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Determination of iron critical level for main agricultural soils cultivated with wheat (*Triticum aestivum L.*) in Sulaimani.

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Abstract

The factorial pot experiment was conducted at Bakrajo Research Station, Ministry of Agriculture and Water Resources, Sulaimani Governorate during the winter growing season from 1/12/2014 to 10/6/2015 for limiting of Fe critical level of soils and wheat plant. The pot factorial experiment included the effect of five levels of Fe- EDDHA (0, 2, 4, 6, and 8) mg Fe kg soil^{-1}, soils of 20 locations and their effects on growth, yield and quality of wheat using completely randomized design with 4 replicates. The results indicated to the significant effect of applied Fe levels on grain yield of wheat, the highest mean value (12.66) g pot^{-1} was recorded from the second treatment (2 mg Fe kg $^{-1}$) which ranged between (3.11-28.02) g pot^{-1}, while the lowest mean value (11.09) g pot^{-1} obtained from the 5 th treatment (8 mg Fe kg $^{-1}$) which ranged between (3.14-27.62) g pot^{-1}. The critical level of Fe was determined in wheat using graphic method and statistical method depending on iron concentration in the plant (mg kg^{-1} dry weight) and relative yield the iron which was (50.50 mg kg^{-1} dry matter .While the critical level of iron in the studied soil was (2.61) mgkg^{-1} using graphical method and (2.50) mgkg^{-1} depending on statistical method for the studied soils in Sulaimani governorate.

Key words: Iron critical level, wheat, calcareous soil.

** =Apart of M.Sc thesis for the 2nd researcher.

INTRODUCTION:

Plants grow in soils with limited availability of Fe are not able to accumulate sufficient amounts of Fe in its edible parts, leading to nutrition disorders (Fe deficiency) in human body that depend on staple

food crops like cereals (White and Broadley, 2009).Iron has many important functions in plant growth and development, such as involvement in the biosynthesis of chlorophyll, respiration, chloroplast development and improves the performance of photosystems. It is an essential part of many enzymes. Iron also participates in the oxidation process that releases energy from sugars and starches and in response of that converting nitrate to ammonium in plant. It plays an essential role in nucleic acid metabolism **.**The availability of Fe in soils is affected by soil properties such as soil pH, calcium carbonate content, organic matter, accumulation of phosphorus, ion imbalance, soil texture, soil temperature, poor soil aeration, high humidity and soil compaction. Availability of iron and most micronutrient is largely pH–depended, availability decreases as pH increase. The lower the pH value of soil solution, causes the higher availability of soluble Fe. The dominant Fe species in the pH range of 5.0 to 7.5 is $Fe(OH)^{2+}$ which decreases 10-folds for each unit increase in pH while the activity of Fe^{3+} decreases 1000-fold. (Havlin *et al*., 2014).

A critical value in the literature is defined as the concentration below which deficiency of specific nutrient occur. Critical values of several plants have been widely published despite the fact that this critical level may not be applicable at different growth stages. Soil Science Society of America defines critical soil test concentration as “The concentration at which 95% of maximum relative yield is achieved.”

Olsen and Carlson (1950), reported that the critical level of Fe extracted by NH_4OAC was (2.0) mg Fe kg^{-1}. The critical level of Fe availability in 35 calcareous soil sample which extracted by DTPA+$CaCl_2$ method was (4.5) mg Fe kg^{-1} (Lindsay and Norvell, 1978). Data indicated that the critical level of Fe which extracted by DTPA+NH_4HCO_3 method for 40 soil sampls in USA was (4.5) mg Fe kg^1 (Havlin and Soltanpour, 1981).

Jarallah (2005) reported that the critical Fe level for wheat plant in some calcareous soils was (77.0) mg Fe kg^{-1} dry matter, while the critical rang of Fe for wheat plant was between 46.4-173.9 mg Fe kg^{-1}. Iron deficiency is likely to occur when Fe content is 50 mg Fe kg^{-1}, Ahmad *et al*., (1996). Kumar (2002) reported that the critical limit in wheat plant was 43.52 mg Fe kg^{-1}. Lindsay and Schwab (1982), reported that the critical limit of Fe in Soybean was 50 mg Fe kg^{-1}.).In Kurdistan region there are some studies about nutrient critical level of phosphorus and potassium which were conducted by Shekh bzayni (2005), Hama–Amin (2012) and Khdir (2017).

Since there are little or no studies about iron critical level in soil and plant in Kurdistan region for this reason this study was selected to determine the iron critical level in soil and wheat plant in Sulaimani governorate.

MATERIALS AND METHODS:

Soil samples were collected from twenty different locations in Sulaimani governorate as shown in table (1). The samples were taken from soil surface (0-30) cm depth **(Halverson, 2001)** up on bringing the samples to the laboratory they were air dried, ground and kept until use. Quantitative amount of soil samples were taken for pot experiment, chemical and physical analysis.

Some soil physical and chemical analysis were done on the (2) mm sieving samples, according to Jackson(1973) .

Available iron for soils was determined by AAS, using (Ammonium Bicarbonate-DTPA) using 1 *M* ammonium bicarbonate (NH_4HCO_3, and 0.005 *M* DTPA) extract (Soltanpour and Schwab, 1977).

-Biological experiment

The factorial pot experiment was conducted at Bakrajo Research Station, Ministry of Agriculture and Water Resources, Sulaimani Governorate during the winter growing season from 1/12/2014 to 10/6/2015 for identifying the critical level of Fe in the studied soil and cultivated wheat. Each pot (35 cm height, 28 cm top diameter) was filled with same weight (13.5 kg) of air dried soil after passing through (4 mm) sieve. The pot experiment included the effect of five levels of Fe-EDDHA (0, 2, 4, 6, and 8) mg Fe kg soil^{-1},soils of 20 locations and their interactions on growth, yield and quality of wheat. On 1/12/2014, 15 seeds of wheat (Tritium aestivum) were planted in each pot at (5) cm depth, after germination the plants were thinned to 8 plants per pot. Nitrogen fertilizer as urea was applied at a level of (200) kg N ha^{-1}, for all pots to give up amount of nitrogen equivalent to (1.338) g N pot^{-1}.On 12/6/2015 the plants were harvested then oven dried at 65 C° for 72 hours, then weighted , grounded and stored for chemical analysis which mentioned previously. Wheat straw and seed were analyzed for (Fe) by atomic absorption from the acid digested, values were computed against curves prepared freshly each day. The atomic absorption spectrometer (AAS) Perkin-Elmer Model 1100B was used.

Determination of iron critical level:

The critical level of Iron in the soil and plant was determined by Cate and Nelson (1965) methods using graphic and statistical methods.

Statistical Analysis:

In all cases, two-way analyses of variance (ANOVA) using with the help of computer software XLSTAT. Revised Least Significant differences (RLSD.$_{01}$) test was used to compare the differences among a means at significant level of 1%, using **SAS, (2001)**.

Table (1): The studied locations and their position according to GPS.

Soil No	location	GPS coordination
1	Qlyasan	**35°34'53.6"N 45°21'59.0"E**
2	Bazyan	**35°35'34.6"N 45°08'26.9"E**
3	Bakrajo	**35°32'52.8"N 45°21'16.6"E**
4	Serwan	**35°14'11.9"N 45°56'56.2"E**
5	Baynjan	**35°38'30.4"N 45°03'57.4"E**
6	Halbja	**35°07'52.1"N 46°02'37.3"E**
7	Keli	**35°48'01.9"N 45°27'31.1"E**
8	SaidSadiq	**35°23'04.5"N 45°47'22.7"E**
9	Kalar	**34°38'59.6"N 45°15'14.6"E**
10	Kifri	**34°39'15.9"N 44°55'08.3"E**
11	Penjwen	**35°37'37.6"N 45°56'59.4"E**
12	Qaldza	**36°13'06.7"N 45°08'58.9"E**
13	Ranya	**36°14'00.1"N 44°50'52.6"E**
14	Chamchamal	**35°31'10.9"N 44°50'01.6"E**
15	Darbandekhan	**35°07'23.8"N 45°39'47.9"E**
16	Kanipanka	**35°22'46.8"N 45°42'17.1"E**
17	Zrgwez	**35°22'30.2"N 45°26'07.2"E**
18	Tasloja	**35°37'53.8"N 45°14'40.0"E**
19	Dukan	**35°54'32.6"N 45°00'09.9"E**
20	Mawat	**35°52'40.5"N 45°26'07.2"E**

RESULTS AND DISSCUION:

Data of the most important properties of the investigated soils were shown in table (2) and (3); it reveals that the soils included various textures, from clay soil to silty loam. The pH value was ranged from 7.24 to 8.36 with mean value of (7.90).

This means that all the tested soils were slightly alkaline. The electrical conductivity (EC) of the studied soil was between (0.55 and 4.3) $dSm^{-1,}$ with mean value of 1.038, which indicates that the soils are non-saline, except Zrgwez location which is saline soil. Cation exchange capacity (CEC) was ranged between (10.05 - 38.61) $cmol_c kg^{-1}$ soil, it means they are differing in fertility. The amount of organic matter in the soils was ranged from (7.00 to 38.70) g kg^{-1}, it mean that most of the soil have low organic matter content, (Baruah and Barthakur,1999) Active lime was ranged between (8.40 - 67.20) g kg^{-1}. The total $CaCO_3$ was between (31.70-325.30) g kg^{-1}, It means most of the soils are very calcareous (contains more than 100 g kg^{-1} $CaCO_3$ and soil No 8 and 11 are slightly calcareous (contain less than 50 g kg^{-1} $CaCO_3$), (Hodgason, 1976).

Table (3) shows that the concentration of Ca^{++} in most of the studied soil were more than Mg^{++} concentration, except locations(SaidSadq , Qaladza , Ranya and Zrgwez) which the concentration of Mg^{++} were more than Ca^{++}, this may be due to the dominate of dolomite mineral in these locations. At the same time the concentration of Na^{+} in the studied soil were more than K^{+}.The soluble cations were determined for this reason the Mg concentration of Penjwen and Qaladza was similar in spite of existing serpentine clay mineral in Penjwen soil which regards a source of Mg but it not dissolve in water but it dissolve in strong acid extracts.The high concentration of HCO_3^- was recorded in10 locations, and the high concentration of Cl^- were obtained in Keli locations, while the highest concentration of SO^-_4 was recorded Bakrajo location (table, 3), this may be due to the reasons mentioned before. The iron concentration in the studied soils was ranged between (1.66-3.96) mg Fe kg^{-1} (table,3**)** which was less than the adequate amount (4**)** mg Fe kg^{-1} **(**Soltanpour and Schwab,1977).

Table (2): Some physical and chemical characteristics of studied soils.*

Locations	Textural name	CEC Cmolc.kg soil^{-1}	F.C%	W.P%	pH	EC dS.m^{-1}	OM (g.kg^{-1} soil)	$ECaCO_3$ g kg^{-1} soil	
								Active	Total
1	Clay	31.38	34.50	20.73	7.70	0.86	22.70	61.60	214.20
2	Silt loam	17.97	24.50	15.23	8.05	1.05	24.80	67.20	198.30
3	Clay	32.78	33.78	24.49	8.26	0.55	19.40	67.20	253.90
4	Clay	35.01	34.46	20.34	7.72	0.86	8.60	36.40	202.30
5	Clay	32.44	33.74	24.37	8.08	1.36	11.50	56.00	325.30
5	Clay	28.87	30.08	18.95	7.80	0.87	24.10	61.60	190.40
7	Silt loam	10.05	22.64	9.32	8.17	0.60	7.00	8.40	87.30
8	Clay	38.61	38.90	28.16	7.68	0.77	26.90	14.00	31.70
9	Loam	12.40	21.98	12.62	7.98	0.95	9.10	28.00	313.40
10	Clay loam	19.71	27.55	17.21	7.56	1.27	9.20	47.60	261.80

11	**Clay loam**	**22.40**	**26.84**	**18.76**	**8.36**	**0.63**	**18.00**	**14.00**	**119.00**
12	**Clay**	**36.45**	**35.72**	**25.88**	**7.85**	**0.59**	**27.10**	**50.40**	**162.60**
13	**Clay**	**34.37**	**36.24**	**26.18**	**7.95**	**0.69**	**16.30**	**30.80**	**119.00**
14	**Clay**	**28.86**	**24.11**	**23.61**	**8.04**	**0.89**	**12.30**	**61.60**	**265.80**
15	**Clay loam**	**24.17**	**28.75**	**21.36**	**8.03**	**0.73**	**9.30**	**39.20**	**249.90**
16	**Clay**	**36.50**	**38.27**	**26.09**	**7.86**	**1.22**	**29.80**	**30.80**	**31.70**
17	**Clay loam**	**20.52**	**24.85**	**14.91**	**7.24**	**4.30**	**16.60**	**42.00**	**91.20**
18	**Clay**	**33.97**	**32.78**	**20.34**	**7.69**	**0.98**	**38.70**	**39.20**	**126.90**
19	**Clay loam**	**24.57**	**28.32**	**21.55**	**7.96**	**0.90**	**11.60**	**44.80**	**218.20**
20	**Clay**	**32.27**	**37.06**	**23.80**	**8.04**	**0.69**	**24.20**	**16.80**	**79.00**

Table (3): Some soluble cations and anions in the studied soil samples collected from different locations in Sulaimani, IKR. *

Locations NO.	Ca2 +	Mg2+	K+	Na+	Cl-	HCO_3^-	CO_3^-	$SO_4^=$	Fe^{2+} mg kg^{-1}
	$mmol_c$ L^{-1}								
1	5.80	2.60	0.27	0.93	3.40	3.70	trace	2.50	3.09
2	5.00	3.40	0.89	2.87	4.20	3.10	0.80	4.06	2.18
3	3.60	0.80	0.14	1.41	1.80	1.30	trace	2.85	2.74
4	5.20	2.80	0.14	1.66	3.20	4.00	trace	2.59	3.68
5	6.80	3.60	0.27	2.79	8.60	2.90	0.80	1.16	2.15
6	6.60	1.20	0.27	0.97	3.00	2.50	1.20	2.34	2.42
7	4.20	1.20	0.14	0.93	1.60	2.70	trace	2.17	1.70
8	3.80	4.20	0.23	1.25	2.80	4.50	trace	2.18	2.79
9	5.60	3.20	0.62	1.13	2.20	5.30	trace	3.05	2.96
10	8.00	5.20	0.37	2.22	3.00	7.10	trace	5.69	2.12
11	3.20	3.20	0.18	0.81	2.40	1.90	0.80	2.29	1.80
12	3.00	3.20	0.09	0.69	2.60	2.50	trace	1.88	2.51
13	4.00	4.60	0.30	0.69	3.40	0.90	trace	5.28	2.83
14	6.00	3.60	0.27	1.21	1.60	5.70	trace	3.79	2.13
15	3.80	2.20	0.25	1.57	3.00	1.70	trace	3.13	1.93
16	9.80	4.60	0.21	1.49	3.00	9.70	trace	3.40	2.98
17	3.60	9.80	0.55	1.33	2.40	27.90	trace	17.38	1.66
18	8.00	2.60	0.37	1.13	3.70	5.10	trace	3.30	3.96
19	6.40	2.20	0.25	1.17	4.00	3.90	0.80	1.32	2.26
20	3.80	3.20	0.14	0.93	2.80	1.90	1.20	2.17	2.12

- **1** = Qlyasan **2=** Bazyan **3=** Bakrajo **4=** Serwan **5=** Baynjan **6=**Halbja **7=**Keli 8=SaidSadiq **9=** Kalar **10=** Kifri **11=** Penjwen **12=** Qaldza **13=** Ranya **14=**Chamchamal 15=Darbandekhan **16= Kanipanka 17= Zrgwez 18= Tasloja 19 = Dukan 20= Mawat**

Effect of iron levels, soil locations and their interactions on wheat grain yield and relative yield %(R.Y%):

Table (4) indicate the significant effect of applied Fe levels on grain yield of wheat (with the RLSD .01 value of 6.29), the highest mean value (12.66) g pot^{-1} was recorded from the second treatment (2 mg Fe kg $^{-1}$) which ranged between (3.11-28.02) g pot^{-1}, while the lowest mean value (11.09) g pot^{-1} obtained from the 5 th treatment (8 mg Fe kg $^{-1}$) which ranged between (3.14-27.62) g pot^{-1}. Similar results were obtained by Al-Mustafa *et al*., (2001). The result indicates that increasing Fe fertilization to certain level is necessary, which caused increase in grain yield of wheat this refers to wheat requirement for Fe fertilization to certain level after that its application may has negative effect. These results agree with those found by Mohsin**, (2013)**.

Table (4) shows that the soil locations has significant effect at ($P \leq 0.01$) (with the $RLSD_{.01}$ value of 2.90) on the grain yield of wheat, the highest mean value of grain yield was (26.29) g pot^{-1} recorded from Penjwen location, and the lowest value was (3.35) g pot^{-1} recorded from Keli. This may be attributed to the differences in some chemical and physical properties like OM, $CaCO_3$,CEC and soil texture, in soil of Penjwen the OM, active lime, total $CaCO_3$,CEC were (18 mg kg^{-1} soil, 14 g kg^{-1} soil,119 g kg^{-1} soil, and 22.40 Cmolc.kg soil^{-1}) respectively, with clay loam texture. While in soil of Keli the OM, active lime, total $CaCO_3$, CEC were (7 mg kg^{-1} soil, 8.40 g kg^{-1} soil, 87.30 g kg^{-1} soil, and 10.05 Cmolc.kg soil^{-1}) respectively with silty loam texture. The interaction between Fe levels and soil locations was significantly affected on grain yield of wheat at ($P \leq 0.01$) with the RLSD.01 value of 12.50), the highest value of grain yield (29.08) g pot^{1} was recorded from treatment combination of Kanipanka lactation and control (Fe_0)while the lowest value (2.61) g pot^{-1} was recorded from treatment combination Keli

Table (4): Interaction effect of locations and iron levels on wheat yield.

Soil locations	Levels of applied Fe (mg Fe kg^{-1} soil)					Yield ($g.pot^{-1}$)	R.Y%
	Fe0	Fe2	Fe4	Fe6	Fe8		
Qlyasan	13.45	9.94	8.68	10.99	9.78	10.50	39.93
Bazyan	16.97	16.78	10.61	17.26	18.80	16.08	61.16
Bakrajo	13.97	11.45	12.03	14.90	12.57	10.48	39.84
Serwan	4.31	8.58	12.29	15.34	11.90	10.48	39.86
Baynjan	16.32	15.21	23.09	15.23	7.92	15.55	59.14
Halbja	9.49	12.26	8.76	10.31	8.34	9.83	37.39
Keli	2.61	3.11	4.42	3.50	3.14	3.35	12.74
Saidsadq	17.44	17.96	11.68	19.21	17.51	16.76	63.76
Kalar	8.08	8.66	8.13	6.77	4.64	7.25	27.57
Kfri	8.08	6.46	6.48	6.94	5.77	6.74	25.63
Penjwen	31.10	21.55	26.33	24.87	27.62	26.29	100
Qaldza	11.52	13.52	12.26	11.45	14.72	12.69	48.26
Ranya	6.13	9.27	12.01	10.85	4.97	8.64	32.86
Chamchamal	6.33	5.81	5.76	4.77	7.69	6.07	23.08
Darbandekhan	10.78	8.15	10.66	6.33	5.28	8.24	31.34
Kanipanka	29.08	28.02	11.25	20.89	15.30	20.90	79.49
Zrgwez	10.78	8.15	10.66	6.33	5.28	8.24	31.34
Tasloja	29.08	28.02	11.25	20.89	15.30	20.90	79.49
Dukan	7.73	17.04	7.83	11.36	10.96	10.93	41.57
Mawat	21.14	18.46	8.77	20.89	18.94	17.04	67.09
Mean of Fe	63.58	62.14	63.27	73.23	64.12		

location at control. This may be due to individual effect of the studied factors due to the large variation between soils of Keli location and soil of Kanipanka location in physical and chemical properties (table 2 and 3), in additional to the combination between the studied factors may created different conditions for plant growth as mentioned by Darwesh and Esmail (2008).

Effect of iron levels, soil locations and their interactions on concentration of iron in wheat grains:

Table (5) indicated that wheat grain's content of iron was significantly influenced by different level of Fe application. The highest value of Fe concentration was (73.23) mg Fe kg^{-1} was recorded from application 6 mg Fe kg^{-1} and the lowest value (62.14) mg Fe kg^{-1} was recorded from application (2) mg Fe kg^{-1} this results agree with those reported by Jarallah, (2005).

Table (5) represents the significant effect of soil type at ($P \leq 0.01$) on Fe concentration in grain wheat. The highest value was (164.40) mg Fe kg^{-1} which was recorded from SaidSadq location, while the lowest value (16.26) mg Fe kg^{-1} was recorded from Penjwen location. This wide range of Fe concentration in wheat grain attributed to the difference in grain weight. The mean grain weight value of wheat for SaidSadq location was (16.76) g pot^{-1} while in Penjwen location the mean value was (26.29) g pot^{-1}. It observes that whenever the grain weight of wheat is less but the concentration of Fe was more (dilution effect). This may be due to the difference in iron concentration of the studied soils (table 3). It is stated that Fe content of grain was affected by Fe content of soil, iron concentration in soil of SaidSadq location was (2.79) mg kg^{-1} ,while iron concentration in soil Penjwen location was (1.80) mg kg^{-1} accordingly, when the amount of iron increases in soil, the concentration of iron will increases in seeds. (Long *et al.*, 2004).

The interaction between levels of Fe and soil types was affected significantly at ($P \leq 0.01$) level on Fe concentration in wheat seeds as shown in table (6).The highest value of Fe was (184.66) mg Fe kg^{-1} was recorded from combination treatment (Halbja location at application 8 mg kg^{-1}), while the lowest values of Fe was (7.01) mg Fe kg^{-1} was recorded from treatment combination (Serwan location and application 6 mg Fe kg^{-1}). This wide range of Fe concentration in wheat seeds may be due to different OM and high $CaCO_3$ content or individual effect of the studied factors, OM content in Halbja location was (24.1) mg kg^{-1} soil and (8.6) mg kg^{-1} soil in soil number 4, $CaCO_3$ content in soil number 6 was (190.40) g kg^{-1}soil which was less than $CaCO_3$ content in Serwan location which was (202.30) g kg^{-1} soil. On the other hand the plants grown in some soils were harvested after storm, which caused decrease in number of leaves then decrease in Fe concentration due to its determination in stem of wheat plant in state of mixture of leaves and stem (16.63 to 35.19) mg kg^{-1} or the ratio between leaves: stem in their treatment was low.

Determination of iron critical level in the studied soils:

As shown in Figure (1a and b) the critical level for the studied soils, using Cate and Nelson (1965, 1971) graphical method by plotting initial concentration of the soluble Iron in soil against relative yield was (2.50) mg kg^{-1}.The result depending on statistical method was (2.61) mg kg-^{1} .This result agree with those found by **Sims and Johnson (1991)**. The highest value of coefficient determination was (R^2= 0.64) recorded at concentration (2.61) mg kg^{-1}.

Table (5): Interaction effect of soils and iron levels on Fe concentration of grains.

Soil locations	Levels of applied Fe (mg Fe kg^{-1} soil)					Fe mg.g^{-1}
	Fe0	Fe2	Fe4	Fe6	Fe8	
Qlyasan	75.49	36.10	16.90	22.65	10.20	32.26
Bazyan	14.93	15.70	16.30	15.50	19.70	16.62
Bakrajo	17.45	28.35	14.18	44.35	14.02	23.67
Serwan	8.74	16.55	10.00	7.01	133.35	35.19
Baynjan	145.60	137.87	142.66	138.53	163.66	143.78
Halbja	144.50	149.83	164.50	177.00	184.66	164.11

Keli	35.45	67.85	40.23	44.72	31.53	43.92
Saidsadq	153.66	163.66	166.50	170.33	167.83	164.40
Kalar	148.00	159.00	165.66	169.66	162.16	160.90
Kfri	139.51	53.81	35.40	129.50	72.22	86.09
Penjwen	22.01	18.70	16.66	12.40	11.40	16.23
Qaldza	54.43	39.76	80.43	74.63	38.55	57.56
Ranya	74.71	35.38	32.97	73.25	24.67	48.19
Chamchamal	9.50	26.70	24.65	36.25	47.85	29.00
Darbandekhan	30.70	16.05	25.83	42.79	12.83	25.64
Kanipanka	7.15	23.75	35.75	109.15	46.70	44.50
Zrgwez	54.51	31.89	98.39	76.34	48.25	61.87
Tasloja	44.65	38.85	81.15	36.90	28.95	46.10
Dukan	68.22	164.42	85.17	62.43	55.33	87.11
Mawat	22.41	18.55	12.20	20.30	18.87	18.57
Mean of Fe	63.58	62.14	63.27	73.23	64.12	
$RLSD_{.01}$	6.25					

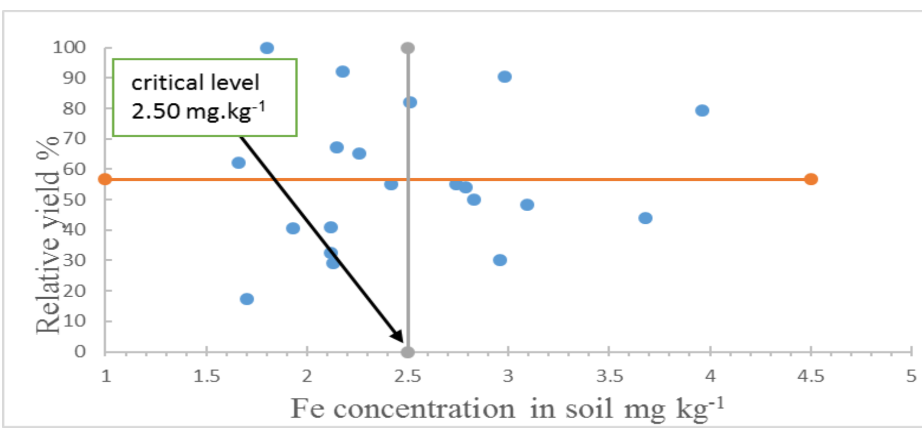

Figure (1a): Critical level of Iron in different soils collected from Sulaimani governorate (graphical method).

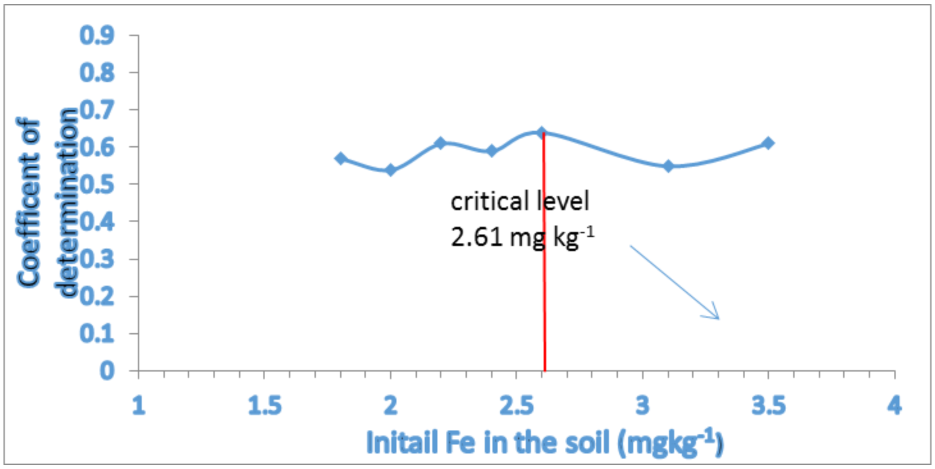

Figure (1b): Critical level of Iron in different soils collected from Sulaimani governorate (statistical method).

It is appear from determined critical level of Iron (figure,1,a) that the concentration of Fe in (11) locations of the studied soils was less than the critical value .

Determination of iron critical level for wheat plant:

Critical level of Fe was determined by using graphic method (figure ,2a) depending on iron concentration in the plant (mg kg^{-1} dry weight) and relative yield (table 6), the iron critical level for wheat was (46.55) mg kg^{-1} dry matter .The highest R^2 (0.63) value was obtained in wheat plant iron at (50.50) mg kg^{-1} and therefore the critical limit of iron for wheat plant was (50.50) mg kg^{1} by using statistical method or depending on (R^2) value as shown in (figure, 2b) These results are very close or similar to those recorded by (kumar, 2002 and Meena, 2013).

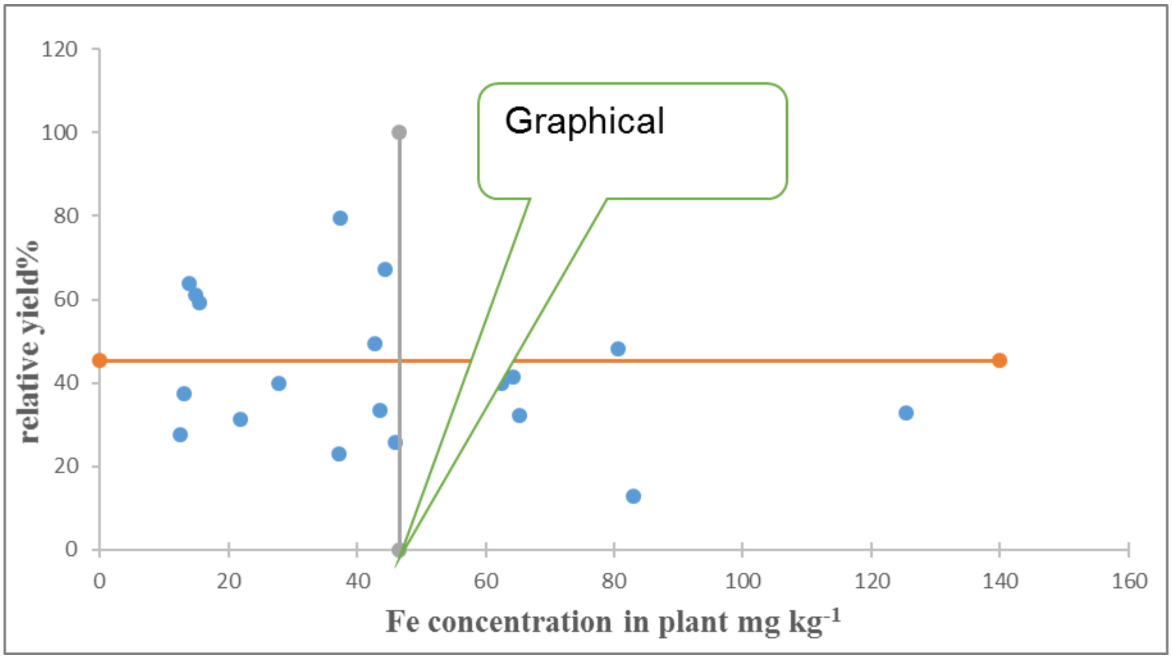

Figure (1a): Critical level of Iron in wheat plants (graphical method).

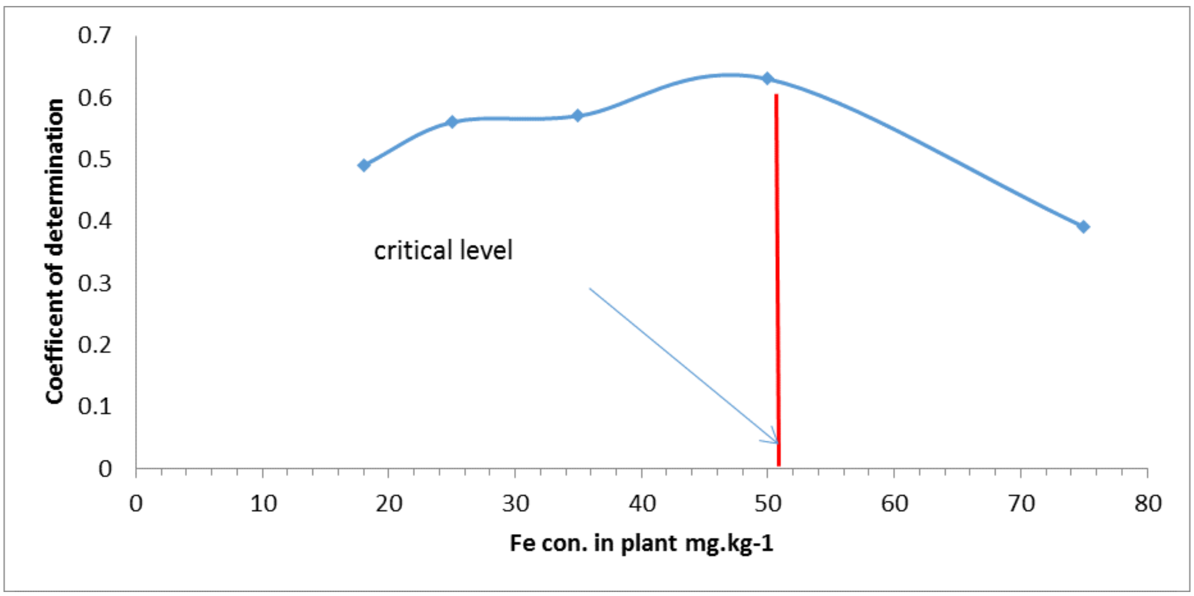

Figure (1b): Critical level of Iron in wheat plants (statistical method)

Table (6): Effect of locations on iron concentration and relative yield % (R.Y.%) of wheat.

Locations	Fe concentration in plant mg kg^{-1}	Relative yield%
Qlyasan	27.76	39.93
Bazyan	14.97	61.16
Bakrajo	42.80	39.84
Serwan	62.49	39.86
Baynjan	15.44	59.14
Halbja	13.05	37.39
Keli	83.02	12.74
SaidSadiq	13.83	63.76
Kalar	12.56	27.57
Kifri	45.90	25.63
Penjwen	79.64	100
Qaldza	80.51	48.26
Ranya	125.38	32.86
Chamchamal	37.12	23.08
Darbandekhan	21.89	31.34
Kanipanka	37.42	79.49
Zrgwez	64.21	41.57
Tasloja	44.29	67.09
Dukan	43.58	33.47
Mawat	65.21	32.33

CONCLUSIONS :

The statistical method was more accurate than graphical method for estimation Fe critical level for wheat plant and soil .

The critical level of soil Fe was (2.50) $mgkg^{-1}$ using graphical method and (2.61) $mgkg^{-1}$ depending on statistical method for the studied soils in Sulaimani.

The critical level of Fe for wheat crop was (46.55 and 50.50) $mg\ kg^{-1}$ depending on graphical method and statistical method respectively.

RECOMMENDATIONS:

According to the results of this investigation the following recommendations were recommended:

-Comparison between Iron critical level under field condition and pot -experiment for different plants in Kurdistan region at different growth stages.

-Comparing the Iron critical level in outdoor and indoor experiments.

-Studying the critical level of iron for different plants.

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