsad/65	Sham/3	Tikadar/3	Karoniah	Zebba/5	Haama/14	Adil/3	Parka/29	Interaction effect between (Fe &seed size)	Effect of seed size	Effect of Fe
seed size	Fe level																		
large	0	80.17	11.33	64.17	6.50	33.67	74.00	46.00	29.33	67.83	68.83	31.67	17.67	29.50	63.67	12.83	42.48		
	0.2	83.67	14.50	53.83	79.00	46.27	9.83	72.00	48.33	32.33	17.33	12.00	71.83	44.17	67.00	90.00	49.47		
	0.4	27.50	13.27	32.67	67.83	63.33	65.33	11.33	30.83	20.67	49.50	80.83	2.00	21.00	17.27	124.67	41.87		
	0.8	15.67	74.77	13.67	41.17	48.83	175.17	69.50	31.00	18.00	14.33	16.33	16.50	23.77	3.00	57.50	41.28		
Small	0	83.5	33.27	36.00	13.00	16.67	82.33	72.50	45.50	40.00	39.00	75.83	86.00	49.00	19.67	22.00	47.62		
	0.2	18.33	22.50	25.17	36.33	32.67	104.67	19.00	8.77	42.33	12.83	12.83	51.00	119.67	61.33	23.00	39.36		
	0.4	13.00	47.00	11.67	45.77	40.27	19.00	6.27	47.33	67.50	20.27	16.83	40.00	34.83	28.17	11.50	29.96		
	0.8	39.00	40.50	8.67	53.00	11.27	10.50	5.27	68.33	35.67	81.33	12.50	41.50	78.33	51.00	21.27	37.21		
Interaction effect between Genotype, &seed size	large	51.75	28.47	41.08	48.63	48.03	81.08	49.71	34.88	34.71	37.50	35.21	27.00	29.61	37.73	71.25		43.78	
	Small	38.46	35.82	20.38	37.03	25.22	54.13	25.76	42.48	46.38	38.36	29.50	54.63	70.46	40.04	19.44		38.54	
Interaction effect between Genotype& Fe	0	81.83	22.30	50.08	9.75	25.17	78.17	59.25	37.42	53.92	53.92	53.75	51.83	39.25	41.67	17.42			45.05
	0.2	51.00	18.50	39.50	57.67	39.47	57.25	45.50	28.55	37.33	15.08	12.42	61.42	81.92	64.17	56.50			44.42
	0.4	20.25	30.13	22.17	56.80	51.80	42.17	8.80	39.08	44.08	34.88	48.83	21.00	27.92	22.72	68.08			35.91
	0.8	27.33	57.63	11.17	47.08	30.05	92.83	37.38	49.67	26.83	47.83	14.42	29.00	51.05	27.00	39.38			39.24
Effect of Genotype		45.10	32.14	30.73	42.83	36.62	67.60	37.73	38.68	40.54	37.93	32.35	40.81	50.03	38.89	45.35			

LSD for Gen. =19.189 Seed size=7.0068 Fe=9.9091 Gen. x Seed size=27.137 Gen. x Fe= 38.378 Seed size x Fe=14.014 Gen. x Seed size x Fe= 54.274

Table 8. Manganese concentration in the roots of the 15 wheat genotypes

Genotypes		Abo-Ghraib	IPA/99	Doma/1	Sham8	Bohuth/4	Bohuth/6	Bohuth/7	Acsad/65	Sham/3	Tikadar/3	Karoniah	Zebba/5	Haama/14	Adil/3	Parka/29	Interaction effect between (Fe &seed size)	Effect of seed size	Effect of Fe
seed size	Fe level																		
large	0	483.77	391.50	398.77	382.33	384.00	345.50	297.77	527.50	279.17	535.50	303.50	361.83	295.33	299.50	397.83	378.92		
	0.2	204.50	364.17	460.83	143.17	326.83	437.17	368.33	363.00	304.50	286.83	249.67	484.67	405.50	622.00	518.50	369.31		
	0.4	397.33	314.83	335.00	155.00	420.00	173.00	256.17	375.00	418.67	509.50	586.00	363.83	334.50	236.33	474.50	356.64		
	0.8	416.33	189.27	217.50	281.27	170.83	354.50	396.00	340.27	402.17	242.77	337.50	253.00	376.83	279.50	284.50	302.82		
Small	0	236.5	215.00	294.50	366.77	308.50	546.17	376.83	431.33	525.00	277.17	400.00	510.50	598.50	281.83	308.00	378.44		
	0.2	391.83	200.67	446.00	326.17	375.83	383.50	221.00	241.33	377.17	331.83	229.83	620.33	519.00	290.67	369.67	354.99		
	0.4	329.33	472.50	405.17	362.17	325.50	356.17	268.83	317.00	664.67	336.00	405.00	347.67	286.83	185.83	296.00	357.24		
	0.8	379.50	211.50	399.50	257.50	300.67	265.17	412.50	364.50	299.77	308.50	473.67	255.50	280.50	228.77	256.17	312.91		
Interaction effect between Genotype, &seed size	large	375.48	314.94	353.03	240.44	325.42	327.54	329.57	401.44	351.13	393.65	369.17	365.83	353.04	359.33	418.83		351.92	
	Small	334.29	274.92	386.29	328.15	327.63	387.75	319.79	338.54	466.65	313.38	377.13	433.50	421.21	246.78	307.46		350.90	
Interaction effect between Genotype& Fe	0	360.13	303.25	346.63	374.55	346.25	445.83	337.30	479.42	402.08	406.33	351.75	436.17	446.92	290.67	352.92			378.68
	0.2	298.17	282.42	453.42	234.67	351.33	410.33	294.67	302.17	340.83	309.33	239.75	552.50	462.25	456.33	444.08			362.15
	0.4	363.33	393.67	370.08	258.58	372.75	264.58	262.50	346.00	541.67	422.75	495.50	355.75	310.67	211.08	385.25			356.94
	0.8	397.92	200.38	308.50	269.38	235.75	309.83	404.25	352.38	350.97	275.63	405.58	254.25	328.67	254.13	270.33			307.86
Effect of Genotype		354.89	294.93	369.66	284.30	326.52	357.65	324.68	369.99	408.89	353.51	373.15	399.67	387.13	303.05	363.15			

LSD for Gen. = 83.779 Seed size=30.592 Fe=43.263 Gen. x Seed size=118.480 Gen. x Fe=167.560 Seed size x Fe=61.184 Gen. x Seed size x Fe=236.96

Table 9. Manganese concentration in the Shoot of the 15 wheat genotypes

Genotypes		Abo-Ghraib	IPA99	Doma/1	Sham8	Bohain/4	Bohain/6	Bohain/7	Acsad/65	Sham3	Tikadar/3	Karoonah	Zebra/5	Hamra/14	Adil/3	Pasha/29	Interaction effect between (Fe &seed size)	Effect of seed size	Effect of Fe
seed size	Fe level																		
large	0	515.33	244.00	284.00	236.17	390.17	195.00	349.67	311.33	485.00	278.83	351.83	279.00	264.00	324.00	344.00	323.49		
	0.2	308.50	280.00	243.17	329.17	288.00	259.67	257.00	254.67	382.17	185.00	306.50	280.33	195.50	109.17	469.50	276.56		
	0.4	411.83	246.33	333.83	132.17	267.67	163.50	239.33	260.33	377.17	184.67	428.17	337.00	280.50	201.50	351.17	281.01		
	0.8	203.27	429.67	213.33	287.27	524.50	274.33	432.00	131.77	381.33	194.00	163.17	245.17	325.27	295.00	502.33	306.83		
Small	0	217.33	280.33	130.33	278.83	335.83	359.83	533.67	352.67	321.33	357.17	448.00	378.83	200.33	294.17	420.67	327.29		
	0.2	371.83	242.50	350.50	301.33	338.17	461.33	320.50	321.83	361.00	247.00	176.00	573.17	302.33	206.67	326.50	326.71		
	0.4	259.67	493.17	243.67	379.17	373.50	277.83	344.17	242.17	357.83	327.50	338.83	311.67	398.50	319.33	221.83	325.92		
	0.8	186.00	442.50	241.67	132.77	219.77	133.27	268.83	282.00	136.50	156.77	281.77	251.50	193.17	211.67	412.00	236.68		
Interaction effect between Genotype, &seed size	large	359.73	300.00	268.58	246.19	367.58	223.13	319.50	239.53	406.42	210.63	312.42	285.38	266.32	232.42	416.75		296.97	
	Small	258.71	364.63	241.54	273.03	316.82	308.07	366.79	299.67	294.17	272.11	311.15	378.79	273.58	257.96	345.25		304.15	
Interaction effect between Genotype& Fe	0	366.33	262.17	207.17	257.50	363.00	277.42	441.67	332.00	403.17	318.00	399.92	328.92	232.17	309.08	382.33			325.39
	0.2	340.17	261.25	296.83	315.25	313.08	360.50	288.75	288.25	371.58	216.00	241.25	426.75	248.92	157.92	398.00			301.63
	0.4	335.75	369.75	288.75	255.67	320.58	220.67	291.75	251.25	367.50	256.08	383.50	324.33	339.50	260.42	286.50			303.47
	0.8	194.63	436.08	227.50	210.02	372.13	203.80	350.42	206.88	258.92	175.38	222.47	248.33	259.22	253.33	457.17			271.75
Effect of Genotype		309.22	332.31	255.06	259.61	342.20	265.60	343.15	269.60	350.29	241.37	311.78	332.08	269.95	245.19	381.00			

LSD for Gen. =74.708 Seed size=27.28 Fe=38.579 Gen. x Seed size=105.65 Gen. x Fe=149.42 Seed size x Fe=54.559 Gen. x Seed size x Fe=211.31

REFERENCES

Ai-Qing ZB, Qiong-Li T, Xiao-Hong L, Xin-Chun and W Jeff Gale. 2011. Combined effect of iron and zinc on micronutrient levels in wheat (Triticum aestivum L.). J. Environ. Biol.32: pp. 235-239.

Al – Ali FAM. 1996. Effect of the polluted water on plant growth and its content of some micronutrients and heavy metals. Ph. D Thesis. College of Science, Mosul University.

Al – Niemi SN and Al – Ali FA. 2010. Minimizing lead and nickel concentrations in human vegetables diet grown in heavy metals polluted calcareous soil. Al- Anbar J. of Agr. Sci. 8(4): pp. 1-10.

Alloway BJ. 2008. Zinc in soils and crop nutrition, international zinc association and international Fertilizer industry association. Belgium and Paris, France.

Bierman PM and Rosen CJ. 2005. Nutrient management for fruit and vegetable crop production. University of Minnesota, College of Agricultural, Food and Environmental Science.

Chaney RL. 1984. Diagnostic practices to identify iron deficiency in higher plants. J Plant Nutr 7: 47-67.

Chany AC, Page AL, Faster KW and Jones TE. 1982. A comparison of cadmium and zinc accumulation by cultivars of barley grown in sludge amended soils. J. Environ. Qual. 11: 409-412.

Crowley DE, Reid CPP and Szaniszlo PJ. 1987. Microbial siderophores as iron sources for plants. In: Winkelmann, G., Van der Helm, D. and Neilands, J.B. (eds) Iron Transport in Animals, Plants and Microorganisms. VCH Chemie, Weinheim, Germany pp. 370-386.

Gourley CJP, Allan DL and Russelle MP. 1994. Plant nutrient efficiency: a comparison of definitions and suggested improvement. Plant Soil 158: 29–37.

Kabata-Pedias A. 1992. Behavioural properties of trace metals in soils. Applied Geochemistry, Suppl. Issue. No. 2: 3-9.

Kabata-Pendias A. 2001. Trace elements in soils and plants, CRC Press, Boca Raton. P 140.

Khoshgoftarmanesh AH, Schulin R, Chaney RL, Daneshbakhsh B and Afyuni M. 2010. Micronutrient-efficient genotypes for crop yield and nutritional quality 434 in sustainable agriculture: A review. Agron. Sustain. Dev. 30: 83–107.

Langdale GW, Thomas JR and Littleton TG. 1973. Nitrogen metabolism of stargrass as affected by nitrogen and soil salinity. Agronomy Journal 65: 468-470.

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

Marschner H. 1993. Mineral Nutrition of Higher Plants. Academic Press, London, pp. 523-542.

Melton JR, Mahtab SK and Swoboda AR. 1973. Diffusion of zinc in soils as a function of applied zinc, phosphorous and soil pH. Soil. Sci. Soc. Am. Proc. 37: 379-381.

Mengel K and Kirkby EA. 2001. Principles of plant nutrition. 5th ed. Kluwer Academic publishers.

O′Connor GA, Lindsay WL and Olsen SR. 1971. Diffusion of iron and iron chelates in soil. Soil Sci. Amer. Proc. 35: 407-410.

Page AL. 1982. Methods of soil analysis, part 2. Amer. Soc. Agric. Pub. Madison, Wisconson U.S.A.

Reid RJ. 2001. Mechanisms of micronutrient uptake in plants. Aust. J. plant physiol. 28: 659-666.

Sims JT and Johnson GV. 1991. Micronutrient soil tests, *In*: Micronutrients in Agriculture. 2nd ed. J. J. Mortvedt, F. R. Cox, L. M. (eds.). Soil Sci. Soc. Am. (eds.) Book Series NO. 4, Madison, WI, USA. PP. 427-476.

Soltanpour PN and Schwab AP. 1977. A new soil test for simultaneous extraction of Macro- and Micro- nutrient in alkaline soil. Communications in Soils Sci. and plant analysis. 8: 195-207.

Tandon HLS. 1999. Micronutrients in soils, crops and fertilizer.Fer. Dev. and Con. Org. New Delhi, India: 41-50.