Kurdistan Regional Government

Ministry of Higher Education & Scientific Research

University of Sulaimani

Faculty of Agricultural Sciences

DETERMINATION OF IRON CRITICAL LEVEL FOR SULAIMANI SOILS CULTIVAITED WITH WHEAT (*Triticum aestivum L.*).

A Thesis
Submitted to the Council of the Faculty of Agricultural Sciences at the University of Sulaimani in Partial Fulfillment of the Requirements for the Degree of Master of science
In
Soil and water sciences

[Soil Fertility]

By

Sazan Fathi Sharef

B.Sc. in Soil Science (2001) - University of Sulaimani

Diploma in Supplementary Irrigation (2009), Field Crop Department - University of Sulaimani

Supervised By

Prof. Dr. Akram O. Esmail

2716 K. **2016 A.D.**

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

﴿لَقَدْ أَرْسَلْنَا رُسُلَنَا بِالْبَيِّنَاتِ وَأَنْزَلْنَا مَعَهُمُ الْكِتَابَ وَالْمِيزَانَ
لِيَقُومَ النَّاسُ بِالْقِسْطِ ۖ وَأَنْزَلْنَا الْحَدِيدَ فِيهِ بَأْسٌ شَدِيدٌ
وَمَنَافِعُ لِلنَّاسِ وَلِيَعْلَمَ اللَّهُ مَنْ يَنْصُرُهُ وَرُسُلَهُ بِالْغَيْبِ ۚ إِنَّ
اللَّهَ قَوِيٌّ عَزِيزٌ﴾

صدَقَ الله العَظِيم

سورة الحديد الاية((25))

Acknowledgment

First of all, I want to express my gratitude and thank to almighty and merciful Allah for providing me with the capability to complete this work.

I must offer my profoundest gratitude to my advisor professor Dr. Akram O. Esmail. For finding an appropriate subject in the beginning to the process of writing this Thesis.

I would like to express my sincere gratitude to Kurdistan Region Government, Ministry of Higher Education and Scientific Research and presidency of Sulaimani University. Thanks to Dr. Karzan Tofiq Mahmood the Dean of the Faculty of Agricultural Sciences and Dr. Omar Ali Fattah, the Head of Soil and Water Sciences Department for supporting and facilitating everything related to the accomplishment of this thesis.

Special thanks to the presidency of Sulaimani Polytechnic University .Thanks to Dr. Kamil S. Saeed the Dean of the Agricultural Technical Institute in Bakrajo.

I would like to express my thanks to my lovely, dear husband Soran, lovely Sons and my brothers especially Zhwan, sisters, for their supports during the study.

DEDICATION

I WOULD LIKE TO DEDICATE THIS THESIS STUDY TO

My beloved mother.

The loving memory of my father.

My husband.

My sisters and brothers.

My sons" lavand and lass".

My teachers.

My friends.

To all those whom, endless support and encouragement assist me in completely this thesis.

SAZAN

SUMMARY

The objective of this study was to determine critical level of iron in 20 agricultural locations , Qlyasan, Bazyan, Bakrajo, Serwan, Baynjan, Halbja, Keli, SaidSadq, Kalar, Kfri, Penjwen, Qaladza, Ranya, Chamchamal, Darbandekhan, ,Kanipanka, Zrgwez , Tasloja , Dukan, and Mawat cultivated with wheat crop in Sulaimani governorate during the winter growing season of 2014-2015 from 1/12/2014 to 12/6/2015 , the experiment was conducted at the center for the agricultural research farm of Bakrajo ,with GPS reading of location is between 35^0, 32', 134" North latitude and 45^0, 22' , 879" East longitude.

Factorial pot experiment was conducted at Bakrajo Agricultural Research Farm to test the effect of five levels of irons (0, 2, 4, 6 and 8) mg Fe kg^{-1} using Fe- EDDHA, contains 6% Fe and 20 soils using complete randomized design (CRD) with three replications on growth, yield and quality of wheat then limiting Fe critical level of the tested soils and wheat plant.

Wheat (*Triticum aestivum L)* seeds have been planted in plastic pots of 13 kg capacity and irrigated whenever needed depending on weighting methods, the plants were harvested on 12/6/2015.

The main results can be summarized as follows:

1. The value of initial iron in the soils was between (1.66-3.96) mg Fe kg^{-1} soil, recorded in Zrgwez and Tasloja locations.
2. The maximum weight of wheat dry matter was (77.5) g pot^{-1} obtained from the application rate (6) mg Fe kg^{-1} in Bazyan location.

3. The location show significant effect on dry matter weight at ($P\leq0.01$) level, the highest value was recorded in Penjwen location with mean of (68.52) g pot^{-1} while the lowest value was recorded in Keli location with the mean of (11.97) g pot^{-1}.
4. Increasing levels of Fe applications caused increase in Fe concentration of wheat grains, the highest value was (73.23) mg Fe kg^{-1} seed recorded in application rate 6 mg Fe kg^{-1} soil, while the lowest value was (62.14) mg Fe kg^{-1} observed in rate 2 mg Fe kg^{-1}. The location also significantly affected on Fe concentration, the highest value was (164.40) mg Fe kg^{-1} seed recorded in Said Sadiq location, while the lowest value was (16.23) mg Fe kg^{-1} seed obtained in Penjwen, On the other hand the highest value was (184.66) mg Fe kg^{-1} seed recorded in treatment combination of S_6Fe_5**.** While the lowest value was (7.01) mg Fe kg^{-1} seed obtained in treatment combination of S_4Fe_4.
5. Increasing levels of applied iron caused increase in protein concentration of wheat grain, the highest value was (174.16) mg kg^{-1} seed recorded at application of 8 mg Fekg^{-1} soil, while the lowest value was (169.32) mg kg^{-1} seed observed in control. The location also significantly affected on protein concentration, the highest value was (201.33) mg kg^{-1} seed recorded in Qaladza location, while the lowest value (131.52) mg kg^{-1} seed was obtained in Kalar location, On the other hand the highest value (205.90**)** mg kg^{-1} seed was recorded from treatment combination of $S_{12}Fe_5$, while the lowest value was (119.50) mg kg^{-1} seed obtained in treatment combination of S_5Fe_0**.**
6. The concentration of Fe in wheat straw affected significantly by levels of applied Fe. Its highest value was (51.03) mg Fe kg^{-1} straw recorded in application rate (4) mg Fe kg^{-1} soil, while the lowest value was (39.86) mg Fe kg^{-1} straw obtained in control treatment. The location affected significantly on iron concentration, the highest value was (125.38) mg Fe kg^{-1} straw recorded in Kfri location, while the lowest value was (12.56) mg Fe kg^{-1} straw obtained in soil Kalar. On the other hand, the highest value (236.47) mg Fe kg^{-1} straw was

recorded in treatment combination of $S_{13}Fe_2$. While the lowest value (11.02) mg Fe kg^{-1} straw was obtained at treatment combination of S_6Fe_1.

7. Increasing levels of Fe application caused increase in P concentration of wheat straw the highest value (7.05) mg g^{-1} straw was recorded in application of 6 mg Fe kg^{-1} soil, while the lowest value (2.08) mg g^{-1} straw was observed in application (2) mg Fe kg^{-1} soil. The location affected significantly on P concentration, the highest value (4.53) mg g^{-1} straw was recorded in soil number 19. While the lowest value (2.16) mg g^{-1} straw was obtained in soil number 7. On the other hand, the highest value (5.40) mg g^{-1} straw was recorded in treatment combination of S_4Fe_3, while the lowest value (1.80) mg g^{-1} straw was obtained in treatment combination of S_7Fe_0.
8. The critical level of Iron was 2.5 mg Fe kg^{-1} for the studied soils in Sulaimani governorate using graphical method and 2.61 mg Fe kg^{-1} soil depending on statistical method.
9. The critical level of Iron for wheat plant was (46.55 and 50.50 mg Fe kg^{-1} plant) depending on graphical and statistical method respectively.

List of Contents

List of Tables

List of Figures

List of Abbreviations

CEC ....Cation exchange capacity

Cmolc....................Centimole of charge

CNC................. .....Critical Nutrient Concentration

CNR...................... Critical Nutrient Range

$dS.m^{-1}$.....................decisiemns per meter

DTPA..................Diethylene triamine penta acitic acid

ECe.......................Electric conductivity of extract

EDDHA-Fe.........Ethylene diamine di (o-hydroxyphenyl acetic acid)-Fe

EDTA................. Ethylene diamine tetra acetic acid

GPS.....................Global Positioning System

IKR..................... Iraq Kurdistan Region

Mole....................Mole

N..........................Normality

NH_4OAC............Ammonium acetate

OM.....................Organic Matter

RLSD................. Revised Lest Significant Difference

R^2 ....Coefficient of determination

SPAD.................Soil and Plant Analyzer Development

TEA....................Tri ethanolamine

1. INTRODUCTION

Wheat (*Triticum aestivum L.*) is a monocotyledon member of Poaceae family. It is an herbaceous annual plant. Wheat is probably the first crop plant which is domesticated and cultivated by human, in modern world it is the most important food crop in all over the world. There are a large number of wheat cultivars which adapted to different climatic conditions and that is why it is being cultivated in nearly all over the world (Khodabandeh; 2008, Noormohammadi *et al*.; 2007). Wheat is the most important cereal crop and it is the third major cereal produced in the world, following maize and rice (FAO, 2013). In Iraq wheat ranked first in terms of planted area, in 2009 the cultivated area was 1.26 million $ha^{-1}$and total production was 1.7 million tons with an average yield of 1.347 ton ha^{-1} (Iraqi Agriculture Static, 2010).

Micronutrients deficiency especially Fe is widely spread on calcareous soil with high pH values, low OM content and high equivalent calcium carbonate content that make soil Fe unavailable or low available for plants (Narimani *et al*., 2010, Abadía *et al*., 2011., Li and *et al*., 2016). Iron plays major role in many plant functions. These function includes respiration, photosynthesis processes, chlorophyll development, energy transfer within the plant, a component in nitrogen fixation (Eskandari; 2011). There are numerous factors affecting Fe availability like high pH, high soil calcium carbonate content, accumulation of phosphorus (P) and imbalance of nutrients in soils, critical physio-chemical state of soils (Lindsay and Schwab, 1982)

Since there is little or no studies about Fe-critical level for wheat production in calcareous soils in Sulaimani, IKR, the study aimed to:

1- The effect of levels of Fe- chelate on growth, yield and quality of wheat.

2- Determination critical level of Fe in the main agricultural soils in Sulaimani.

3- Determination the critical level of Fe for wheat plant.

2. REVIEW OF LITERATURE

2.1. Iron role in plant

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 (Havlin *et al*., 2014).

2.2 Forms of iron in soil

Iron is the fourth of the most abundant element in the earth's crust and in most types of soil occurs in excess. This element can exist in aqueous solution in two states: Fe^{2+} and Fe^{3+}; however, Fe^{3+} forms are not readily utilizable by plants and microbes because they often form insoluble oxides or hydroxides which limit bioavailability (Zuo and Zhang, 2011). Among Fe pedogenetic forms of crystalline Fe (hydro) oxides, goethite (α-FeOOH) and hematite (α-Fe_2O_3) are the most abundant minerals in well-drained soil. Other Fe oxides may exist in poorly drained soil as crystalline minerals (lepidocrocite, maghemite, and magnetite), or short-range ordered crystalline minerals (ferrihydrite and ferroxite) or non-crystalline precipitates (Cornell and Schwertmann, 2003). The general factors governing the behavior of Fe are the redox potential (i.e). Oxidizing or reducing conditions) and pH. Neutral pH conditions promote the precipitation of poorly ordered.

Fe minerals (ferrihydrite), whereas reducing and acid conditions promote the mobilization of Fe minerals. Goethite and hematite are characterized by high stability (lower solubility) in the most habitual Eh–pH soil conditions. At a specific value of pH, Fe oxides (hematites) and hydroxides (goethite) produce the same Fe concentration in a solution, while ferrihydrite only at a much lower Eh. However, in spite of their lower stability, metastable forms such as lepidocrocite and ferrihydrite often occur in many soils, particularly in younger soils characterizing the nonequilibrium state in the pedo-environment as cold climate and acidic soils (Schwertmann , 1988).

Small amounts of Fe minerals can also be found in reducing conditions in acid soil like pyrite (FeS_2) or in alkaline soil like siderite ($FeCO_3$). Many crystalline and poorly ordered Fe species may interact with soil components such as inorganic and organic colloids to form even more complex aggregates with new surfaces **(**Colombo and Torrent, 1991).

The solubilization of Fe from soil mineral sources is a slow process regulated by pH and by the dissolution–precipitation phenomena of both crystalline and poorly ordered Fe-hydroxide minerals (Mengel *et al*., 1994; Lindsay, 1988). The solubility product of Fe carbonates is 3.2×10^{-11} whereas the solubility product of Fe $(OH)_3$ is 4×10^{-38} (Lindsay and Schwab, 1982). Therefore, the species of Fe in the soil environment could be summarized in the following:

(1) Fe^{++} in primary minerals; (2) Fe^{+++} in secondary minerals, as Fe crystalline minerals and poorly ordered crystalline (hydro) oxides; (3) soluble and exchangeable

Fe; and (4) Fe bound to organic matter in soluble or insoluble forms that is, 104 –105-folds lower than that required for an optimal growth of plants (Römheld and Marschner, 1986). Its availability is crucial for their growth, under aerated conditions and pH values above 7, It has been estimated that the total concentration of inorganic Fe species in the soil solution is around $10^{-10}M$ (Boukhalfa and Crumbliss, 2002).

2.3. Factors influencing iron availability in soils for plants:

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 **(**Mengel *et al*., 2001).

2.3.1. Bicarbonate:

The most prevalent cause of Fe chlorosis in the Mediterranean area is the bicarbonate ion, which occurs in high levels in calcareous soils (Jaegger *et al*., 1999). Iron deficiencies in agricultural crops are commonly associated with calcareous soils (Tagliavini and Rombola, 2001**)**; the high level of bicarbonate ions in the soil affects metabolic processes in roots and leaves, decreasing soil and plant Fe availability Mengel (1995), leading to the condition known as lime-induced Fe chlorosis.

Under oxidizing soil conditions, soluble ferric and ferrous salts react rapidly with calcium carbonate to form solid Fe-hydroxides as represented in the following reactions **(Loeppert, 1986)**:

$4Fe_2^+ + O_2 + 4CaCO_3 + 2H_2O \rightarrow 4FeOOH + 4Ca_2^+ + 4CO_2$ ………. (1)

$2Fe_3^+ + 3CaCO_3 + 3H_2O \rightarrow 2Fe\ (OH)_3 + 3Ca_2^+ + 3CO_2$ .... (2)

The formed compound depends on the reactive surface area of calcium carbonate, and on the partial pressures of O_2 and CO_2. At pH lower than 7.4, ferrihydrite ($Fe_2O_3.nH_2O$) is the dominant form; between pH 7.4 and 8.5 goethite (FeOOH) is (Eq. 1), and at pH higher than 8.5 ferric hydroxides Fe $(OH)_3$ were formed (Lindsay, 1995).

According to Lindsay and Schwab (1982), for each increment of one unit in pH value the ionic iron solubility drops thousand times. Within the pH range of most calcareous soils the concentration of dissolved iron is approximately 10^{-10} *M*, considerably less than the range of values (10^{-4} to 10^{-8} *M*) required for optimum plant growth (Haleem *et al*., 1995).

2.3.2. Calcium carbonate:

Iron deficiency is a worldwide agricultural problem on calcareous soils with low-Fe availability due to high soil pH (Ishimaru *et al*., 2007). Calcium carbonate has dominate influence on any system in which it is present due to its high buffering capacity, basicity and relatively high solubility compared to the most components. Calcium carbonate provide a reactive surface which acts as a sink for protons during acid /base reactions involving dissolved Fe species in the soil solution (Abd EL-Haleem, 1996). AL- Malak, (1986) found that total and active $CaCO_3$ plays an important role in decreasing Fe availability to corn plant. Singh and Dahiya, (1975) found that chemical available Fe was decreased with increasing of $CaCO_3$ .They also reported that increasing level of $CaCO_3$ of the soil causes decrease in some forms of iron (exchangeable and available); the decrease in exchangeable iron was probably from the release of Ca^{+2} from hydrolysis of $CaCO_3$ as explained in the following equation:

$$2Fe^{3+} + 3\ CaCO_{3+}H_2O \longrightarrow 2FeOOH+3Ca^{2+}+3CO_2$$

The decrease in the other forms of iron might be due to oxidation of soluble – native and added iron through direct reaction with $CaCO_3$. Total lime is another criteria to predict Fe chlorosis development. While the fine, clay-sized, fraction of active $CaCO_3$ is more reactive (Drouineau, 1942) and maintain high levels of HCO_3 in the soil solution (Inskeep and Bloom, 1986).

2.3.3. Soil pH:

Iron deficiency is a well-documented problem in cultivated soils and it is affectts seriously yield quantity and nutritional quality of crops, particularly in alkaline soils (Aciksoz *et al*., 2014). The solubility of Fe- bearing minerals is controlled by dissolution – precipitation equilibria and it is dependent on soil pH and Ionic strength. Iron (Fe) is very insoluble in aerobic conditions at neutral and alkaline pH. At neutral pH, the solubility of Fe^{+3} dropped very fast. At pH neutral, Fe oxides reach a minimum solubility near 10^{-10} *M* (Barker and Pilbeam, 2007).

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. (Robin *et al*, 2008).

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.

Calcareous soils are strongly buffered in the pH range near 8.0 where Fe reaches its minimum solubility; hence Fe chlorosis is appropriately referred to as lime-induced chlorosis (Lindsay, 1995).

2.3.4. Redox potential:

The solubility of Fe^{+3} is usually controlled by the most soluble oxide present; thus, freshly precipitated amorphous magnetite or siderite. Soil-Fe $(OH)_3$ is the most soluble Fe^{+3} oxide and generally the activity of Fe^{+3} and the solubility of Fe^{+2} in soils, depending on redox and CO_2 (Bodek, 1988). Under oxidizing conditions (pe + pH > 11.5), soil-Fe $(OH)_3$ (which is intermediate in solubility to amorphous hydroxide and crystalline oxide) controls the solubility; Below 11.5, magnetite (Fe_3O_4) is the stable phase until siderite ($FeCO_3$) forms, as determined by the partial pressure of CO_2 (g) (Lindsay, 1979).

2.3.5. Iron interaction with other nutrients:

High levels of iron compounds in soil are known to greatly decrease trace metal uptake (Mengel *et al*., 2001). Iron chlorosis can also be induced or enhanced by other nutrients, such as nitrogen, magnesium, phosphorus, calcium, manganese, zinc and copper. High levels of other micronutrients (manganese, copper and zinc) may impair iron nutrition. Due to metals competition with Fe for ligands both in soils and plants (Wallace *et al*., 1992). Manganese can substitute for Fe in catalase and peroxidase, as found in citrus (Lavon and Goldschmidt, 1999).

Depending on their concentration, zinc and copper can competitively inhibit access of Fe to chelators, thereby decreasing Fe uptake from soil (Alva and Chen, 1995).Several studies conducted by Wallace *et al*., (1992) indicated the interaction between phosphorus and Fe in both soils and plants, especially in calcareous soils.

2.3.6. Microorganisms:

The existence of microorganisms found in the rhizosphere or it is application through inoculation may have a good role in improving Fe availability and Fe uptake (Khan, 2005). Microorganisms respond to Fe deficiency with production of specific microbial Fe (III) chelating agents, known as siderophores (Illmer, 2006). Microorganisms can create small anaerobic pockets and release siderophores, which chelate Fe and increase its bioavailability (Masalha *et al*., 2000). These mechanisms are especially important when Fe in solution is scarce, such as in calcareous soils (Marschner, 1991).

2.3.7. Organic matter (OM):

Soil OM has the significant influence on iron levels in soil, Fe levels decreases as OM decreases (Douglas, 2002). Organic sources not only helps in increasing Fe solubility by providing chelates but also stimulate the microbial activities which results in powerful sidersphore production (O'Hallorans *et al*., 2005).

2.4. Critical level:

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.” Fageria and Baligar, (2005) defined critical value as follow:

1-The concentration that is just deficient for maximum growth.

2-The point where the growth is 10% less than the maximum.

3-The concentration where plant growth begins to decrease.

4-The lowest amount of the element in the plant accompanying the highest yield.

Somani and Kanthalyia, (2004) defined the critical level as the concentration level of any nutrient below, which planted show deficiency symptoms and would respond to the application of that nutrient. Black, (2000) defined the critical concentration as the most commonly used concept in relating plant composition to nutrient sufficiency in plants. Cox *et al*., (1984) indicated that the concentration that represents the division between responsive and non –responsive conditions is termed “critical level”. Wolt, (1994) critical concentration is definable as the inflection along the intensity response curve leading to the maximum response. The measurement and the response function from which this critical level is the frequently identified as the inflection along the adown word-declining asymptotic response function.

Critical plant nutrient concentration or level or optimum concentration". It has been defined in various ways as follow: Ulrich, (1952) it is the narrow range of concentration at which growth rate or yield begins to decline in comparison to plants at a higher nutrient level. Tyner, (1947) is the concentration which is just adequate for maximum growth. Jones, (1970) defined it as the concentration above which sufficiency occurs.

Factors that influence the critical level are known to be: chemical and physical properties of soils, available nutrient concentration, plant properties, interaction with other nutrient, and method of extraction, pH, time of extraction and temperature of extraction (Lindsay and Norvell, 1978).

2.5. Iron critical level in soil and plant:

Olsen and Carlson (1950), reported that the critical level of Fe which 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).

The critical level of available Fe content extracted by three methods of extraction DTPA+NH_4HCO_3, DTPA+$CaCl_2$ $_+$ TEA and EDTA+$(NH_4)_2CO_3$ in Kurdistan soils were (14, 13 and 2.8) mg Fe kg^{-1} respectively (Mohammad, 2006). The critical level of Fe availability in 20 calcareous soils of Mesopotamian in Iraq was 6.19 mg Fe kg^{-1} which extracted by DTPA+$CaCl_2$ (Jarallah, 2005). Feiziasl *et al*., (2009) reported that critical level of iron in West Azerbaijan, East Azerbaijan, Kurdistan and Kermanshah Provinces of Iran was (4.7) mg Fe kg^{-1}. Meena *et al.*, (2013) Recorded that the critical level of Fe in Indian soils was (4.67) mg Fe kg^{-1}.

There are several researches about critical level of Fe in plant. Critical nutrient level for plant influence by many factors (plant species, genes, family, plant organ, growing stage and method of extraction (Havlin *et al*., 1999).

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 contents 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}. The critical limit of Fe in Oats was 40 mg Fe kg^{-1} (Loop and Finck 1984).

2.7. Critical nutrient concentration (CNC) and critical nutrient range (CNR):

The (CNC) critical nutrient concentration is defined as the concentration that is just deficient for the maximum growth. Critical nutrient range (CNR) is the concentration between just deficient for maximum growth and just adequate for the maximum growth, on the other hand (CNC) is that portion in nutrient response curve where the plant nutrient –concentration changes from deficient to adequate –below which crop yield, quality or performance is not satisfactory. While the (CNR) is the concentration between just adequate for the maximum growth (Das, 2003). Jones (2001) classified Fe concentration in soil as:

1. 0-5 mg Fe kg^{-1} (very low).
2. 6-10 mg Fe kg^{-1} (low).
3. 11-16 mg Fe kg^{-1} (medium).
4. 17-25 mg Fe kg^{-1}(very high)

Assessment of Fe critical levels in 42 calcareous soils, detected by AB-DTPA through separating plots, the graphical method, the Cate and Nelson 3-classical, and the Chi-square method gave quite similar results. The Fe critical level as estimated using AB-DTPA was ranged from (3.4 to 4.8) mg Fe kg^{-1}soil (Al-Mustafa *et al*., 2001).

2.7. Methods for determining nutrient critical level:

The methods for determining nutrient critical level are:

2.7.1. Cate–Nelson (1965) analysis is a technique traditionally used in agronomy, particularly to calibrate soil test data to an expected crop response this method include two techniques:

2.7.1.1. Graphic technique:

Graphic technique which described by Cate-Nelson, (1965) has two dimensions, which explains the relationship between the relative yield and the nutrient concentration in soils. The relative yields were plotted on the Y- axis against the soil test values on the X-axis, then a transparent overlay with vertical line and an intersecting horizontal line is positioned so as to maximum the number of points in the second and fourth quadrants (counting in clockwise direction). The soil test value corresponding to the location of the vertical line is taken as the critical value that best separates the high responding group of experiments on the right from the low-responding group on the left.

2.7.1.2. Statistical technique:

The statistical technique mentioned in the second publication by Cate and Nelson, (1971) one calculated the corrected sum squares of deviation of observed yield or other biological values on the Y-axis from the means of the population on the left and rights of an arbitrarily placed vertical line representing atrial or postulated critical value. This information is used to calculate the Proportion of the total variance of biological value (R^2) that is calculated by dividing the observation into two groups at the postulated critical value.

The value of coefficient of determination (R^2) changes according to the postulated critical value and reaches a maximum where it meets the statistical critical value. The purpose of Cate-Nelson methods is to separate the data into groups with maximum statistical homogeneity within groups .The Cate-Nelson methods may be used to find critical level of both soil test and plant tissue tests ,this method is consider continuum to graphical method depending upon ANOVA table.

2.7.2 .Plant response column order procedure:

In plant response column order procedure, soil numbers or experimental locations and soil micronutrient amount (before applying of fertilizer treatments) is drawn in column figure in X and Y axis, respectively, columns of X axis is ordered upon rising order of soil micronutrient amount in Y axis. In this condition, columns in X axis can be divide in two main parts Singh and Takkar, (1981). The first part (Columns) include the soils in which plant or crop show positive and significant response to applied micronutrient at $p \leq 5\%$ and this part is named as Response or Deficient part. The second part include the soils that which plant and crop did not show any significant response to applied micronutrient and also in these soils, the crop did not show any micronutrient deficiency symptom. This part is named as Non-response or Sufficient part in order to separate the deficient and sufficient parts or determining micronutrient critical level in the soil, a line from end of response (deficient) part is draw to Y axis and the critical level is detect in cross point of line with X axis. In this method response and non-response of dry land crop to micronutrient fertilizers is the base on classifying them to deficient and sufficient groups at Probability 0.05. But existing of marginal region between deficient and sufficient groups caused that boundary between deficient and sufficient groups is in doubt, thus interaction Chi-square statistical procedure or contingency tables can be used to solve this problem, which determine independency of soil testing groups (Feiziasl, 2006). For this purpose, grouping of data and calculation of chi-square value by contingency table based on observation number related to deficient and sufficient part (fault and trust) is done by using soils of end part of deficient zone which has characteristic of deficient soils (response to applied fertilizer) continually. Statistical procedure or contingency tables was used to solve this problem, which determined independency of soil testing groups (Rezaei, 2007).

2.8. Methods of iron extraction:

Available forms of Fe in soil can be assessed through the use of chemical extraction methods. Soil test provide an indication of nutrient level in the soil and together with plant analysis are important agronomic tools for determination crop nutrient needs (Eteng and Asawalam, 2015).

Generally, soil extractants used for predicting available forms of micronutrients in soils included the weak replacement in ion salts ($CaCl_2$, NH_4OAC, etc...) Whitney (1988), Kabata- Pendias (2001). Weak acids (acetic acid and hydrochloric acid), (Shittu *et al.,* 2010), and weak chelating agents; EDTA Aggrawal and Sastry (1995), and DTPA Lindsay (1995). EDTA can used successfully as extractant for estimating mobile forms of Fe in soils of different types whereas, DTPA was observed to be unsuitable for use as extractant in acid soils (Norvel, 1984).

A positive correlation between the nutrient concentration that is determined by the method and nutrient quantity which is taken up by plants, is fundamental proper choice of an extraction method of soil test analysis (Adiloglu, 2003). The use of acid extractants is based on lowering the pH and the compounds containing these elements (Dahnke and Olson, 1990). On the other hand, chelating extractants have the capacity of reducing the activity of dissolved metals, resulting in release of more soluble compounds in buffering pH (Adiloglu, 2003).

There is substantial variations in the amount of extractable Fe in the soil, available Fe varied widely depending on the extraction method .The reasons may be due to type, concentration, pH, shaking time and solution ratio of the extraction solution (Whitney, 1988), also availability it's related to the physical and chemical properties of the soils, (Loeppert and Iskeep, 1996; Elinç, 1997). The amount of available iron content extracted by DTPA +$CaCl_2$ in 24 calcareous soil samples ranged between (1.2 to 7.2) mg Fe kg^{-1} soil in Northern Iraq (Al-Obaddi *et al*., 1994). While the amount of available iron content extracted by NH_4OAC from four calcareous soils in Erbil ranged between (16.55 and 20.12) mg Fe kg^{-1} soil (Al-Malak, 1986). Studying 20 soil samples from Iraq indicated that the available Fe content extracted by DTPA+$CaCl_2$; DTPA+NH4HCO_3; NH4OAC and HCl ranged between (0.47-11.91) ;(4.07-16.12) ;(0.16-1.12) and (0.14-0.87) mg Fe kg^{-1} soil respectively (Jarallah, 2005).

Average extracted Fe values by EDTA+ NH_4OAC,DTPA+NH_4HCO_3, DTPA+ $CaCl_2$+TEA, NH_4OAC, EDTA+$(NH_4)_2CO_3$, and HCl+H_2SO_4 methods were (17.62, 16.64, 14.29, 4.47 ,2.71,and 1.68) mg Fe kg^{-1} soil, respectively (Mohammad, 2006).

Available Fe extracted by DTPA+ $CaCl_2$ in a medium black calcareous clay soil is 3.0 mg Fe kg^{-1} soil (Tupatkar and Sonar, 1995). The result of study conducted in Indian on 756 soil samples showed that the Available Fe extracted by DTPA+$CaCl_2$+TEA ranged between" (4.20 to 360.0) mg Fe kg^{-1} soil with average of (71.9) mg Fe kg^{-1} soil (Sakal *et al*, 1986).

3. MATERIALS AND METHODS

3-1: Soil preparation

Soil samples were collected from twenty different locations in Sulaimani Governorate (Qlyasan, Bazyan, Bakrajo, Serwan, Baynjan, Halbja, Keli, Said Sadiq, Kalar, Kifri, Penjwen, Qaldza, Ranya, Chamchamal, Darbandekhan, Kanipanka, Zrgwez, Tasloja, Dukan and Mawat) as shown in figure (1) and table (1). The samples were taken from soil surface (0-30) cm depth, which consider as the active zone for plant root (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.

Figure (1): The locations of studied soils in Sulaimani governorate.

Table (1): Soil sampling location names 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**

3-2: Soil physical and chemical analysis

The physical and chemical analysis were done on the (2) mm sieving samples, which included the following:

3-2-1- Physical analysis

The physical analysis included determination of the following properties.

3-2-1-1: Particle size distribution

The particle size distribution of the soil was determined according to the international pipette method as described in Klute (1986).

3-2-1-2: Percent of moisture content at field capacity (F.C)

The percent moisture at field capacity was estimated using the model prepared by Karim (1999) according to the following equation:

FC=13.28+0.397* Clay%

3-2-2: Chemical analysis

The chemical analysis were conducted as follows:

3-2-2-1: Electrical conductivity (EC)

Electrical conductivity of the soil saturated extract was measured using an EC-meter (model CM-205 and adjusted to 25°C) according to Hesse (1971).

3-2-2-2: Soil pH

The pH of the soil saturated extract was measured with pH-meter model (332 JENWAY) as mentioned by Jackson (1973).

3-2-2-3: Organic matter

The organic matter was determined by Walkly and Black method (wet digestion) as described by Jackson (1973).

3-2-2-4: Carbonate and bicarbonate ($CO_3^{=}$, HCO_3^{-})

These were determined by titrimetric method using (0.01*N*) HCl and phenolphthalein and methyl orange indicators according to Richards (1954).

3-2-2-5: Equivalent calcium carbonate ($ECaCO_3$)

Which involves the dissolution of carbonate in excess of HCl (2*M*), as followed by back titration with (0.1*M*) NaOH as described in Black (1982).

3-2-2-6: Total nitrogen (N)

Total nitrogen was determined by the Kjeldahl method as mentioned by Black (1982).

3-2-2-7: Phosphorous (P)

Extractable phosphorous (P) has been extracted by Olsen's method using ($NaHCO_3$ 0.5*M* at pH8.5) then determined spectrometrically as described in **Rowel (1996).**

3-2-2-8: Iron (Fe)

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).

3-2-2-9: Calcium and magnesium (Ca^{2+}, Mg^{2+})

Calcium and Magnesium are determined by titrimetric method using 2Na-EDTA (0.01*N*) as described in Jackson (1973).

3-2-2-10: Sodium and potassium (Na^{+}, K^{+})

Sodium and potassium were determined by using (corning flame photometer) according to Hesse (1971).

3-2-2-11: Chloride (Cl^{-})

Chloride determined titremetrically by Mohr method according to Baruah and Barthakue (1999).

3-2-2-12: Sulphate (SO_4^{2-})

Indirect determination of combined Ca and Mg by titration with (0.01*N* EDTA) according to Jackson (1973).

3-2-2-3-13: Cation exchange capacity (CEC)

Determined by using (1 *N*) NaOAC then substitution by (1*N*) NH_4OAC according to Hesse (1971).

3-3: Biological experiment

3-3-1: Pot experiment

The pot experiment was conducted as follow:

3-3-1: Packing pots:

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.

3-3-2: Cultural details:

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 limit critical level of Fe in the studied soil and cultivated wheat, 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 effects 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 plant thin to 8 in each 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 (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 the dried plant material were grounded and stored for chemical analysis which mentioned previously.

3-4: Preparing plant samples for analysis:

3-4-1: Drying plants:

Before oven drying the samples at 65^0 C the plants were cleaned with reusing D.W then air dried and placed in paper bags. After drying, they were homogenized, ground and then stored in airtight plastic bags.

From the compost samples, sub-samples were taken for analysis of nutrients (N, P and Fe). The analysis was carried out in Taran-Accredited Laboratory Institute of Standard and Industrial Research of Iran.

3-4-2: Digestion of plant samples:

Plant sample were digested according to (Schuffelen and Schauwenburg, 1961) using (1:1 conc.H_2O_2: H_2SO_4).

3-4-5: Nitrogen determination:

Total nitrogen was determined by the Kjeldahl method as mentioned by Jones (1991).

3-4-6: Phosphorous determination:

Total P was determined in plant straw using Spectrophotometer (ECOM6122, Eppendorf)) at 660 nm wave length (Reuter *et al.*, 1997).

3-4-7: Iron determination:

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.

3-4-8: Protein determination:

Protein content of seed was calculated by equation described by Fujihara *et al*, (2008) by multiplying total nitrogen by a factor of 5.81 (protein = N%*5.81)

The studied parameters were:

1- Grain yield ($g.pot^{-1}$).
2- Weight of dry matter ($g.pot^{-1}$).
3- Plant height (cm)
4- Chlorophyll content (SPAD)
5- Weight of 1000 seed ($g.pot^{-1}$).
6- Number of spikes per plant.
7- Number of seeds per plant.
8- Iron concentration in the plant (straw and seed) mg Fe kg^{-1}
9- leaf area after flowering was determined depending on model as mentioned by Thomas, (1975) as follow:

Leaf area (cm^2) = (Length * width) of leaf *0.95.

3-5:-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).

3-6: 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 technique as mentioned in detail in review of literature.

3-6-1: Graphic method:

The critical level of Fe in soil and plant tissue were determined by plotting relative yield against Fe concentration Cate and Nelson (1965). According to this procedure two perpendicular lines, one parallel to the X- axis and other to the Y- axis were drawn, so that there as minimum number of observations in the upper left hand and the lower right hand quadrants. The intersection of the line perpendicular to the X-axis was taken as the critical level (Shuman *et al*.1980).

3-6-2: Statistical technique:

In this method (R^2) was calculated by using the following equation as mentioned by (Cate and Nelson, 1971):-

$$\mathbf{R^2 = TCSS-(CSS_1+CSS_2)/TCSS}$$

R^2= square for postulated critical level.

TSS= Total corrected sum of square.

CSS1=Corrected sum of square of deviation from mean (population I)

CSS2=Corrected sum of square of deviation from mean (population ∏)

n1= Number of points in first group.

n2= Number of points in second group.

n= Number of total points (n1+n2).

CSS1= $\Sigma yi2 - [(yi)^2/n1]$

CSS2= $\Sigma yi2 - [(yi)^2/n2]$

TCSS= $\Sigma yi2 - [(yi)^2/n]$

4. RESULTS AND DISSCUION

4.1 Soil characteristics

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 range of sand, silt and clay percentage for the studied soils were between (103.10 and 523.60), (234.00 and 520.50) and (159.40 and 612.90) mg kg^{-1} soil respectively. 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) ds $m^{-1,}$ 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, with the mean value of (27.66) $cmol_c kg^{-1}$ 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} with mean of 18.36 g kg^{-1}, it mean that most of the soil have low organic matter content, while some of them have high OM content or more than 12.8 g kg^{-1}(Baruah and Barthakur,1999).

Active lime was ranged between (8.40 - 67.20) g kg^{-1} with a mean value of (40.88) g kg^{-1}. The total $CaCO_3$ was between (31.70-325.30) g kg^{-1} with mean of (177.95) g kg^{-1} it means most of the soils are very calcareous (contains more than 100 g kg^{-1} $CaCO_3$) and soil of locations SaidSadq and Penjwen are slightly calcareous (contain less than 50 g kg^{-1} $CaCO_3$), (Hodgason, 1976).

Table (2): Some physical and chemical characteristics of studied soil sample collected from different locations in Sulaimani, IKR

Locations	Sand	Silt	Clay	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	
	g kg^{-1} soil										Active	Total
Qlyasan	137.10	366.00	496.90	Clay	31.38	34.50	20.73	7.70	0.86	22.70	61.60	214.20
Bazyan	215.60	520.50	263.90	Silt loam	17.97	24.50	15.23	8.05	1.05	24.80	67.20	198.30
Bakrajo	103.10	370.50	526.40	Clay	32.78	33.78	24.49	8.26	0.55	19.40	67.20	253.90
Serwan	137.10	279.50	583.40	Clay	35.01	34.46	20.34	7.72	0.86	8.60	36.40	202.30
Baynjan	137.10	328.50	534.40	Clay	32.44	33.74	24.37	8.08	1.36	11.50	56.00	325.30
Halbja	203.10	345.50	451.40	Clay	28.87	30.08	18.95	7.80	0.87	24.10	61.60	190.40
Keli	523.60	317.00	159.40	Silt loam	10.05	22.64	9.32	8.17	0.60	7.00	8.40	87.30
SaidSadiq	128.10	259.00	612.90	Clay	38.61	38.90	28.16	7.68	0.77	26.90	14.00	31.70
Kalar	446.20	355.90	197.90	Loam	12.40	21.98	12.62	7.98	0.95	9.10	28.00	313.40
Kifri	328.10	351.00	320.90	Clay loam	19.71	27.55	17.21	7.56	1.27	9.20	47.60	261.80
Penjwen	278.10	370.50	351.40	Clay loam	22.40	26.84	18.76	8.36	0.63	18.00	14.00	119.00
Qaldza	127.10	296.50	576.40	Clay	36.45	35.72	25.88	7.85	0.59	27.10	50.40	162.60
Ranya	112.10	328.50	559.40	Clay	34.37	36.24	26.18	7.95	0.69	16.30	30.80	119.00
Chamchamal	144.10	384.00	471.90	Clay	28.86	24.11	23.61	8.04	0.89	12.30	61.60	265.80
Darbandekhan	298.60	304.50	396.90	Clay loam	24.17	28.75	21.36	8.03	0.73	9.30	39.20	249.90
Kanipanka	148.60	279.50	571.90	Clay	36.50	38.27	26.09	7.86	1.22	29.80	30.80	31.70
Zrgwez	287.10	391.00	321.90	Clay loam	20.52	24.85	14.91	7.24	4.30	16.60	42.00	91.20
Tasloja	153.10	334.00	512.90	Clay	33.97	32.78	20.34	7.69	0.98	38.70	39.20	126.90
Dukan	369.10	234.00	396.90	Clay loam	24.57	28.32	21.55	7.96	0.90	11.60	44.80	218.20
Mawat	219.10	254.50	526.40	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	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Cl^{-}	HCO_3^{-}	CO_3^{-}	$SO_4^{=}$	Fe^{2+} ($mg\ kg^{-1}$) extractable
	$mmol_c\ L^{-1}$								
Qlyasan	5.80	2.60	0.27	0.93	3.40	3.70	trace	2.50	3.09
Bazyan	5.00	3.40	0.89	2.87	4.20	3.10	0.80	4.06	2.18
Bakrajo	3.60	0.80	0.14	1.41	1.80	1.30	trace	2.85	2.74
Serwan	5.20	2.80	0.14	1.66	3.20	4.00	trace	2.59	3.68
Baynjan	6.80	3.60	0.27	2.79	8.60	2.90	0.80	1.16	2.15
Halbja	6.60	1.20	0.27	0.97	3.00	2.50	1.20	2.34	2.42
Keli	4.20	1.20	0.14	0.93	1.60	2.70	trace	2.17	1.70
SaidSadq	3.80	4.20	0.23	1.25	2.80	4.50	trace	2.18	2.79
Kalar	5.60	3.20	0.62	1.13	2.20	5.30	trace	3.05	2.96
Kifri	8.00	5.20	0.37	2.22	3.00	7.10	trace	5.69	2.12
Penjwen	3.20	3.20	0.18	0.81	2.40	1.90	0.80	2.29	1.80
Qaldza	3.00	3.20	0.09	0.69	2.60	2.50	trace	1.88	2.51
Ranya	4.00	4.60	0.30	0.69	3.40	0.90	trace	5.28	2.83
Chamchamal	6.00	3.60	0.27	1.21	1.60	5.70	trace	3.79	2.13
Darbandekhan	3.80	2.20	0.25	1.57	3.00	1.70	trace	3.13	1.93
Kanipanka	9.80	4.60	0.21	1.49	3.00	9.70	trace	3.40	2.98
Zrgwez	3.60	9.80	0.55	1.33	2.40	27.90	trace	17.38	1.66
Tasloja	8.00	2.60	0.37	1.13	3.70	5.10	trace	3.30	3.96
Dukan	6.40	2.20	0.25	1.17	4.00	3.90	0.80	1.32	2.26
Mawat	3.80	3.20	0.14	0.93	2.80	1.90	1.20	2.17	2.12

In soil samples concentration of DTPA –extractable Fe was ranged between (1.66-3.96) mg Fe kg^{-1} with the mean of (2.50) mg Fe kg^{-1} (table,3**)** which was less than the adequate amount of Fe in calcareous soils (4) mg Fe kg^{-1} as stated by Soltanpour and Schwab (1977).

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^{+}, this may be due to the chemical compositions and geological formation of the studied locations.

The high concentration of HCO_3^{-} were recorded in10 locations, and the high concentration of Cl^{-} were obtained in Keli locations, while the highest concentration of SO^{-}_4 was recorded in locations Bakrajo (table, 3), this may be due to the reasons mentioned before.

4.2 Pot experiment

4.2.1 Response of wheat to Fe – fertilizer

1- Effect of different iron levels, soil locations and their interactions on dry matter weight:

The results in (table, 4) indicates to the significant effect of applied Fe levels on dry matter weight. The highest mean value (41.26) g pot^{-1} was recorded from the second treatment (2 mg Fe kg^{-1}) which ranged between (9.81- 77.09) g pot^{-1}, while the lowest mean value was (37.30) g pot^{-1} recorded from the 5 th treatment (8 mg Fe kg^{-1}) which ranged from (13.51-77.3) g pot^{-1}. (Figure, 2) shows non-significant negative correlation between dry matter weight and levels of applied iron with the correlation coefficient of (r= - 0.68).

Table (4) shows that the soil location significantly affected on the dry matter weight of wheat at ($P \leq 0.01$), the highest mean value (68.52) g pot^{-1} of the dry matter was obtained from Penjwen location, and the lowest value (11.97) g pot^{-1} of dry matter was recorded in Keli location. This may be attributed to the differences in some of the chemical and physical properties of the studied soils like OM, $CaCO_3$, CEC and soil texture, in Penjwen location 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 Keli the OM, active lime, total $CaCO_3$, CEC was (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 location was affected significantly ($P \leq 0.01$) on dry matter weight of wheat, the highest value (77.55) g pot^{-1} was recorded in treatment combination Bazyan at application 6 $mgFekg^{-1}$ soil, while the lowest value

(9.31) g pot^{-1} was recorded from treatment combination Keli at control. This may be due to individual effect of the studied factors due to the large variation between Keli and Bazyan in physical and chemical properties like, texture, OM, active and total lime, CEC, EC, Ca^{+} and Fe concentration. In Keli location the soil texture was silty loam and OM, active and total lime, CEC, EC, Ca^{2+} and Fe^{2+} concentration were (7 $mgkg^{-1}$ soil, 8.40 g kg^{-1} soil, 87.30 g kg^{-1} soil, and 10.05 Cmolc.kg $soil^{-1}$, 0.60 $dS.m^{-1}$, 4.20 $mmolc.l^{-1}$, 1.70 mg kg^{-1}) respectively, while in Bazyan location the texture was silt loam and OM, active and total lime, CEC, EC, Ca^{2+} and Fe^{2+} concentration was (24.80 mg kg^{-1} soil, 67.20 g kg^{-1} soil, 198.30 g kg^{-1} soil, and 17.97 Cmolc.kg $soil^{-1}$, 1.05 dSm^{-1}, 5.00 $mmolc.l^{-1}$, 2.18 mg kg^{-1}) respectively (table 2 and 3).

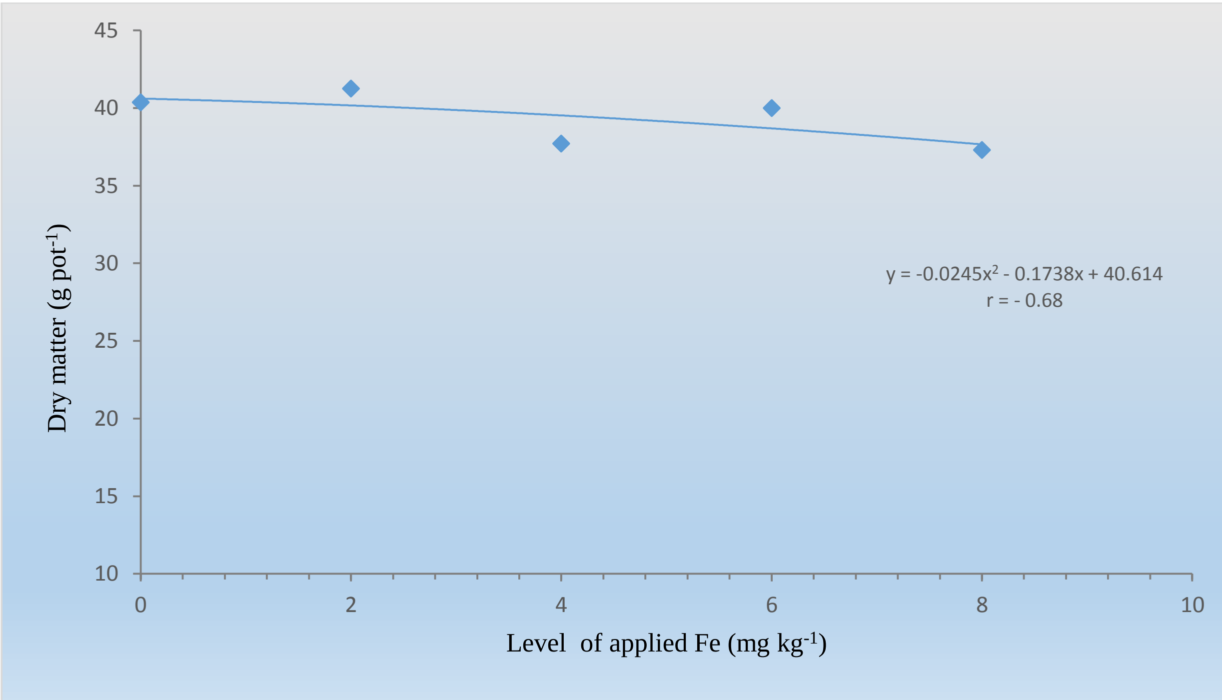


Figure (2): Relationship between levels of applied Fe fertilizer and dry matte weight

Table (4): Effect of iron levels, soil locations, and their interactions on dry matter of wheat (g pot $^{-1}$)

Location	Levels of applied Fe (mg Fe kg^{-1} soil)					Dry matter Average g.pot^{-1}	Relative Yield %
	Fe 0	Fe 2	Fe 4	Fe 6	Fe 8		
	Dry matter weight (g pot^{-1})						
Qlyasan	42.99	31.97	27.10	33.08	30.06	33.04	48.21
Bazyan	58.69	66.93	49.59	77.55	77.35	63.19	92.21
Bakrajo	40.09	38.49	35.53	40.33	34.14	37.71	55.04
Serwan	22.89	25.42	38.12	26.39	38.01	30.16	44.02
Baynjan	46.67	42.09	68.00	38.52	34.62	45.98	67.10
Halbja	36.51	37.07	32.07	34.44	36.14	37.71	55.04
Keli	9.31	9.81	15.45	11.80	13.51	11.97	17.47
Saidsadq	55.94	46.33	31.93	51.26	39.47	37.11	54.15
Kalar	22.35	20.63	23.84	19.04	17.08	20.58	30.04
Kfri	27.92	23.14	20.40	21.84	18.58	22.37	32.65
Penjwen	62.11	68.85	73.78	68.36	69.52	68.52	100.00
Qaldza	58.67	57.44	54.13	56.45	54.05	56.14	81.92
Ranya	24.68	33.91	42.73	39.63	31.04	34.39	50.18
Chamchamal	20.50	18.36	19.41	15.84	25.28	19.87	28.99
Darbandekhan	34.31	28.58	36.31	18.77	21.78	27.75	40.49
Kanipanka	73.03	77.09	53.73	61.37	44.97	62.03	90.52
Zrgwez	34.24	57.97	26.60	46.75	48.21	42.55	62.09
Tasloja	**75.70**	53.36	25.68	62.45	55.08	54.47	79.49
Dukan	37.96	58.47	25.68	46.10	41.06	44.63	65.13
Mawat	22.84	30.42	40.44	30.23	16.15	28.01	40.87
Average	40.37	41.26	37.72	40.01	37.30	38.91	56.78

*****RLSD$_{.01}$ Fe=0.67, RLSD$_{.01}$Soil=0.42, RLSD$_{.01}$ interactions Fe*Soil = 2.10

2 - Effect of iron levels, soil locations and their interactions on grain yield of wheat:

Table (5) indicate 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}. 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. Figure (3) explains the non-significant negative correlation which recorded between levels of applied Fe and grain yield with the correlation coefficient value of (r = - 0.57). This results agree with those found by Mohsin, (2013).

Table (5) shows that the soil locations has significant effect at ($P\leq0.01$) level 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 of 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 was (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.

Table (5): Effect of Iron levels, soil locations, and their interactions on grain yield ($g\ pot^{-1}$) of wheat.

Locations	Levels of applied Fe ($mg\ Fe\ kg^{-1}$ soil)					% Grain ratio (Fe0/Fe8)*100	Yield % (Yield /highest of yield)
	Fe0	Fe2	Fe4	Fe6	Fe8		
	Grain $g\ pot^{-1}$						
Qlyasan	13.45	9.94	8.68	10.99	9.78	141.77	39.93
Bazyan	16.97	16.78	10.61	17.26	18.80	90.26	61.16
Bakrajo	13.97	11.45	12.03	14.90	12.57	111.13	39.84
Serwan	4.31	8.58	12.29	15.34	11.90	36.21	39.86
Baynjan	16.32	15.21	23.09	15.23	7.92	206.06	59.14
Halbja	9.49	12.26	8.76	10.31	8.34	113.78	37.39
Keli	2.61	3.11	4.42	3.50	3.14	83.12	12.74
Saidsadq	17.44	17.96	11.68	19.21	17.51	99.60	63.76
Kalar	8.08	8.66	8.13	6.77	4.64	174.13	27.57
Kfri	8.08	6.46	6.48	6.94	5.77	140.03	25.63
Penjwen	31.10	21.55	26.33	24.87	27.62	112.84	100
Qaldza	11.52	13.52	12.26	11.45	14.72	78.26	48.26
Ranya	6.13	9.27	12.01	10.85	4.97	123.39	32.86
Chamchamal	6.33	5.81	5.76	4.77	7.69	82.31	23.08
Darbandekhan	10.78	8.15	10.66	6.33	5.28	204.16	31.34
Kanipanka	29.08	28.02	11.25	20.89	15.30	190.06	79.49
Zrgwez	7.73	17.04	7.83	11.36	10.96	70.52	41.57
Tasloja	21.14	18.46	8.77	20.89	18.94	111.16	67.09
Dukan	7.29	12.06	5.66	11.76	7.63	95.54	33.47
Mawat	7.58	9.02	12.31	8.58	5.47	138.57	32.33
average	12.47	12.66	11.2	12.61	11.09		45.30

***RLSD**$_{.01}$ Fe=0.42, RLSD$_{.01}$Soil=0.35, RLSD$_{.01}$ interactions Fe*Soil = 1.25

The interaction between Fe levels and soil locations was significantly affected on grain yield of wheat at ($P \leq 0.01$) level, the highest value of grain yield (29.08) g pot^{1} was recorded from treatment combination Kanipanka lactation at control while the lowest value (2.61) g pot^{-1} was recorded from treatment combination Keli 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 like, texture, OM, active and total lime, CEC, EC, Ca^{2+} and Fe^{2+} concentration. In Keli the soil texture was silty loam, OM, active and total $CaCO_3$, CEC, EC, Ca^{2+} and Fe^{2+} concentration 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}, 0.60 dS.m^{-1}, 4.20 mmolc.l^{-1}, 1.70 mg kg^{-1}) respectively, while in soil of Kanipanka the texture was clay ,OM, active and total $CaCO_3$, CEC, EC, Ca^{2+} and Fe^{2+} concentration were (29.8 mg kg^{-1} soil, 30.80 g kg^{-1} soil, 31.70 g kg^{-1} soil, and 36.50 Cmolc.kg soil^{-1}, 1.22 dS.m^{-1}, 9.80 mmolc.l^{-1}, 2.98 mg kg^{-1}) respectively (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).

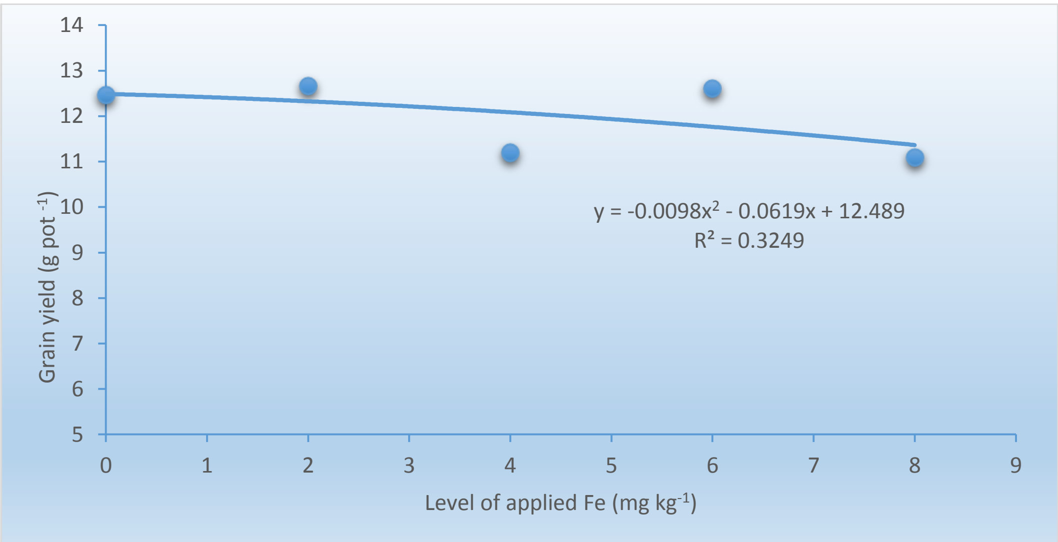


Figure (3): Relationship between level of Fe fertilizer and grain yield weight (g pot $^{-1}$) of wheat

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

Figure (4) indicate 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)**.

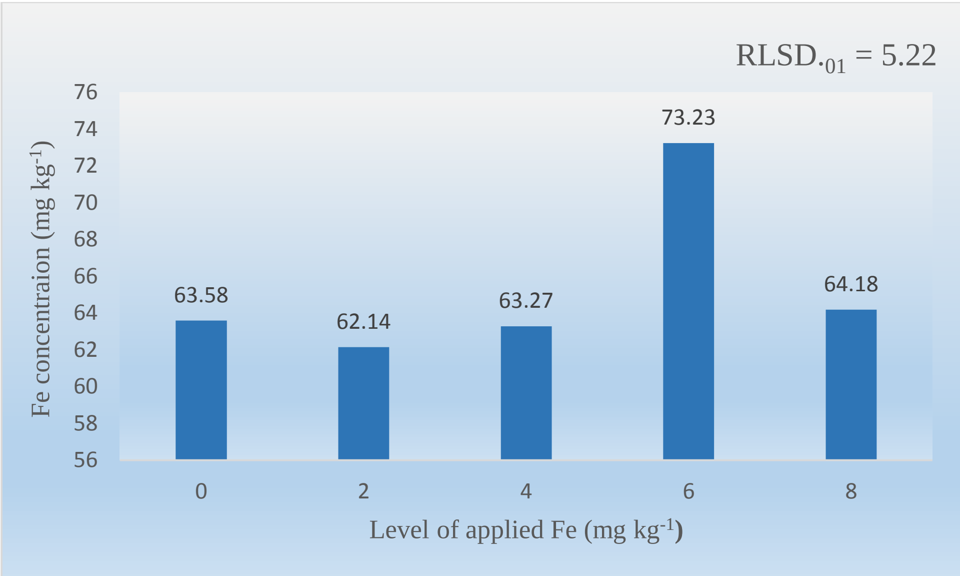


Figure (4): Effect of iron application on iron concentration in wheat grains

Figure (5) represent the significant effect of soil type at ($P \leq 0.01$) on Fe concentration in grain wheat. Statistical analysis showed the highest value of Fe concentration 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 observe 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} recorded from combination Halbja location at application 8 mg kg^{-1}, while the lowest values of Fe was (7.01) mg Fe kg^{-1} were recorded from treatment combination Serwan allocation at 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. In additional to the combination between the studied factors it may create different condition for plant growth. 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.

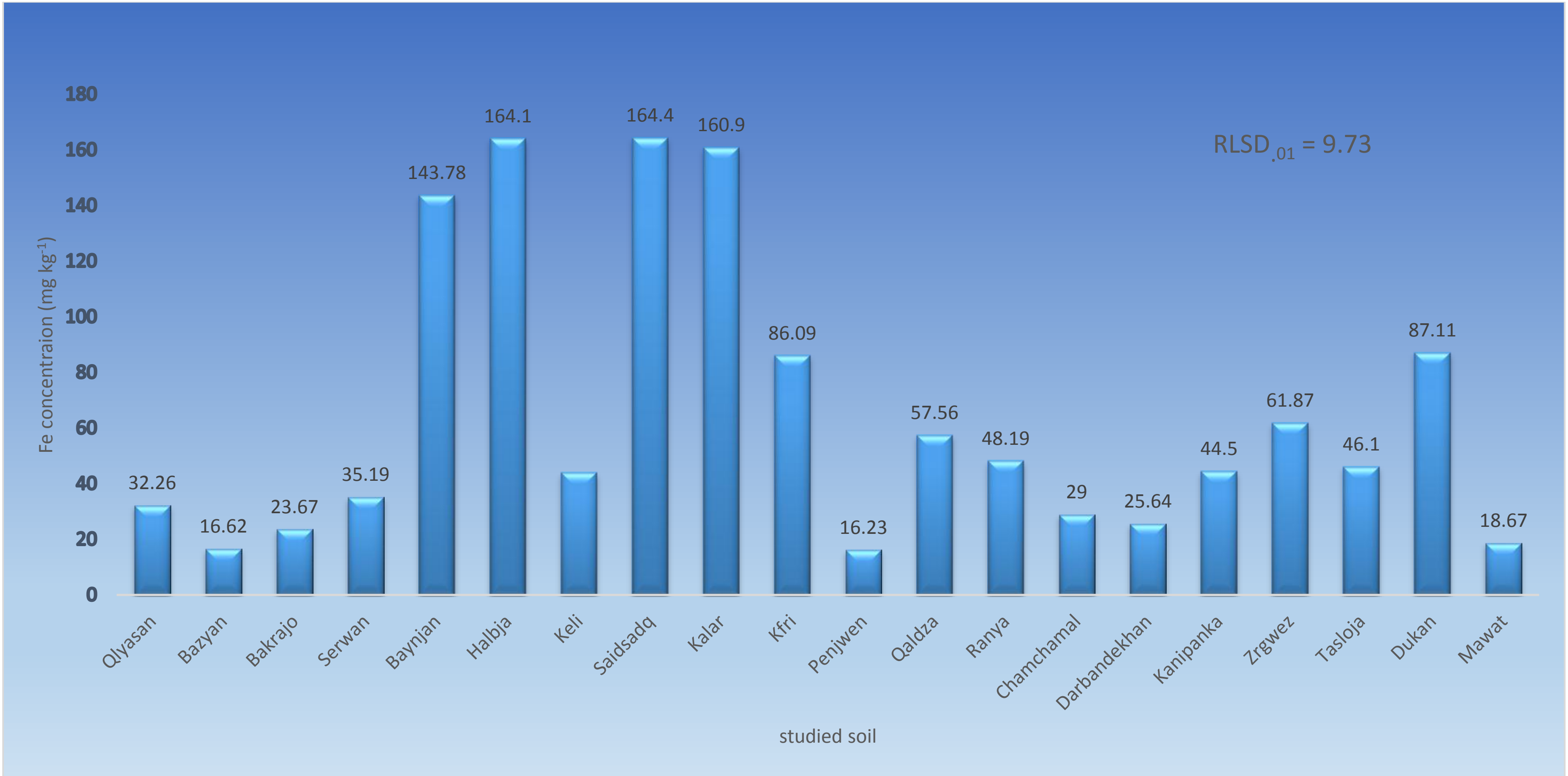


Figure (5): Effect of soil types on iron concentration in wheat grains.

Table (6): Effect of interaction between soil types and iron levels on iron concentration in wheat grains

Soil locations	Levels of applied Fe (mg Fe kg^{-1} soil)				
	Fe0	Fe2	Fe4	Fe6	Fe8
Qlyasan	75.49	36.10	16.90	22.65	10.20
Bazyan	14.93	15.70	16.30	15.50	19.70
Bakrajo	17.45	28.35	14.18	44.35	14.02
Serwan	8.74	16.55	10.00	**7.01**	133.35
Baynjan	145.60	137.87	142.66	138.53	163.66
Halbja	144.50	149.83	164.50	177.00	**184.66**
Keli	35.45	67.85	40.23	44.72	31.53
Saidsadq	153.66	163.66	166.50	170.33	167.83
Kalar	148.00	159.00	165.66	169.66	162.16
Kfri	139.51	53.81	35.40	129.50	72.22
Penjwen	22.01	18.70	16.66	12.40	11.40
Qaldza	54.43	39.76	80.43	74.63	38.55
Ranya	74.71	35.38	32.97	73.25	24.67
Chamchamal	9.50	26.70	24.65	36.25	47.85
Darbandekhan	30.70	16.05	25.83	42.79	12.83
Kanipanka	7.15	23.75	35.75	109.15	46.70
Zrgwez	54.51	31.89	98.39	76.34	48.25
Tasloja	44.65	38.85	81.15	36.90	28.95
Dukan	68.22	164.42	85.17	62.43	55.33
Mawat	22.41	18.55	12.20	20.30	18.87
$RLSD_{.01}$	6.25				
Effect	**				

4 - Effect of Iron levels, soil locations and their interactions on protein concentration in wheat grains:

Figure (6) show the significant effect of levels of applied Fe on protein content of wheat seeds. The highest values were recorded from application 8 mg Fe kg^{1}, while the lowest values were recorded from Fe_0 (control). This may be to the role of iron in chlorophyll formation, then increase in nitrogen absorption and protein formations (**Mengle *et al*., 2001**).

The locations (soils) also affected significantly on protein concentration of seeds. The highest values of nitrogen and protein was (201.33) mg kg^{-1} recorded in Qaldza location, while the lowest values was (131.52) mg kg^{-1} recorded in Kalar location (figure, 8). This variation in protein concentration between Qaldza location and Kalar location attributed to some soil physical and chemical properties like soil texture, CEC, Active and Total $CaCO_3$, OM, EC and Ca^{2+} concentration in soil solution. The texture of Qaldza location was clay while for Kalar location was loam, CEC. Active and total $CaCO_3$, OM, EC and Ca^{2+} concentration in Qaldza were (36.45 Cmolc.kg $soil^{-1}$, 50.40 g kg^{-1} soil, 313.46 g kg^{-1} soil, 27.1 mg kg^{-1} soil, 0.59 $dS.m^{-1}$ and 3.0 $mmolc.l^{-1}$) respectively. While CEC, active and total $CaCO_3$, OM, EC and Ca^{+2} concentration in Kalar were (12.40 Cmolc.kg $soil^{1}$, 14 g kg^{-1} soil, 31.70 g kg^{-1} soil, 9.1 mg kg^{-1} soil, 0.95 $dS.m^{-1}$ and 5.60 $mmolc.l^{-1}$) respectively. Similar results were obtained by **Shahrokhi *et al*., (2012**).

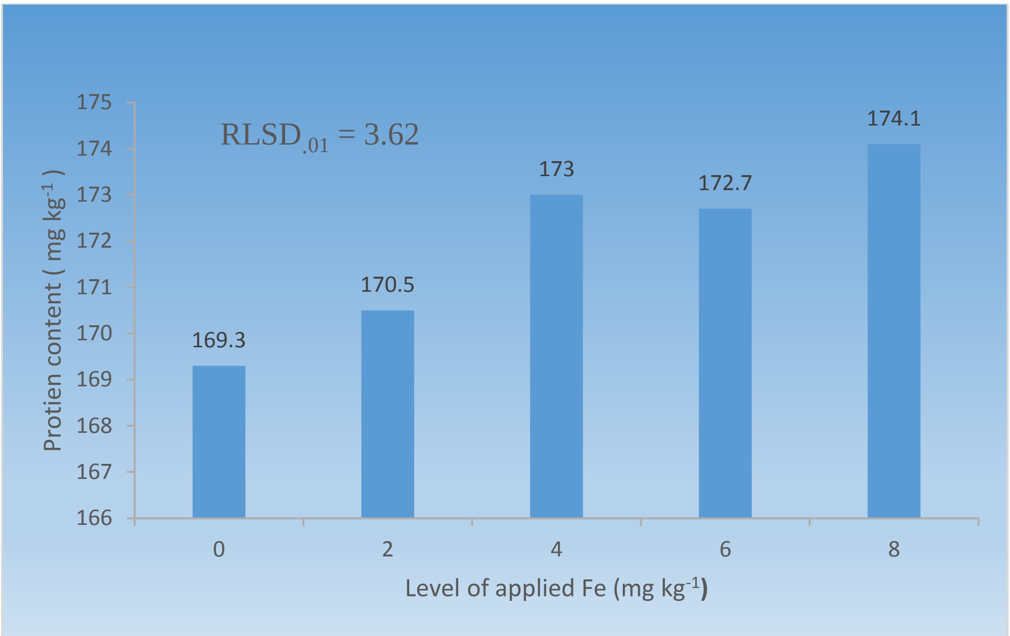


Figure (6): Effect of applied iron on protein concentration in wheat grains.

The interaction between Fe levels and soil location has significant effect on protein content of wheat grains (Table, 7). The highest values was (205.90) mg kg^{-1} recorded from treatment combination Qaladza at application 8mg Fe kg^{-1} and the lowest values was (119.50) mg kg^{-1} recorded from treatment combination Baynjan at control treatment respectively. It may be related to various conditions that may effect on protein contents like, carbonate calcium, OM, CEC, pH, EC and Ca^{2+} in soil. Calcium Carbonate, OM, CEC, pH, EC and Ca^{2+} in soil of Qaldza location were (162.6g kg^{-1} soil, 27.1 mg kg^{-1} soil, 36.45 Cmolc.kg $soil^{-1}$, 7.85, 0.59 $dS.m^{-1}$ and 3.0 $mmolc.l^{-1}$) respectively. While the values of them in soil of Baynjan location were (325.3 g kg^{-1} soil, 11.5 mg kg^{-1} soil, 32.44 Cmolc.kg $soil^{-1}$, 8.08, 1.36 $dS.m^{-1}$ and 6.80 $mmolc.l^{-1}$) respectively.

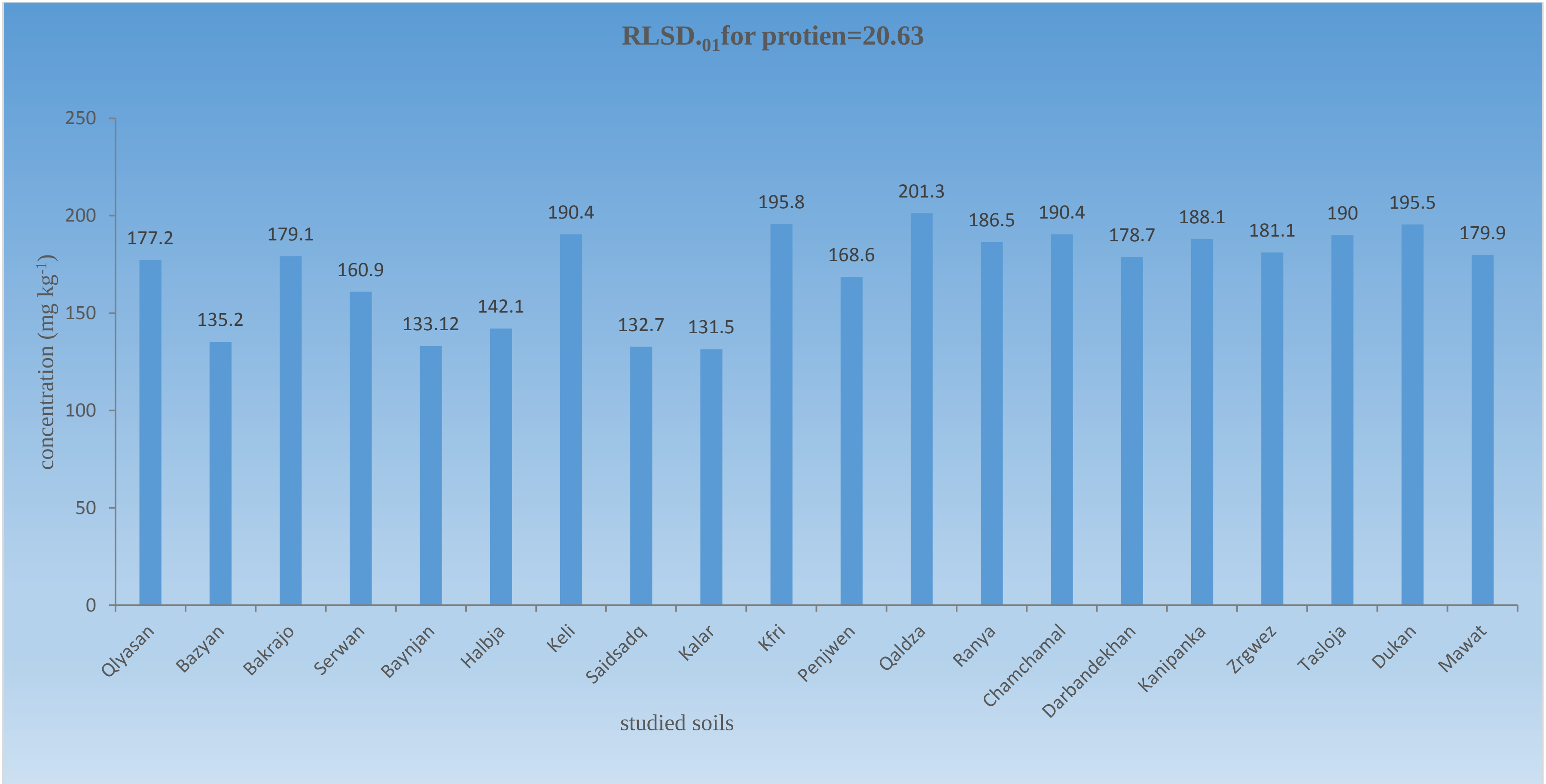


Figure (7): Effect of soil types on protein concentration in wheat grains.

Table (7): Effect of interaction between iron levels and soil types on protein concentration in wheat grains.

Soil locations	Protein mg kg^{-1}				
	Fe0	Fe2	Fe4	Fe6	Fe8
Qlyasan	172.90	176.80	178.70	176.80	180.70
Bazyan	146.50	130.00	132.30	133.10	134.00
Bakrajo	180.70	178.70	182.60	176.80	176.80
Serwan	161.30	163.20	161.30	153.50	165.10
Baynjan	119.50	128.40	138.30	137.50	141.60
Halbja	127.20	131.10	146.10	152.70	153.50
Keli	184.60	190.40	194.30	190.40	192.30
Saidsadq	130.20	131.90	133.50	131.80	136.00
Kalar	128.60	127.00	128.80	136.00	137.00
Kfri	190.40	194.30	198.20	198.20	198.20
Penjwen	161.30	169.00	169.00	167.10	176.80
Qaldza	198.20	196.20	202.10	204.00	205.90
Ranya	188.50	186.50	184.60	184.60	188.50
Chamchamal	186.50	190.40	192.30	190.40	192.30
Darbandekhan	178.70	176.80	180.70	178.70	178.70
Kanipanka	186.50	188.50	188.50	190.40	186.50
Zrgwez	178.70	182.60	180.70	182.60	180.70
Tasloja	190.40	188.50	190.40	192.30	188.50
Dukan	194.30	198.20	196.20	196.20	192.30
Mawat	180.70	180.70	180.70	180.70	176.80
$RLSD_{.01}$	30.20				
Effect	**				

5- Effect of iron levels, soil locations and their interactions on iron concentration in wheat straw:

The concentration of iron in wheat straw affected significantly by levels of applied Fe. The highest value (51.03) mg Fe kg^{-1} straw was recorded from application of (4) mg Fe kg^{-1} soil, while the lowest value (39.86) mg Fe kg^{-1} straw was obtained from control treatment, (Figure, 8). It is appear that the applications of Fe to a certain level caused increase in Fe concentration. Or it means that the concentration of Fe in control treatment was less than critical level of iron in wheat straw (40-42) mg kg^{-1}, for this reason the wheat plant responded to Fe application.

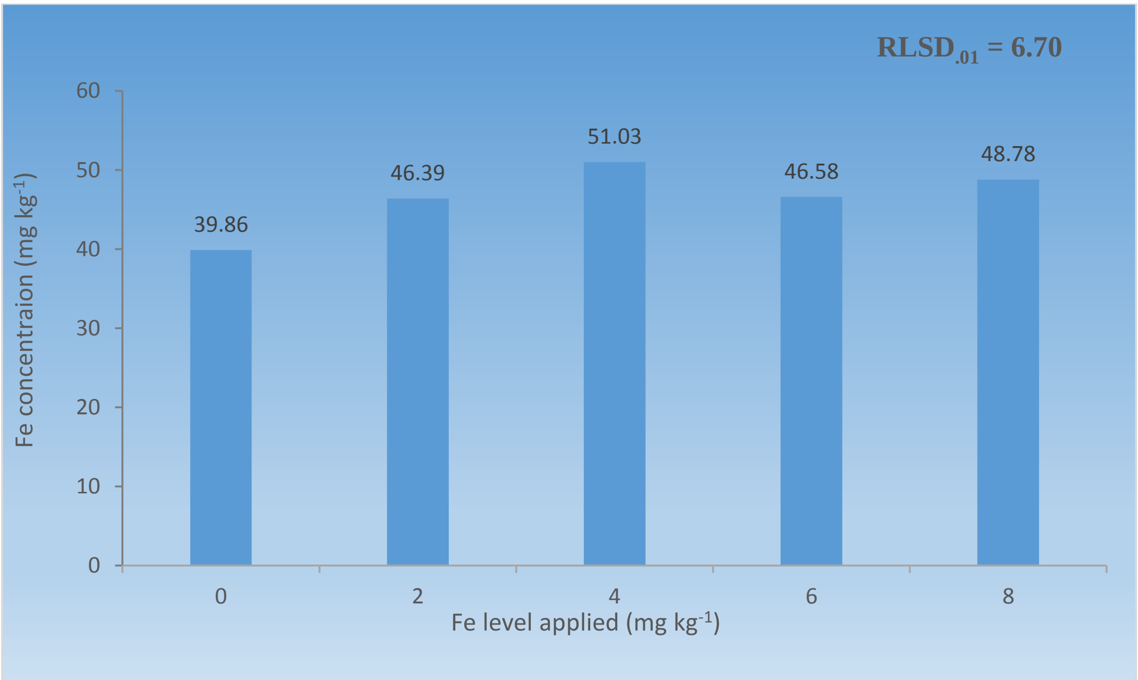


Figure (8): Effect of iron levels on iron concentration in wheat straw.

(Figure, 9) explains the significant effect of soil type at ($P \leq 0.01$) on Fe concentration in wheat straw. The highest value (**125.38)** mg Fe kg^{-1} straw was recorded in Ranya location, while the lowest value (**12.56)** mg Fe kg^{-1} straw was recorded in Kalar location. It observe from this results that there are differences in carbonate calcium, CEC, OM and texture between soil of Ranya and Kalar. In soil of Ranya the texture is clay while texture of Kalar location was loam, carbonate calcium, CEC and OM for soil of Ranya location were (119.0 $g.kg^{-1}$ soil, 34.37 Cmolc.kg $soil^{-1}$ and 16.30 $mg.kg^{-1}$ soil) respectively .while for Kalar were (313.40 g kg^{-1} soil, 12.40 Cmolc.kg $soil^{-1}$ and 9.10 mg kg^{-1} soil) respectively.

The interaction between Fe levels and soil types has significant effect on Fe concentration in wheat straw at ($P \leq 0.01$) level as shown in table (8).The highest value was (236.47) mg Fe kg^{-1} recorded in treatment combination of Ranya location at application of 2 mg $Fekg^{-1}$ and the lowest value (11.02) mg Fe kg^{-1} was recorded in treatment combination of Halbja at control. This may be attributed to the variation in iron concentration of the studied soils, Fe in Ranya location was more than critical limit while iron content in Halbja location was less than the critical limit (table, 3). It means the combination between the two studied single factors created different conditions for plant growth, nutrient availability and uptake **(Darwesh, 2007)**.

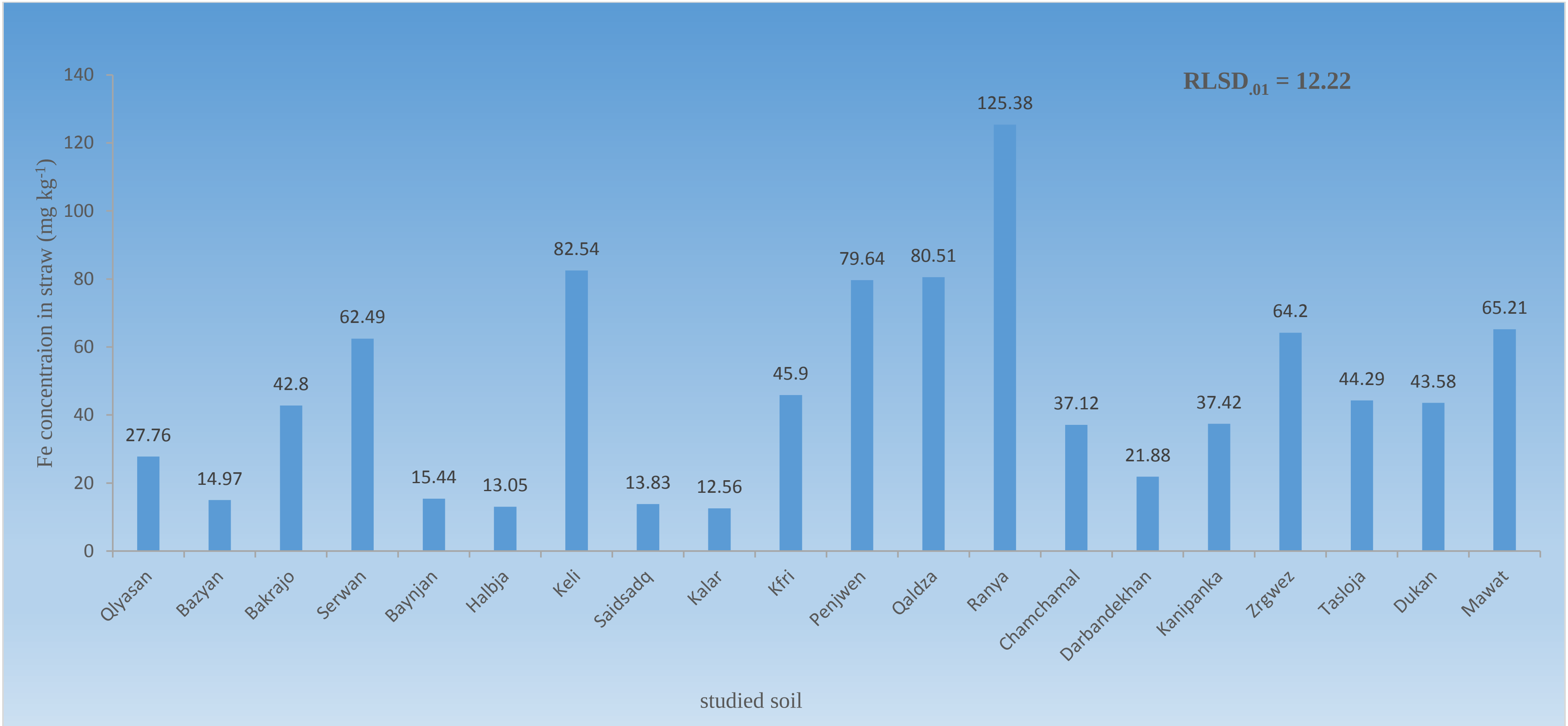


Figure (9): Effect of soil types on iron concentration in wheat straw.

Table (8): Effect of interaction between iron levels and soil types on iron concentration in wheat straw.

Soil No	Levels of applied Fe (mg Fe kg^{-1} soil)				
	Fe0	Fe2	Fe4	Fe6	Fe8
Qlyasan	28.57	27.11	24.43	27.65	31.07
Bazyan	13.96	14.30	14.66	15.85	16.10
Bakrajo	24.19	16.35	25.46	44.95	103.08
Serwan	27.40	13.50	31.02	206.49	34.06
Baynjan	13.73	14.43	15.16	16.65	17.25
Halbja	**11.02**	13.03	13.37	14.00	13.85
Keli	41.51	139.82	117.15	47.03	67.21
SaidSadq	12.72	13.66	13.96	14.41	14.41
Kalar	11.62	12.02	14.40	13.32	13.43
Kfri	40.82	45.05	58.22	42.52	42.87
Penjwen	205.22	28.88	38.08	19.79	106.21
Qaldza	39.50	56.53	126.92	110.00	69.54
Ranya	26.44	**236.47**	223.29	44.90	95.82
Chamchamal	38.75	34.17	39.03	39.94	33.73
Darbandekhan	21.68	18.02	24.23	25.88	19.57
Kanipanka	33.43	24.76	25.68	16.23	86.99
Zrgwez	40.57	91.19	64.02	78.19	47.07
Tasloja	46.08	46.79	40.28	37.14	45.76
Dukan	54.66	38.28	42.04	37.14	45.76
Mawat	64.48	43.41	71.25	72.14	74.77
$RLSD_{.01}$	18.33				
Effect	**				

6- Effect of iron levels, soil locations and their interactions on phosphorus concentration in wheat straw:

Figure (10) explain the effect of applied Fe levels on concentration of phosphorus in plant straw, the highest value was (7.05) mg g^{-1} straw recorded from application of application 6 mg Fe kg^{-1}soil while the lowest value (2.08) mg g^{-1} straw was obtained from application of 2mg Fe kg^{-1}soil. This may be due to the role of iron in chlorophyll formation then increase plant requirement for (P) and other nutrient and absorbed it.

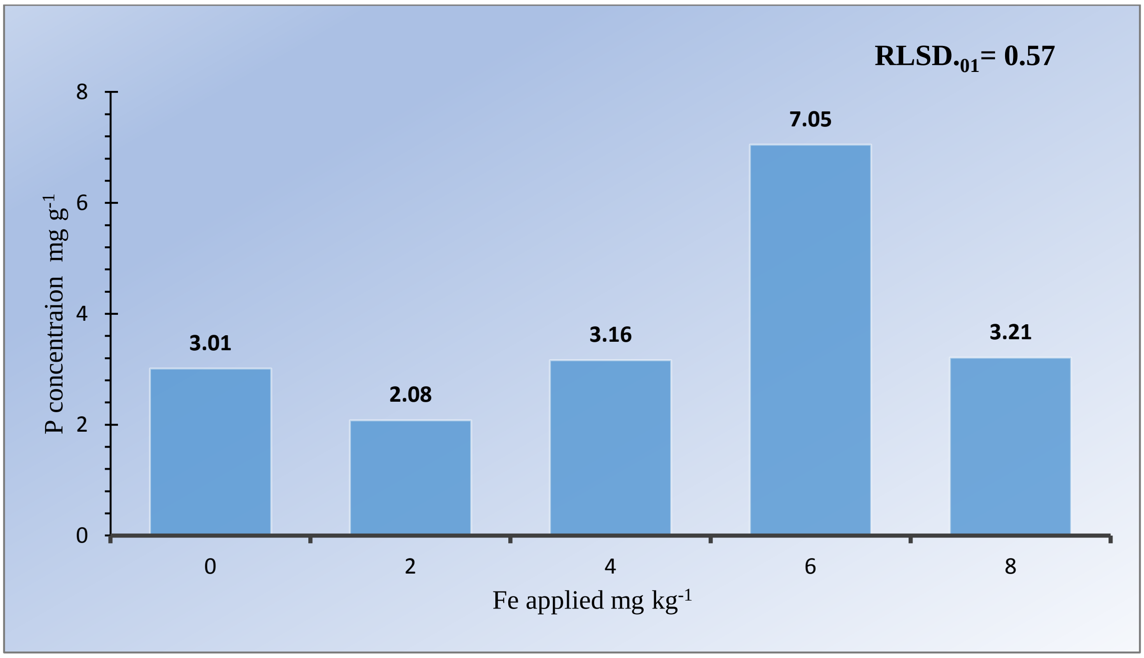


Figure (10): Effect of applied Fe levels on phosphorus concentration in wheat straw.

Figure (11) explains the significant effect of soil type at ($P \leq 0.01$) on phosphorus concentration in wheat straw. The highest value was (**4.53**) mg g^{-1} recorded from Dukan location, while the lowest value was (2.16) mg g^{-1} recorded from Keli location. This wide range of P concentration in wheat straw may be due to difference among studied soils in their properties like calcium carbonate, P can precipitate with Ca generating dicalciumphoshpate that is available to plants (Arai and Sparks, 2007).

The interaction between levels of Iron and soil types was significantly affected on phosphorus concentration in wheat straw at ($P \leq 0.01$) level as shown in table (9).The highest value of P was (5.40) mg g^{-1} recorded in recorded from treatment combination of Serwan location at application of 6 mg Fe kg^{-1}, while the lowest values of P was (1.80) mg g^{-1} obtained from treatment combination of Keli location at control. This wide range of Fe concentration in wheat grain may be due to different OM and high $CaCO_3$ content and due to specific adsorbent P on surface of $CaCO_3$.

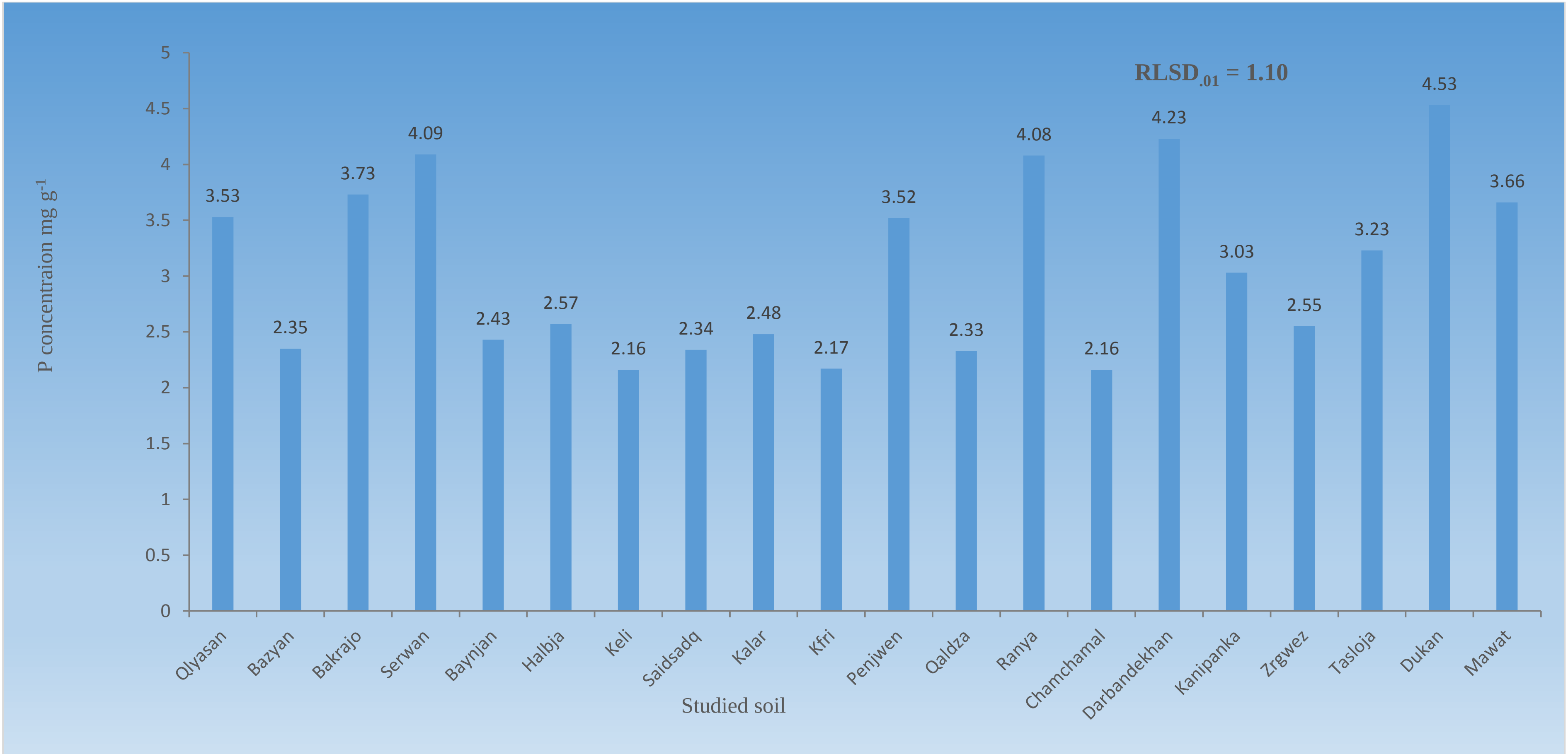


Figure (11): Effect of soil types on phosphorus concentration in wheat straw.

Table (9): Effect of interaction between levels of iron and soil types on phosphorus concentration in wheat straw.

Soil locations	P mg g^{-1}				
	Fe0	Fe2	Fe4	Fe6	Fe8
Qlyasan	3.50	3.60	3.60	3.50	3.40
Bazyan	2.20	2.10	2.40	2.50	2.50
Bakrajo	3.90	3.20	3.90	3.90	3.40
Serwan	3.20	3.10	**5.40**	0.33	0.52
Baynjan	2.30	2.40	2.40	2.40	2.50
Halbja	0.19	2.40	2.50	3.10	2.90
Keli	**1.80**	2.30	2.30	2.00	2.20
SaidSadq	2.20	2.10	2.50	2.40	2.40
Kalar	2.00	2.40	2.30	2.80	2.80
Kfri	2.70	2.00	1.90	1.80	2.30
Penjwen	3.80	3.90	3.20	3.00	3.50
Qaldza	2.40	2.20	2.40	2.20	2.30
Ranya	4.10	4.10	4.00	3.50	4.60
Chamchamal	1.81	2.30	2.30	2.00	2.20
Darbandekhan	4.10	4.60	4.60	3.80	3.90
Kanipanka	3.50	2.60	2.50	3.00	3.40
Zrgwez	2.50	2.50	2.60	2.50	2.50
Tasloja	3.10	3.30	3.60	2.90	3.00
Dukan	4.50	4.40	4.50	4.20	4.80
Mawat	3.90	3.50	3.90	3.20	3.60
$RLSD_{.01}$	2.11				
Effect	**				

7- Effect of iron levels of, soil locations and their interactions on of nitrogen concentration in wheat straw:

The Results as shown in (figure, 12) that there is significant effect of Iron levels on nitrogen concentration in straw. The highest value of nitrogen was (10.39) mg kg^{-1} recorded from iron level (6 and 8) mg Fe kg^{-1}. While the lowest value of nitrogen was (9.78) mg kg^{-1} recorded from control treatment, this attributed to the relationship between iron and nitrogen like Participation of both nitrogen and iron in the formation of chlorophyll and many metabolic processes in plants.

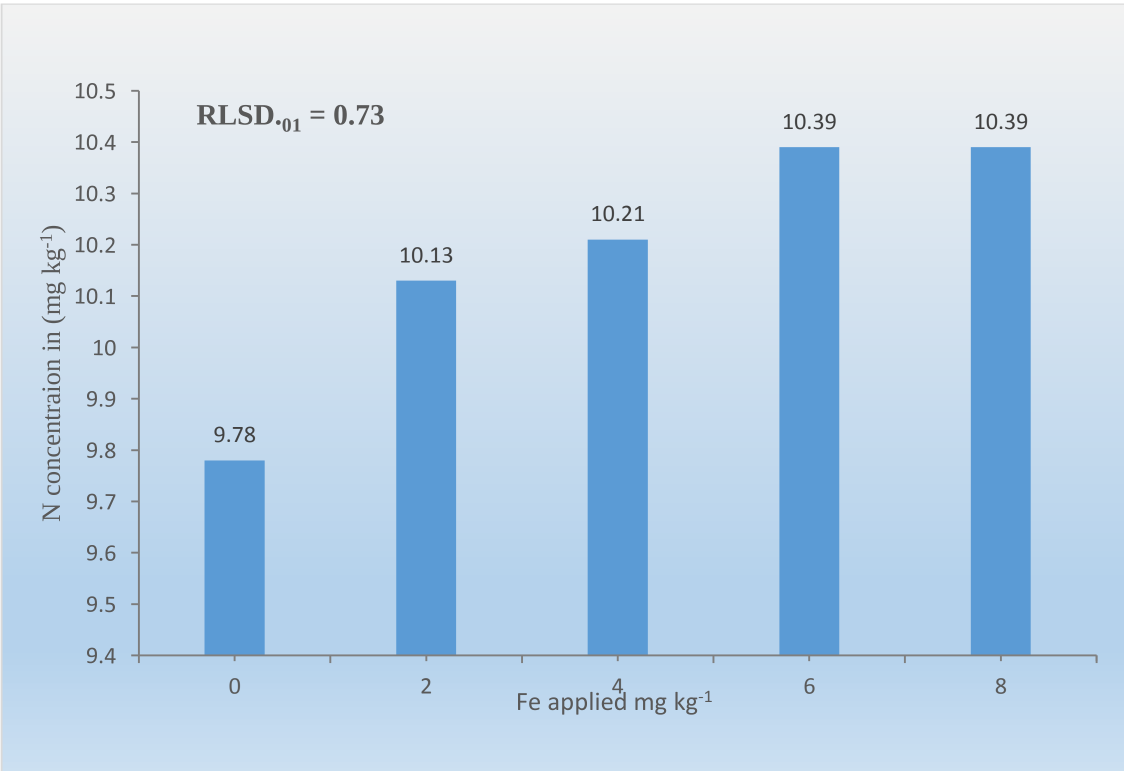


Figure (12): Effect of different levels of iron fertilizer on nitrogen concentration in wheat straw.

Figure (13) shows the significant effect of soil type at ($P \leq 0.01$) on nitrogen concentration in wheat straw. The highest value was (13.47) mg kg^{-1} recorded in soil of both location Kifri and Tasloja, while the lowest value was (2.65) mg kg^{-1} recorded in Keli location. This may be attributed to some soil physical and chemical properties like soil texture, CEC. Active and total $CaCO_3$, OM, EC and Ca^{2+} concentration in soil solution. The texture for soil of Tasloja was clay while for soil of Keli location was silty loam, CEC. Active and total $CaCO_3$, OM, EC , pH and Ca^{+2} concentration in soil Tasloja was (33.97 Cmolc.kg $soil^{-1}$, 39.20 g kg^{-1} soil, 126.9 g kg^{-1} soil, 38.7 mg kg^{-1} soil, 0.98 $dS.m^{-1}$,7.69 and 8.0 $mmolc.l^{-1}$) respectively. While CEC. Active and total $CaCO_3$, OM, EC and Ca^{2+} concentration in soil of Keli location was (10.05 Cmolc.kg $soil^{-1}$, 8.40g kg^{-1} soil, 87.30 g kg^{-1} soil, 7.0 mg kg^{-1} soil, 0.60 $dS.m^{-1}$ and 4.20 $mmolc.l^{-1}$) respectively.

The interaction between levels of Fe and soil locations has significant effect on nitrogen concentration in wheat straw as shown in table (10). The highest value (14.30) mg kg^{-1} was recorded in treatment combination Kifri location at application of 2 mg Fe kg^{-1} and the lowest value (2.00) mg kg^{-1} was recorded in treatment combination Keli location at application of 2 mg Fe kg^{-1}. It may be related to various conditions that may affected on nitrogen like Fe content, calcium carbonate, OM, CEC, pH and texture. In soil number 10 iron content, calcium carbonate, OM, CEC, pH and soil texture were (2.12 mg kg^{-1},261.80 g kg-^{1}, 9.2 mg kg^{-1}, 19.71Cmolc.kg $soil^{-1}$, 7.56 , Clay loam) respectively .while the values of the mentioned properties for soil number 7 were (1.70 mg kg^{-1}, 87.30 g kg-^{1}, 7 mg kg^{-1}, 10.05 Cmolc.kg $soil^{-1}$, 8.17, Silty loam) respectively.

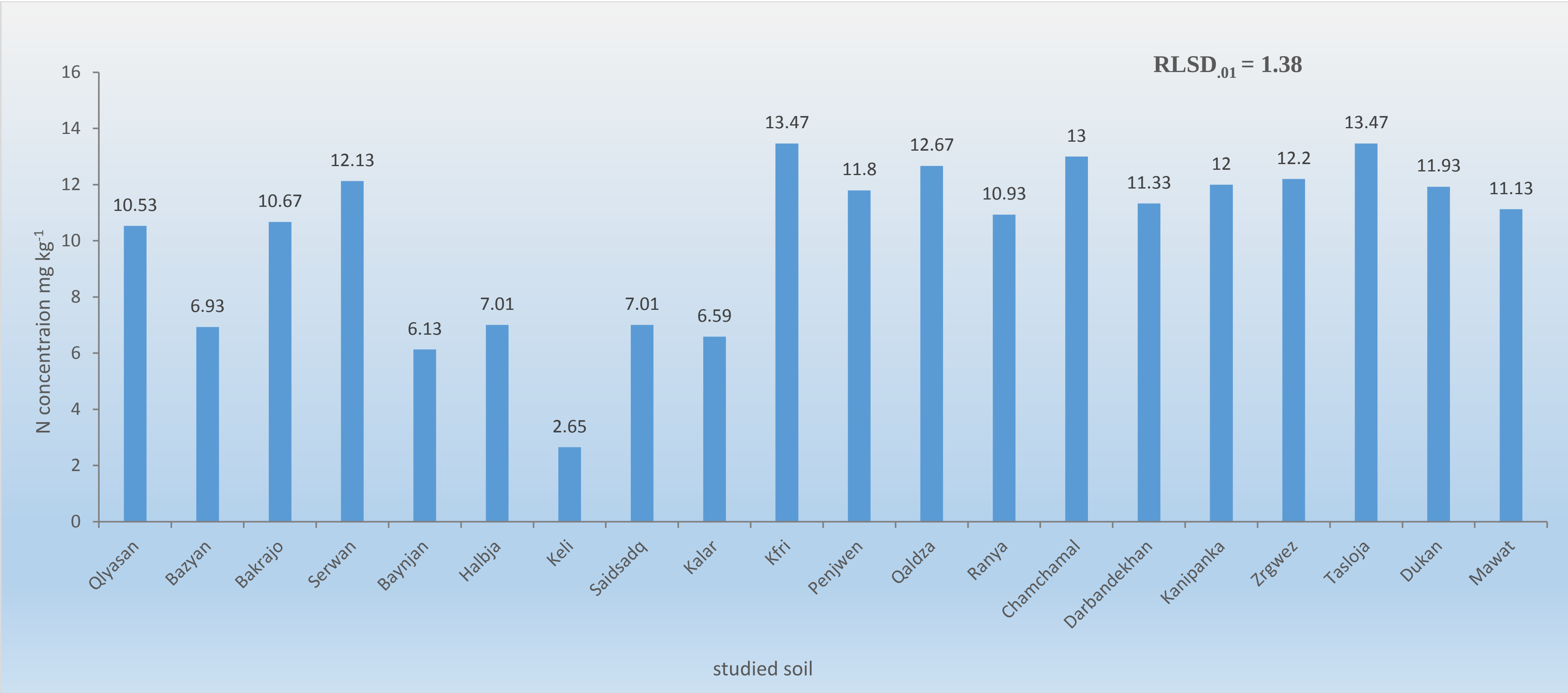


Figure (13): Effect of soil types on nitrogen concentration in wheat straw.

Table (10): Effect of the interaction between soils type and levels of iron on nitrogen concentration in wheat straw.

Soil locations	N mg kg^{-1}				
	Fe0	Fe2	Fe4	Fe6	Fe8
Qlyasan	10.30	11.00	10.30	10.30	10.60
Bazyan	6.60	6.80	6.70	7.30	7.20
Bakrajo	8.70	11.00	11.00	11.60	11.00
Serwan	12.00	12.00	12.60	12.00	12.00
Baynjan	6.00	6.00	6.10	6.10	6.40
Halbja	6.10	6.90	7.00	7.40	7.50
Keli	2.40	**2.00**	2.90	2.70	3.00
SaidSadq	6.10	6.90	7.00	7.40	7.50
Kalar	5.60	5.90	6.00	7.30	8.00
Kfri	13.60	**14.30**	13.30	13.60	2.00
Penjwen	11.60	11.60	11.60	12.00	12.00
Qaldza	12.60	12.30	13.00	13.00	12.30
Ranya	10.30	11.60	11.00	10.60	11.00
Chamchamal	12.30	12.60	13.60	13.00	13.30
Darbandekhan	12.00	11.30	11.30	11.60	10.30
Kanipanka	12.00	12.00	12.00	12.30	11.60
Zrgwez	11.60	12.60	11.60	12.00	13.00
Tasloja	13.60	13.30	13.30	14.00	13.00
Dukan	11.60	12.30	12.00	11.60	12.00
Mawat	11.00	10.30	10.60	11.60	12.00
$RLSD_{.01}$	2.87				
Effect	**				

4.2. Effect of Iron levels, soil locations and their interactions on some growth characters of wheat plant:

The levels of applied Fe affected significantly on chlorophyll content and seed pot-1 only (Figure, 14 and 15). The highest value of number of seeds pot^{-1} and chlorophyll were (374.68 seed pot^{-1} and 40.08 SPAD) recorded from application of 2 mg Fe kg^{-1} and control respectively. While the lowest value of number of seeds pot^{-1} and chlorophyll (311.78 seed pot^{-1} and 38.31 SPAD) were recorded at application of 4 mg Fe kg^{-1}. Fe is important in chlorophyll formation, photosynthesis, enzyme systems, chloroplast development and respiration of plants (Miller *et al*., 1995; Halvin *et al*., 1999). While other studied characters (plant height, leaf area, number of spike pot^{-1} and weight of dry matter were not affected significantly by Fe levels.

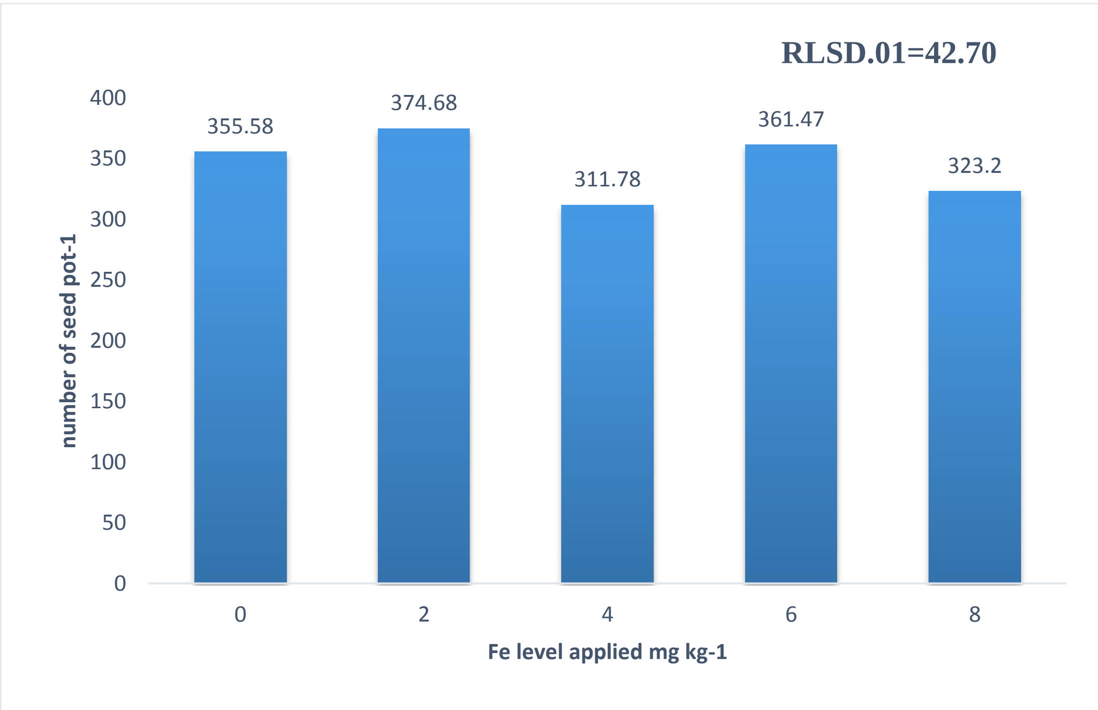


Figure (14): Effect of iron fertilizer on No of seeds Pot^{-1} in wheat

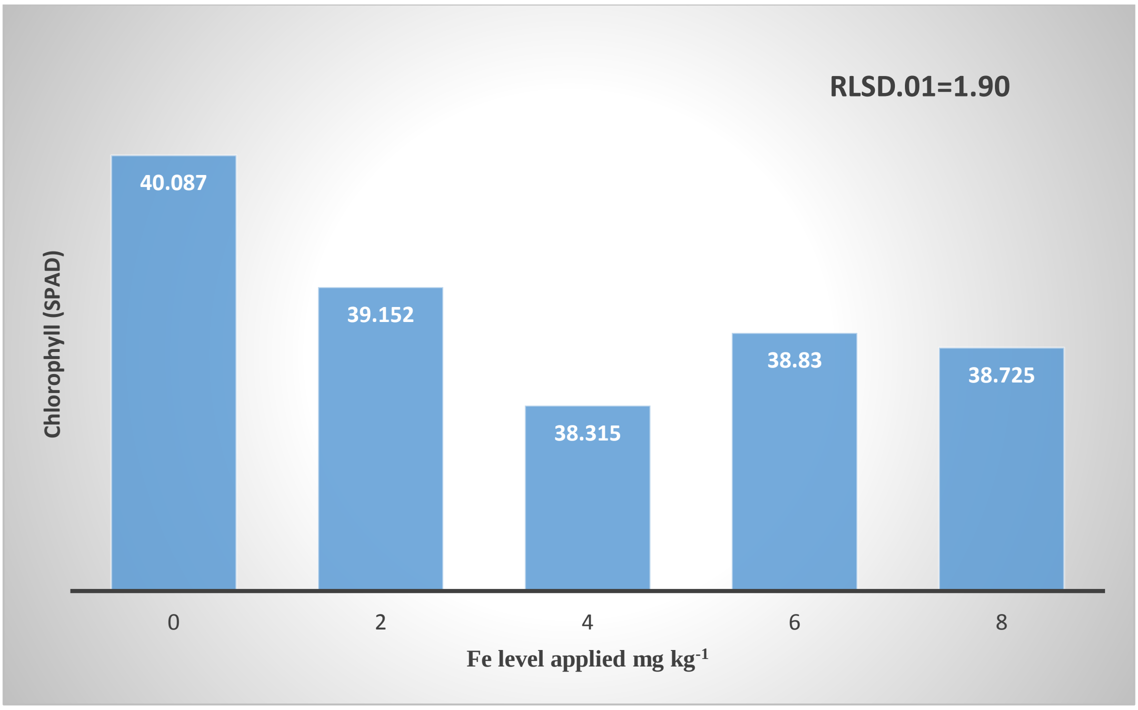


Figure (15): Effect of iron fertilizer on chlorophyll content in wheat (SPAD)

Table (11) results explain the significant effect of soil locations on all the studied plant growth characters, the highest value of plant height, seeds pot^{-1}, seeds weight .pot^{-1} and dry matter weight were (70.26 cm, 720.86 seeds pot^{-1}, 26.27 g.pot^{-1}, 70.59 g.pot^{-1}) respectively recorded in Penjwen location, and the highest values of number of spike and chlorophyll (29.53) pot^{-1} and 44.89 SPAD) were recorded in Bazyan location. On the other hand the lowest values of most of the mentioned characters except chlorophyll content were recorded Keli location and the lowest chlorophyll content was obtained in Ranya location. This may be due to the variation in soil chemical and physical properties of the studied soils especially soil organic matter content, CEC, and texture (table, 3).

Table (11): Effect of different levels of iron, soil location and their interactions on some growth characters of wheat.

Soil locations	Plant height (cm)	Leaf area (cm^2)	No of spike pot^{-1}	No of seed pot^{-1}	Seed wt.($g.pot^{1}$)	Wt. of DM ($g.pot^{1}$)	Chlorophyll (SPAD)
Qlyasan	62.60	34.86	15.00	308.53	10.56	33.04	35.05
Bazyan	63.63	28.38	**29.53**	467.00	16.08	66.05	**44.89**
Bakrajo	67.26	31.31	15.66	331.53	12.98	37.71	38.84
Serwan	64.70	35.64	14.20	324.80	11.33	29.16	38.21
Baynjan	66.83	26.29	18.20	409.26	16.24	44.98	36.84
Halbja	64.76	35.59	15.80	339.80	10.42	34.38	39.58
Keli	**48.03**	**22.96**	**11.26**	**120.73**	**3.31**	**12.06**	38.26
Saidsadq	66.76	33.76	17.33	434.86	16.76	44.89	39.14
Kalar	55.13	24.46	12.86	242.73	7.06	19.99	39.76
Kfri	61.40	28.52	14.06	229.93	6.75	22.31	41.13
Penjwen	**70.26**	29.68	25.26	**720.86**	**26.27**	**70.59**	35.87
Qaldza	68.03	**41.63**	27.80	345.93	12.68	56.15	43.92
Ranya	58.40	26.49	18.46	292.80	8.64	34.40	**32.53**
Chamchamal	60.70	30.99	14.06	190.40	6.14	19.88	39.01
Darbandekhan	62.13	29.60	13.13	242.66	8.19	27.08	36.06
Kanipanka	67.43	40.94	20.53	531.40	20.89	61.94	38.28
Zrgwez	59.56	27.98	20.53	362.93	10.98	45.82	39.12
Tasloja	62.17	31.18	22.80	502.00	17.64	54.45	42.58
Dukan	64.66	31.48	23.80	266.53	8.68	44.63	43.12
Mawat	59.86	28.89	16.53	242.13	8.59	28.06	38.16
$RLSD_{.01}$	5.12	6.71	4.79	20.31	3.85	8.20	5.75
Effect	**	**	**	**	**	**	**

The interaction between levels of Fe and soil locations was significantly affected on some growth characters of wheat plant The highest value of plant height, No of seeds pot^{-1}, seeds weight pot^{-1} ,number of spike pot^{-1} ,leaf area, chlorophyll and weight of dry matter which were (73.33 cm, 767.33 seeds pot^{-1}, 31.10 g pot^{-1}, 33.66 spike pot^{-1} ,90.43 cm^2, 47.26 SPAD and 77.56 g $pot^{-1)}$ recorded in treatments combinations ($S_{11}Fe_5$, $S_{16}Fe_2$, $S_{11}Fe_1$, S_2Fe_5, $S_{16}Fe_5$, $S_{18}Fe_1$ and S_2Fe_4) respectively. While the lowest values (44.33 cm, 94.66 seeds pot^{-1}, 2.61 g pot^{-1},10.33 spike pot^{-1} ,17.01cm^2, 30.50 SPAD and 9.74 g pot^{-1}) of most of the mentioned characters were recorded in combination treatments (S_7Fe_1), expected plant height, leaf area which were recorded in combination treatments (S_7Fe_2) and chlorophyll ($S_{13}Fe_4$) respectively (Appendix,1). This may be due to the variation in soil chemical and physical properties of the studied soils especially soil organic matter content, CEC, and texture (table, 3).

4.4. Determination of iron critical level in the studied soils:

As shown in Figure (16 a 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 (2.5) mg kg^{-1}.This result in agreement with those found by **Sims and Johnson (1991)** who reported that the critical level of iron in calcareous soil was (2.5) mg kg^{-1}. Table (12) explains that the highest value of coefficient determination was (R^2= 0.64) recorded at concentration (2.61) mg kg^{-1}. That is why this point is regarded as critical level for iron of the studied soil depending on initial iron concentration.

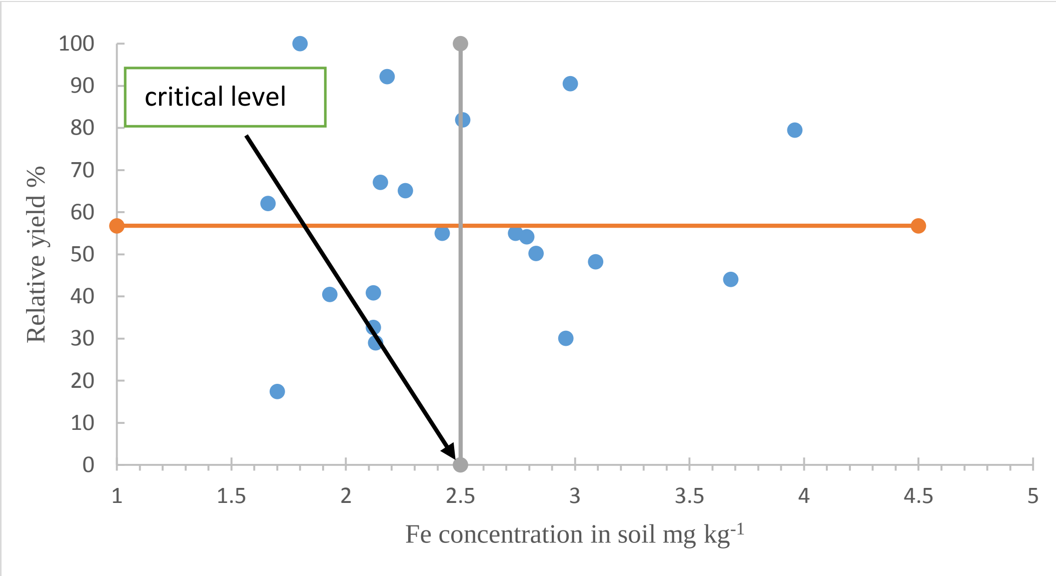


Figure (16a): Critical level of Iron in different soils collected from Sulaimani governorate (graphical method).

It is appear from determined critical level of Iron (figure, 17a) that the concentration of Fe in (11) locations of the studied soils was less than the critical value .These soils included the soils from locations (Bazyan, Bakrajo, Baynjan, Keli, Kfri, Penjwen, Chamchamal, Darbandekhan, Kanipanka, Dukan and Mawat).

Table (12): The coefficient of determination (R^2) for soil

Initial iron concentration	Coefficient determination R^2
1.8	0.57
2	0.54
2.2	0.61
2.4	0.59
2.6	**0.64**
3.1	0.55
3.5	0.61

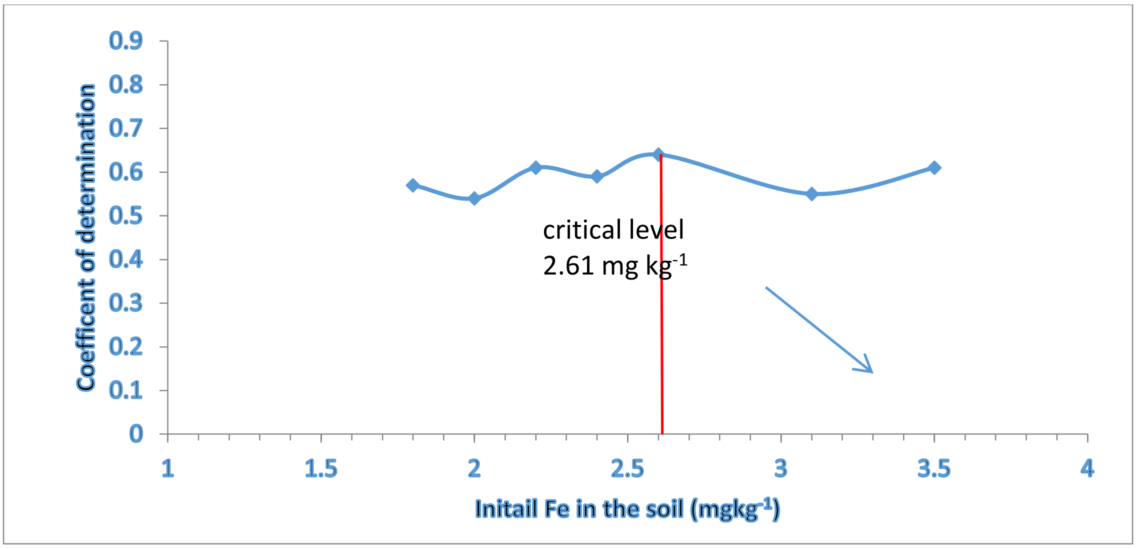


Figure (16b): Critical level of Iron in different soils collected from Sulaimani governorate (statistical method).

4.5. Determination of iron critical level for wheat plant

Critical level of Fe was determined by using graphic method (figure ,17a) depending on iron concentration in the plant (mg kg^{-1} dry weight) and relative yield as shown in table (13), 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 concept up to (50.5) mg kg^{-1} and therefor 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, 18b) and table (14). These results are very close or similar to those recorded by (kumar, 2002 and Meena, 2013).

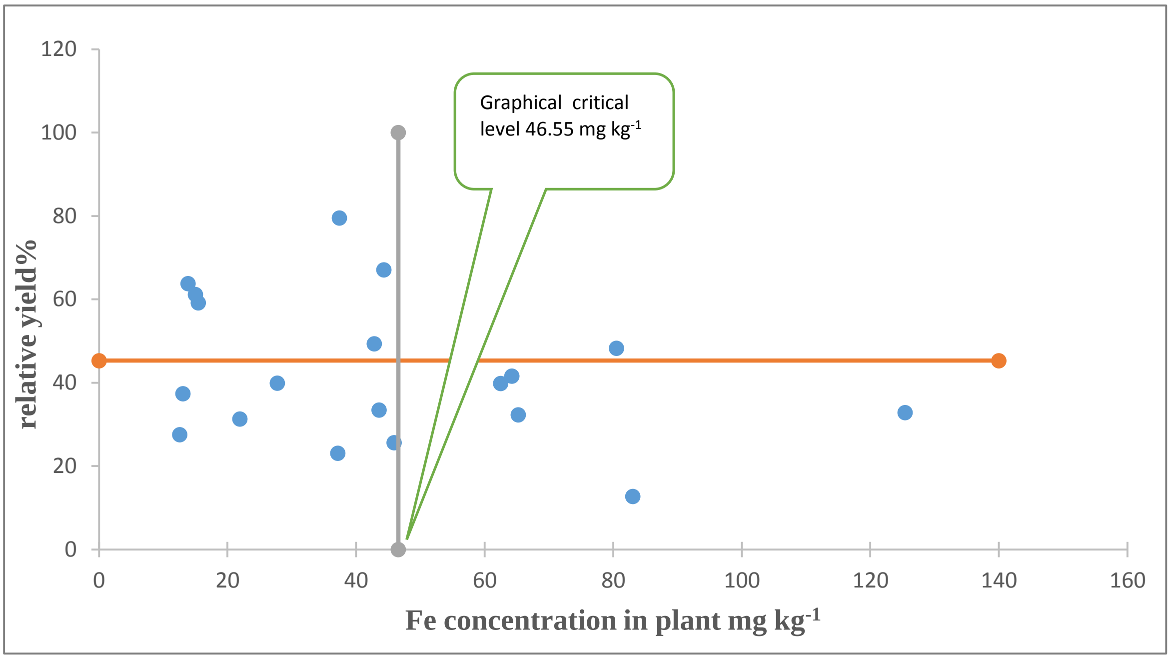


Figure (17a): Critical level of Iron in wheat plants (graphical method).

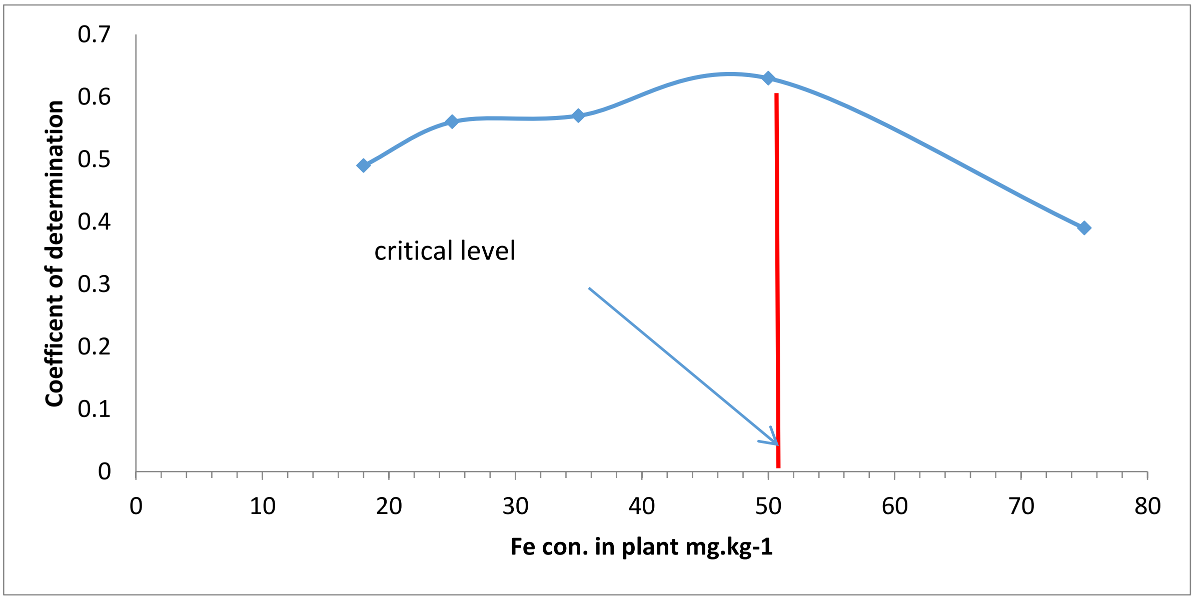


Figure (17b): Critical level of Iron in wheat plants (statistical method)

Table (13): Effect of locations on iron concentration and relative yield% of wheat

Soil No.	Locations	Fe concentration in plant mg kg^{-1}	Relative yield%
1	Qlyasan	27.76	39.93
2	Bazyan	14.97	61.16
3	Bakrajo	42.80	39.84
4	Serwan	62.49	39.86
5	Baynjan	15.44	59.14
6	Halbja	13.05	37.39
7	Keli	83.02	12.74
8	SaidSadiq	13.83	63.76
9	Kalar	12.56	27.57
10	Kifri	45.90	25.63
11	Penjwen	79.64	100
12	Qaldza	80.51	48.26
13	Ranya	125.38	32.86
14	Chamchamal	37.12	23.08
15	Darbandekhan	21.89	31.34
16	Kanipanka	37.42	79.49
17	Zrgwez	64.21	41.57
18	Tasloja	44.29	67.09
19	Dukan	43.58	33.47
20	Mawat	65.21	32.33

Table (14): The coefficient of determination (R^2) for wheat plant

Fe concentration in plant mg kg^{-1}	Coefficient determination (R^2)
18	0.49
25	0.56
35	0.57
50	0.63
75	0.39

4.6. The optimum level of iron fertilizer level:

As shown in table (15) and figures (18.a, b, c, d, e, f, j) the variation in optimum level of iron fertilizer for obtaining the highest relative yield vary depending on the soil properties. Optimum Fe fertilizer level for locations (Qlyasan, Kifri, Penjwen, Darbandekhan, Kanipanka and Tasloja) was at control. Several studies have suggested a relationship between available Fe content in the soil and the plant response. Fe content in locations (Kifri and Darbandekhan) was less than the critical level, while Fe content in soils (Qlyasan, Penjwen, Kanipanka and Tasloja) was more than the critical level in the current study.

Optimum fertilizer level in locations (Bazyan, Halbja, Kalar, Zrgwez and Dukan) was at 2 mg Fe kg^{-1}, Fe content in locations (Bazyan, Halbja and Zrgwez) was less than the critical level, while Fe content in locations(Kalar and Dukan) was more than the critical level.

Optimum fertilizer level in locations (Baynjan, Keli, Ranya and Mawat) was at 4 mg Fe kg^{-1}. Fe content in soil 20 was less than the critical level, while Fe content in locations (Baynjan, Keli and Ranya) was more than the critical level.

Optimum Fe fertilizer level in locations (Bakrajo, Serwan and Saidsadiq) was at 6 mg Fe kg^{-1}. Fe content in 8 was less than the critical level, while Fe content in locations (Bakrajo and Serwan) was more than the critical level.

Optimum Fe fertilizer level in locations (Qaldza and Chamchamal) was at 8 mg Fe kg^{1}. Fe content in location Qaldza was less than the critical level, while Fe content in Chamchamal location was more than the critical level.

The variation in optimum level of Fe fertilizer to obtain the highest relative yield affected by several factors, including plant types, Cyprus reciprocity of the root system and the soil factor, which includes available iron in the soil and the method of extraction and chemical properties, including the soil texture, pH, active lime and $CaCO_3$. Or attributed to adsorption of Fe in the soil solution. There is a positive correlation between the adsorption of Fe and carbonate minerals content, while a negative relationship was recorded in several calcareous soils. Several studies have also indicated to the retention of Fe in soils by active carbons which led to reduce the Fe available for plants. Figures (19 a, b, c, d, e.....j) refer to differences in the relation between levels of applied Fe and seeds yield among the studied soils. This also explain that the optimum level of applied Fe is depended on soil type.

Table: (15): Optimum level of iron fertilizer level in soils at different locations of Sulaimani governorate.

Soil locations	Relative yield %				
	Fe0	Fe2	Fe4	Fe6	Fe8
Qlyasan	13.45				
Bazyan		12.66			
Bakrajo				14.90	
Serwan				15.34	
Baynjan			23.08		
Halbja		12.26			
Keli			9.42		
Saidsadiq				19.21	
Kalar		8.66			
Kifri	8.08				
Penjwen	31.01				
Qaldza					17.72
Ranya			21.01		
Chamchamal					7.69
Darbandekhan	10.78				
Kanipanka	29.08				
Zrgwez		17.04			
Tasloja	21.014				
Dukan		12.06			
Mawat			12.31		

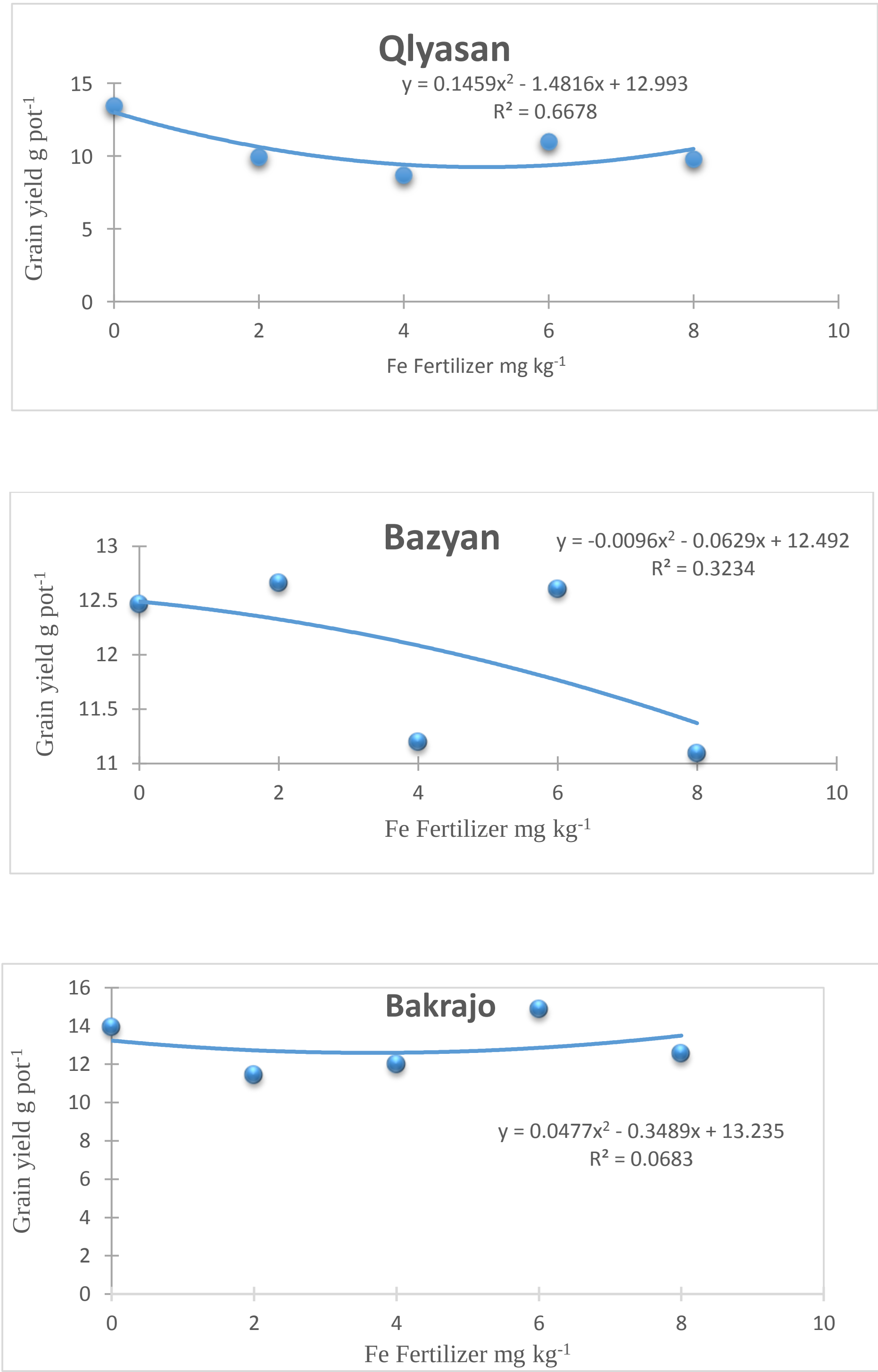


Figure (18a): Relationship between iron fertilization level and wheat grains yield in different locations (Qlyasan, Bazyan and Bakrajo) of Sulaimani governorate

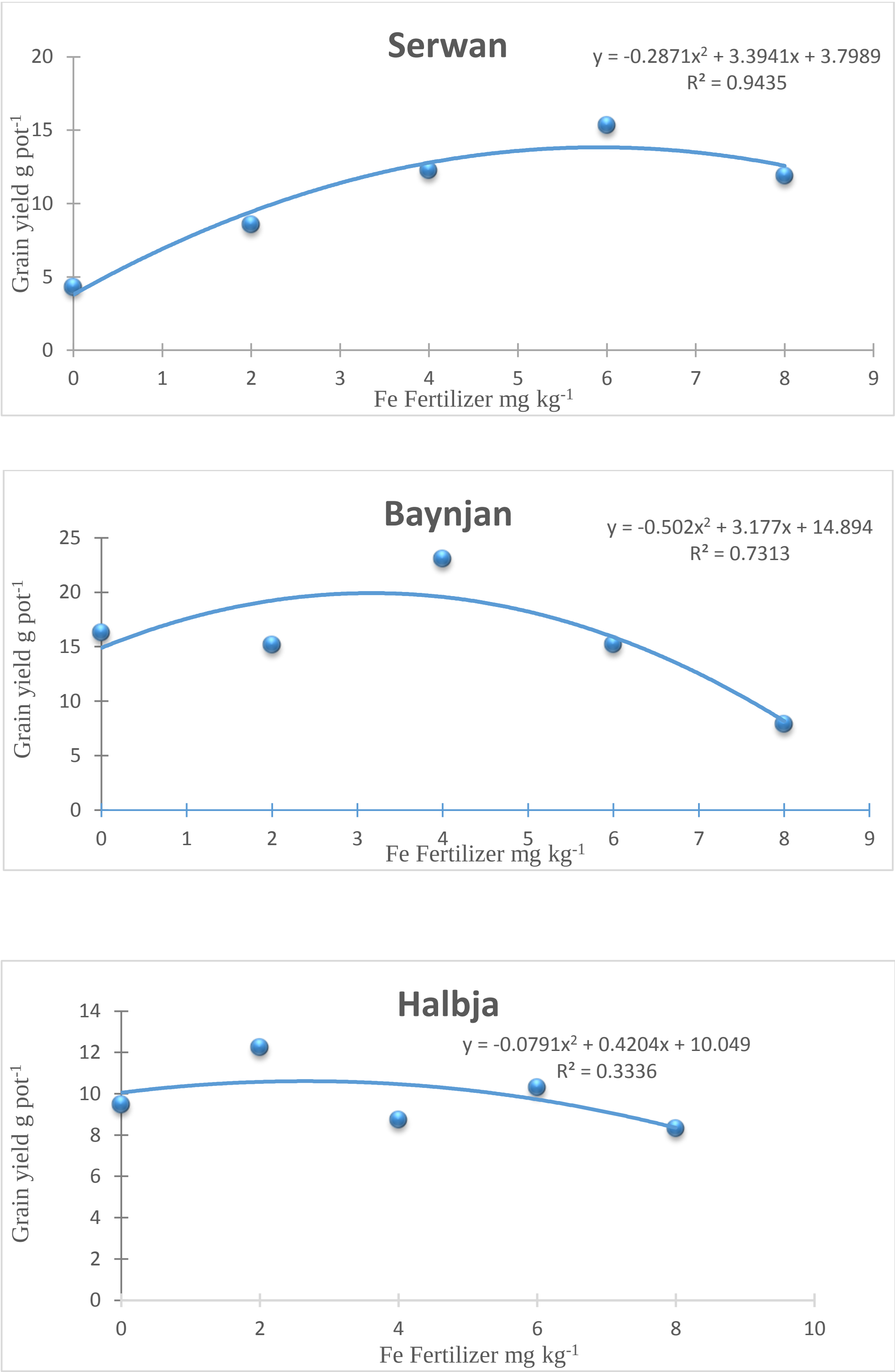


Figure (18b): Relationship between iron fertilization level and wheat grains yield in different locations (Serwan, Baynjan and Halbja) of Sulaimani governorate

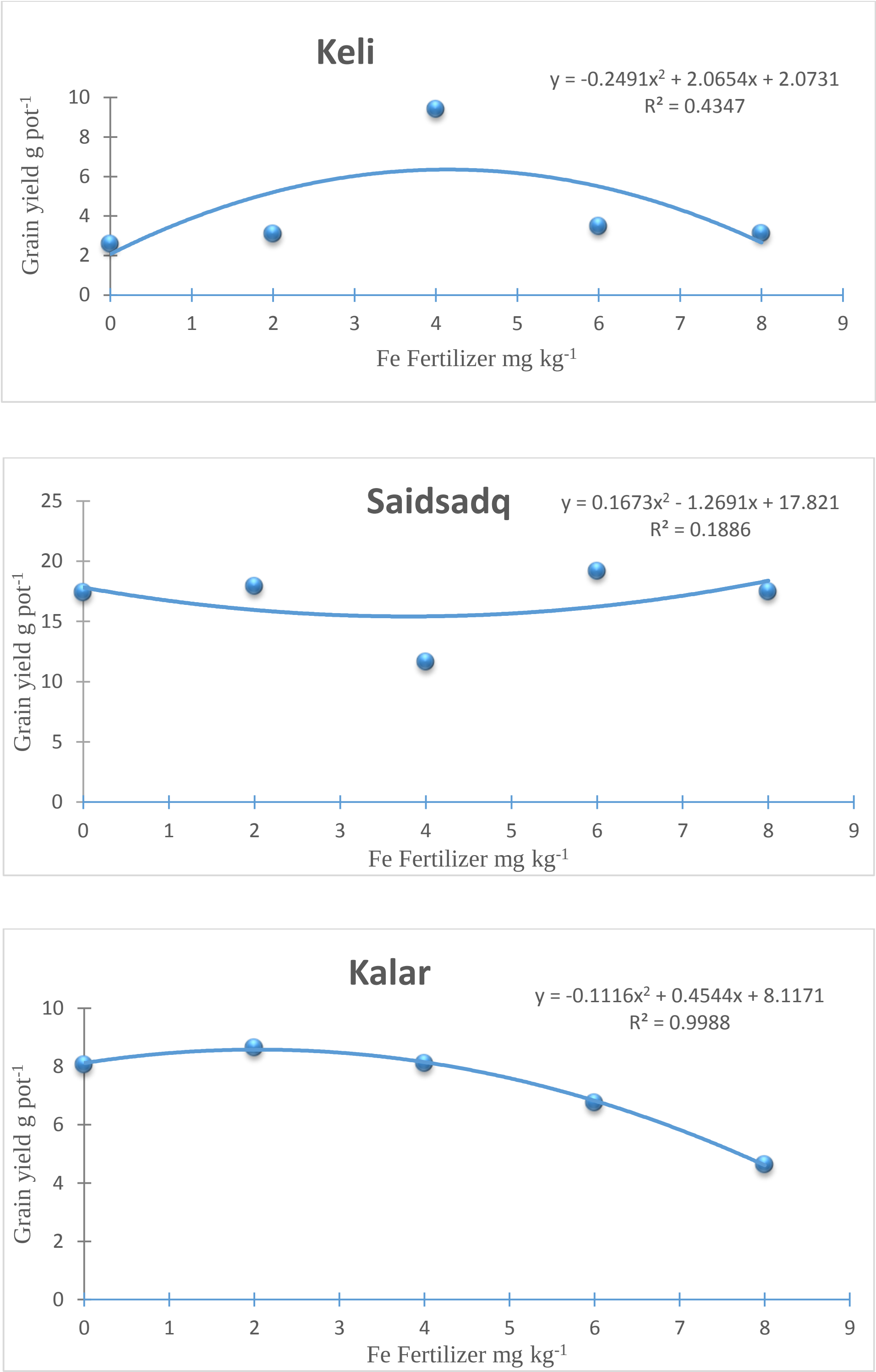


Figure (18c): Relationship between iron fertilization level and wheat grains yield in different locations (Keli, SaidSadq and Kalar) of Sulaimani governorate

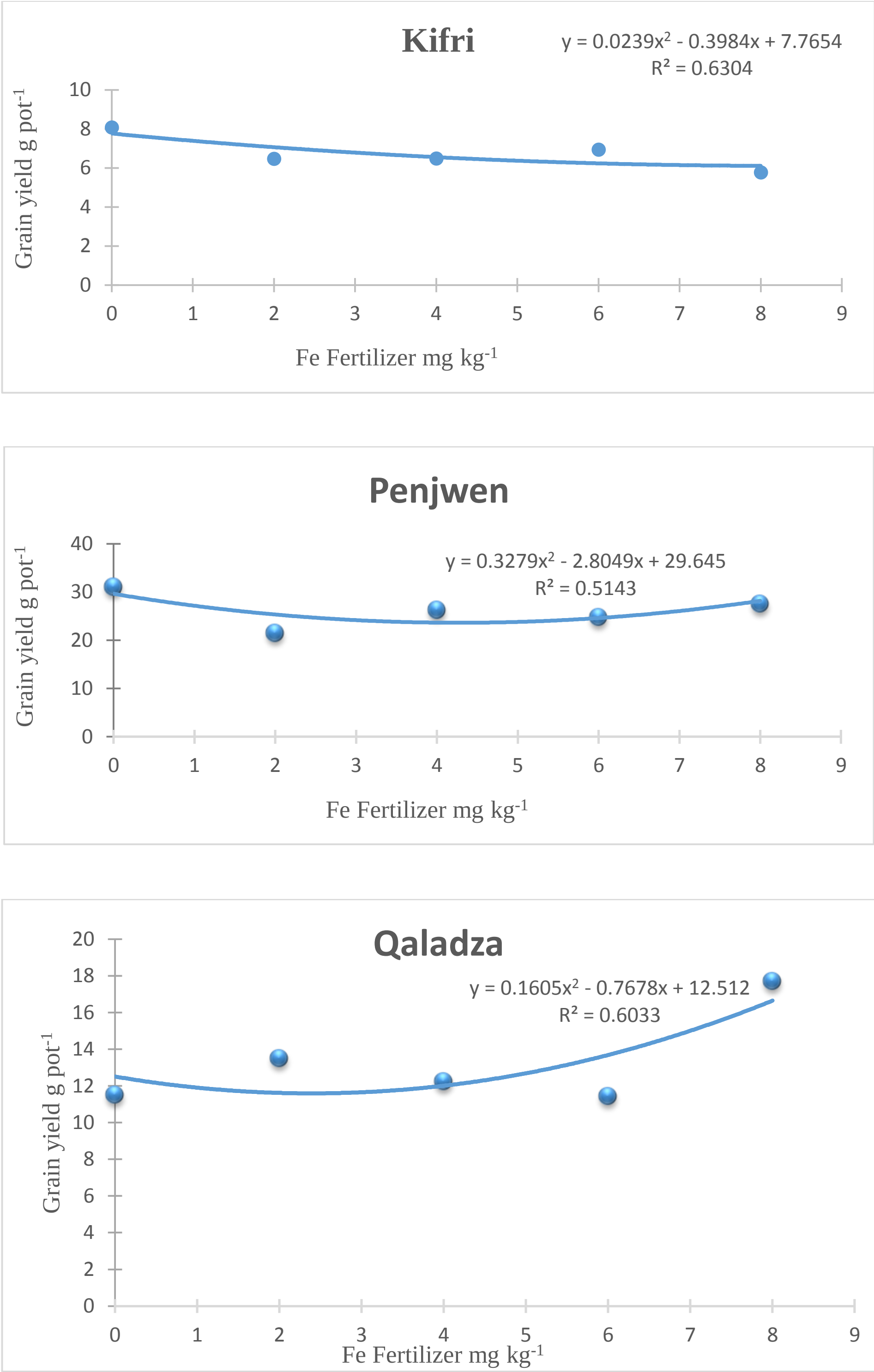


Figure (18d): Relationship between iron fertilization level and wheat grains yield in different locations (Kifri, Penjwen and Qaladza) of Sulaimani governorate

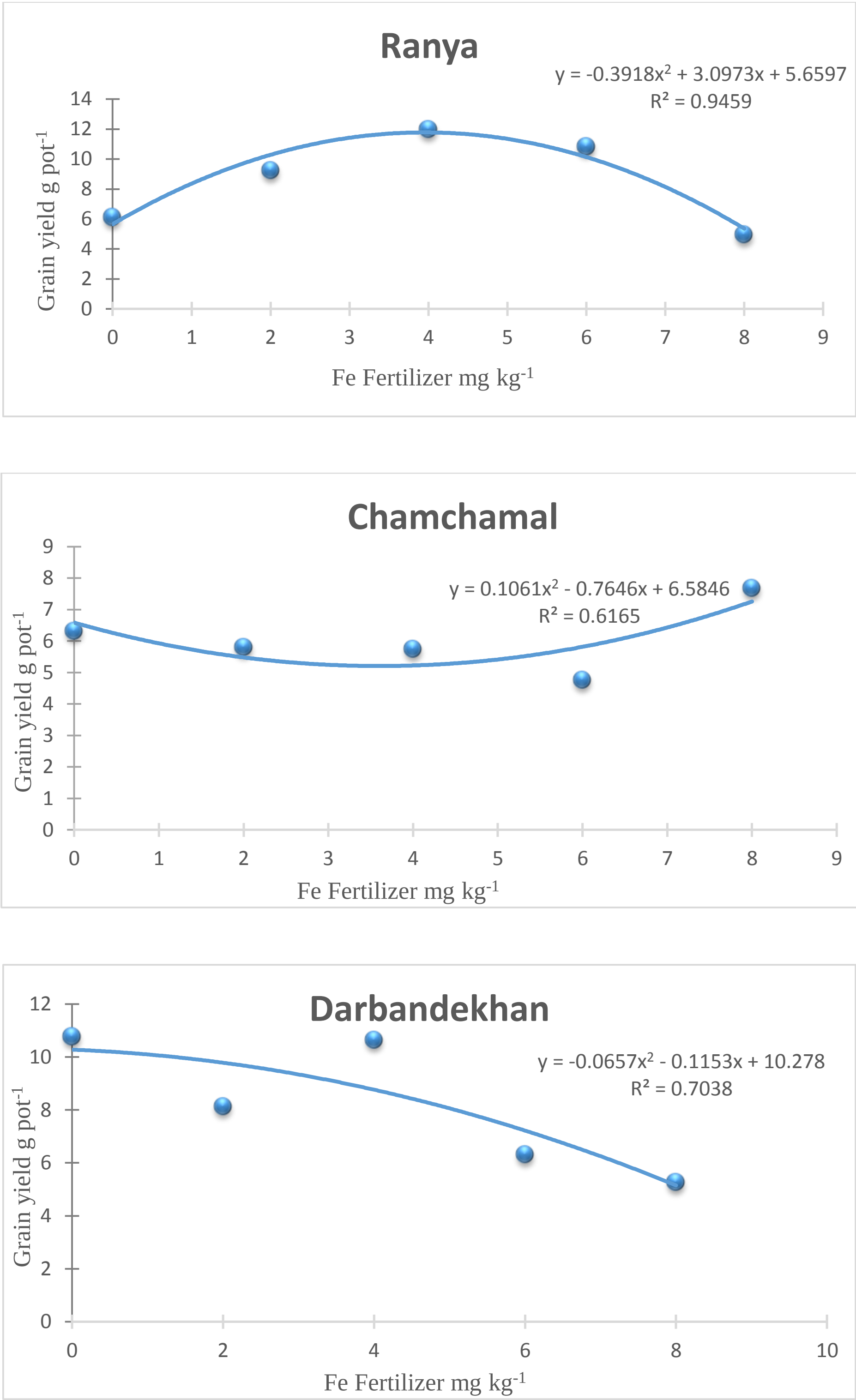
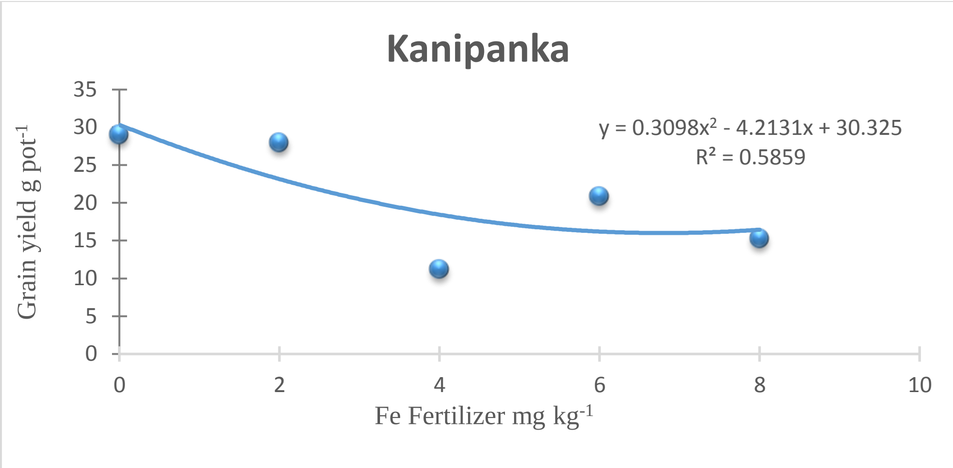
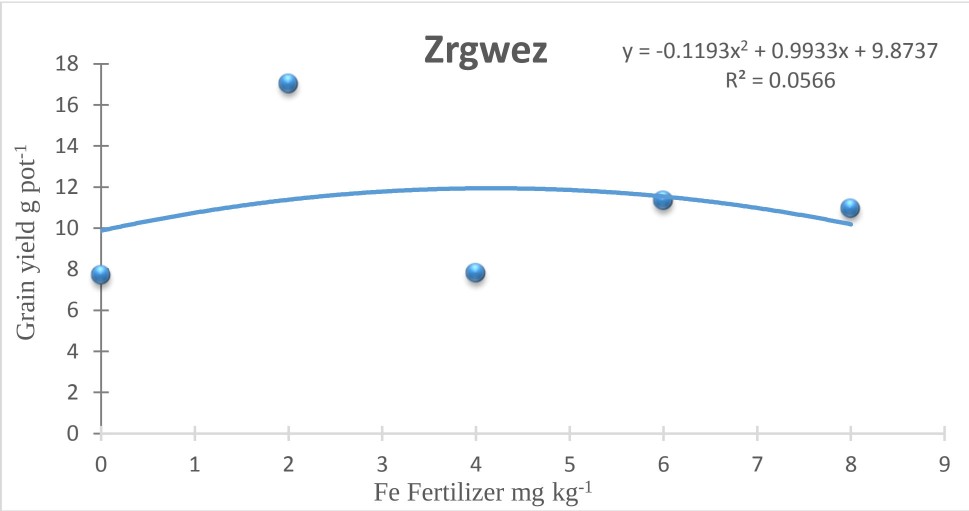


Figure (18e): Relationship between iron fertilization level and wheat grains yield in different locations (Ranya, Chamchamal and Darbandekhan) of Sulaimani governorate





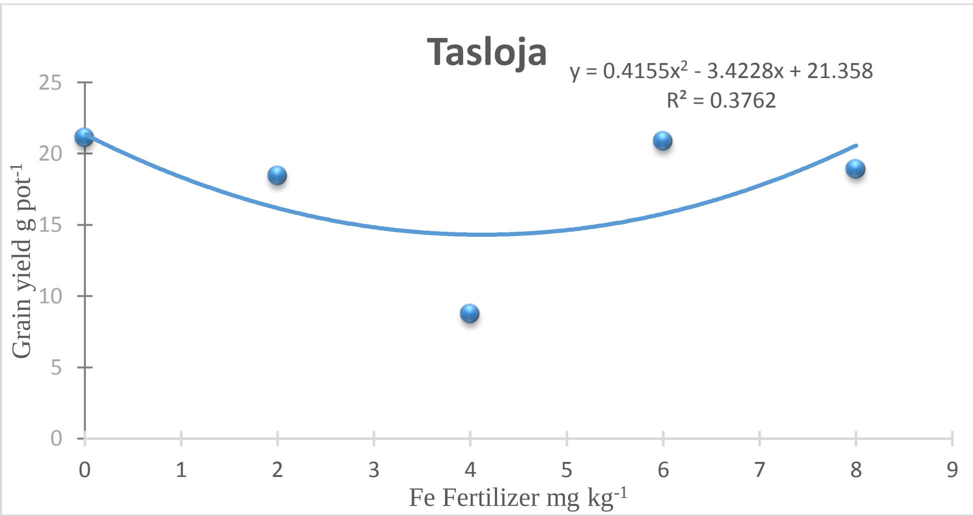
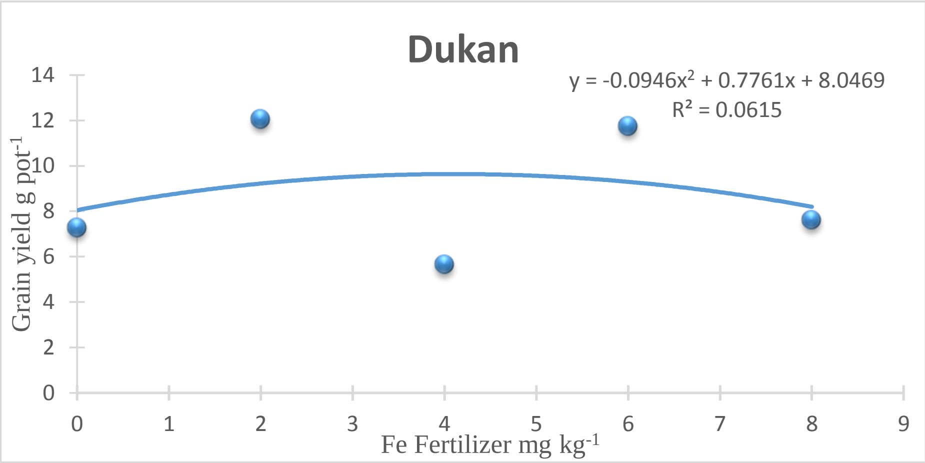


Figure (18f): Relationship between iron fertilization level and wheat grains yield in different locations (Kanipanka, Zrgwez and Tasloja) of Sulaimani governorate



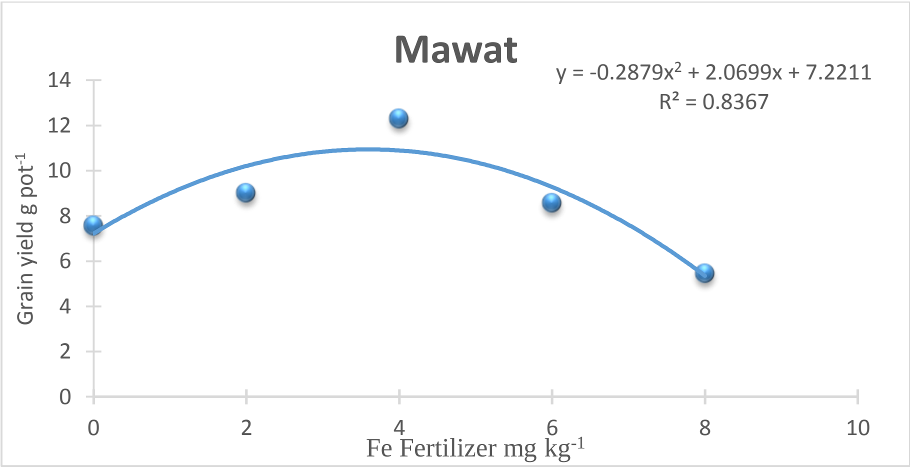


Figure (18j): Relationship between iron fertilization level and wheat grains yield in different locations (Dukan and Mawat) of Sulaimani governorate

5. CONCLUSION AND RECOMMENDATION

A. CONCLUSIONS

The results of the current study can be concluded as follow:

1- The statistical method was more efficient than graphical method for estimation plant Fe availability as depending on coefficient of determination (R^2) as a statistical index.

2- The critical level of Fe was (2.5) $mgkg^{-1}$ using graphical method and (2.61) $mgkg^{-1}$ depending on statistical method for the studied soils in Sulaimani.

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

4- The increase in level of applied Fe was effected significantly on Fe concentration in both seed and straw of wheat crops.

5- The increase in level of applied Fe was effected significantly on protein concentration in seed and N concentration in straw of wheat crops.

6- Location affected significantly on dry matter weight and grain yield for wheat crop.

7- The studied soils was varied in it is requirements for iron depending on iron content and soil chemical properties.

B. RECOMMENDATIONS

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

1. Comparison between Iron critical level under field condition and pot experiment.
2. Comparing the Iron critical level in outdoor and indoor experiments.
3. Studying the critical level of iron for different plants.
4. Comparing among the Iron critical values at different growth stages.
5. Studying the critical level for other micro nutrients like Zn, Cu and Mn for soils and wheat plant in Sulaimani governorate.
6. Study the effect of other iron fertilizer on identifying the critical level of Fe in different soils and crops

6. REFERENCES

Abadía, J., Vázquez, S., Rellán-Álvarez, R., El-Jendoubi, H., Abadía, A., Álvarez-Fernández, A., and López-Millán, A. F. (2011). Towards a knowledge-based correction of iron chlorosis. Plant Physiology and Biochemistry, 49(5): 471-482.

Abadia J. (1995) Iron nutrition in soils and Plants. Kluwer Academic Publishers, Dordech, Pp. 7-28.

Abd El-Haleem,A.A.(1996). Iron availability as affected by $CaCO_3$ Particle size and Fe: P ratio in Fe-P-containing compounds. Egypt, Journal of Applied.Sciences.11:308-327.

Aciksoz, S. B., Ozturk, L., Yazici, A., and Cakmak, I. (2014). Inclusion of urea in a 59FeEDTA solution stimulated leaf penetration and translocation of 59Fe within wheat plants. Physiologia plantarum, 151(3):348-357.

Adiloglu, A. (2003). Determination of suitable chemical extraction methods for available iron content of the soils of Edirne province in Turkey. Pakistan journal of biological Sciences 6(5): 505-510.

Ahmad, N., Rashid, M., and Vaes, A. G. (1996). Fertilizers and their use in Pakistan: an extension guide (No. 2. ed.).

Aggarwal, B., and Sastry, T. G. (1995). CDTA-an extractant for iron and zinc from different soils. Journal of Indian Society of Soil Science, 43(1):126-127.

AL-Malak, S.D. (1986). Iron availability in some calcareous soils in Northern in Iraq. M. Sc. Thesis, Dept. of Soil Science, Collage of Agric. Salahadin University.

Al-Mustafa, W. A., Abdallah, A. E., and Falatah, A. M. (2001). Assessment of five extractants for their ability to predict iron uptake and response of sorghum grown in calcareous soils. Communications in Soil Science and Plant Analysis, 32(5-6):907-919.

Al-Obaidi, M. A. J., Khalil, N. F. and Sadullah, A. M. (1994). Iron status in some soils of northern Iraq. Journal of Agronomy Science. No.2.

Alva, A. K., and Chen, E. Q. (1995). Effects of external copper concentrations on uptake of trace elements by citrus seedlings. Soil Science, 159(1):59-64.

Arai, Y., and Sparks, D. L. (2007). Phosphate reaction dynamics in soils and soil components: A multiscale approach. Advances in Agronomy, 94:135-179.

Baruah, T. C. and Barthakur, H.P. (1999). A text book of soil analysis. Printed at Vishal printers. New- Delhi.

Barker, A. V. and Pilbeam, D. J. (2007). Handbook of Plant Nutrition. Printed in the United States of America. Pp. 120-124.

Black, C.A. (1965). Methods of soil analysis. Part2. American Society of Agronomy.lnc. Publishers Madison, Wisconsin. U.S.A.

Black, C.A. (2000). Soil fertility evaluation and control. Lewis publishers, Boco Rotan, Florida. U.S.A.

Bodek, I. (1988). Environmental inorganic chemistry: properties, processes, and estimation methods. Pergamon.

Boukhalfa, H., and Crumbliss, A. L. (2002). Chemical aspects of siderophore mediated iron transport. Biometals, 15(4):325-339.

Cate, R. B.,and Nelson, L. A. (1965). A rapid method for correlation of soil test analyses with plant response data. NC State University Agricultural Experiment Station.

Cate, R. B., and Nelson, L. A. (1971). A simple statistical procedure for partitioning soil test correlation data into two classes. Soil Science Society of America Journal, 35(4): 658-660.

Chen, Y. and Hadar, Y. (1991). Iron Nutrition and Iron Interactions in Plants. Kluwer Academic Publishers, Dordrecht, Pp.365-372

Colombo, C., and Torrent, J. (1991). Relationships between aggregation and iron oxides in Terra Rossa soils from southern Italy. Catena, 18(1):51-59.

Cornell R.M., Schwertmann U., (2003). The iron oxides, (2nd edt). Wiley- VCH, Weinheim.

Cox, F. R., and Lins, I. D. G. (1984). A phosphorus soil test interpretation for corn grown on acid soils varying in crystalline clay content 1.Communications in Soil Science and Plant Analysis, 15(12):1481-1491.

Dahnke, W. C. and Olson, R. A. (1990). Soil test correlation, calibration, and recommendation. Pp 45-71., Madison, Wisconsin 1990.

Darwesh, D.A. (2007). Role of supplemental irrigation and fertilizer treatments on yield and nutrients balance in wheat by using modified DRIS. PhD. Thesis College of Agriculture. Salahaddin.Univ. Iraq.

Darwesh, D. A. and Esmail A. O. (2008). The role of supplemental irrigation and fertilizer treatments on yield component of wheat. Mesopotamia Journal of Agriculture .36 (1): 30-38.

Das, D.K. (2003). Introductory Soil Science. Kaylan publishers, Ludhiana, New Delhi.NOI1 DA (U.P.).

Douglas P (2002). Micronutrients. Alberta Environmentally sustainable Agriculture (AESA), Available on line (Feb 6th, 2013) at http //www1.agric.gov.

Drouineau, G. (1942). Rapid determination of active limestone in soil. Ann. Agron. 12:441.

Elinç, F. (1997). Plant available Zn, Fe, Mn, Cu and B status of Vertisol and Non-Calcareous Soils in Meriç Basin. Proceedings of Thrace I. Soil and Fertilizer Symposium, 20-22 October, Tekirdag, pp.119-126, (in Turkish).

Eskandari, H. (2011). The importance of iron (Fe) in plant Products and Mechanism of Its uptake by plants. Journal of Applied Environmental and Biological Sciences, 1(10):448-452.

Eteng, E. U., and Asawalam, D. O. (2015). Evaluation of five extraction methods for predicting available forms of Iron in soils of southeastern, Nigeria. Journal of Agriculture and Veterinary Science (IOSRJAVS), 8(1): 1-8.

Fageria, N. K., and Baligar, V. C. (2005). Enhancing nitrogen use efficiency in crop plants. Advances in Agronomy, 88: 97-185.

FAO Statistical (2013). World Food and Agriculture. Food and Agriculture Organization of the United Nations.

Feiziasl, V., (2006). Determination of Fe, Mn, Zn and Cu critical levels and classification by cate-nelson ANOVA methods for Dryland Wheat (*Triticum aestivum L*) in North Western of Iran. Iranian Journal of Agricultural Sciences. 37: 389-401.

Feiziasl, V., Jafarzadeh, J., Pala, M., and Mosavi, S. B. (2009). Determination of critical levels of micronutrients by plant response column order procedure for dry land wheat (*Triticum aestivum L*) in Northwest of Iran. International Journal of Soil Science, 4(1):14-26.

Fujihara, S., Sasaki, H., Aoyagi, Y., and Sugahara, T. (2008). Nitrogen-to-Protein Conversion Factors for Some Cereal Products in Japan. Journal of food science, 73(3), C204-C209.

Haleem, A. A., Loeppert, R. H., and Anderson, W. B. (1995). Role of soil carbonate and iron oxide in iron nutrition of soybean in calcareous soils of Egypt and the United States. C.F: Abadía, J., (1995).Iron nutrition in soils and plants. Kluwer Academic Publishers Pp. 307–314.

Halverson, A.R. (2001). Soil sampling accuracy. Manual 19. Pacific. North West Fertilizer Conference .Pullman. Washington.

Havlin, J. L., and Soltanpour, P. N. (1981). Evaluation of the NH_4HCO_3-DTPA soil test for iron and zinc. Soil Science Society of America Journal, 45(1): 70-75.

Havlin, J. (1999). Soil fertility and fertilizers: An introduction to nutrient management. Upper Saddle River, N.J: Prentice Hall.

Havlin, J.L., Tisdale, S.L., Nelson W.L., and Beaton J.D (2014). Soil fertility and nutrient Management: an introduction to nutrient management. (8th ed) Pearson (p 505), Upper Saddle River, New Jersey. U.S.A.

Hesse, P. R. (1971). A text book of soil chemical analysis. William Clowes and Sons. Limited, London, Beccles and Colchester.

Hodgson J.M. (1976). Soil survey field handbook. Technical Monograph, 5:56-57.printed in England.

Illmer, P. (2006). A commercially available iron-chelating agent, Desferal, promotes Fe-and Al-mobilization in soils. Soil Biology and Biochemistry, 38(6): 1491-1493.

Inskeep, W. P., and Bloom, P. R. (1986). Calcium carbonate super saturation in soil solutions of Calciaquolls. Soil Science Society of America Journal, 50(6):1431-1437.

Ishimaru, Y., Kim, S., Tsukamoto, T., Oki, H., Kobayashi, T., Watanabe, S., and Nishizawa, N. K. (2007). Mutational reconstructed ferric chelate reductase confers enhanced tolerance in rice to iron deficiency in calcareous soil. Proceedings of the National Academy of Sciences, 104(18):7373-7378.

Iraq Agricultural statistics. (2010). Report the production of wheat and barley. The Ministry of Planning and Development Cooperation. Central Organization for Statistics and Information Technology. Iraq.

Jackson, M. L. (1973). Soil chemical analysis. Prentice Hall, Inc. London.

Jaeger, B., Goldbach, H., and Sommer, K. (1999). Release from lime induced iron chlorosis by CULTAN in fruit trees and its characterisation by analysis. In II ISHS Conference on Fruit Production in the Tropics and Subtropics 531: 107-114.

Jarallah, Kh. A. (2005). Evaluation of iron fertility status and response of wheat in some of Mesopotamian plain soils. PhD Thesis, Dept. of Soil and water Science, College of Agriculture, Baghdad University.

Jones, J.B., Jr. (1970). Distribution of fifteen elements in corn leaves. Communications in Soil Science and Plant Analysis, 1(1): 27-33.

Jones, J.B., Jr., Wolf, B. and Mills, H.A. (1991). Plant Analysis Handbook, Micro-Macro pub, Athens, GA, Pp. 23-26.

Kabata-Pendias, A, (2001). Trace Elements in Soils and Plants (3rd ed). Lewis Publ. Boca Raton. Fl. 480 pages.

Karim, T. H. (1999). Models to predict water retention of Iraqi soils. Journal of Indian Society of Soil Science, 47:19-20.

Khan, A. G. (2005). Role of soil microbes in the rhizo spheres of plants growing on trace metal contaminated soils in phytoremediation. Journal of Trace Elements in Medicine and Biology, 18(4):355-364.

Khodabandeh, N. (2008). Cereal Cultivation. Tehran University Press, Tehran, Iran.

Kumar, M. (2002). Effect of manganese and iron on the soil properties, nutrient uptake and performance of wheat (L.) and barley (L.) M.Sc. (Ag.) Thesis, Maharana Pratap University of Agriculture and Technology, Udaipur (Raj.).

Klute, A. (1986). Method of soil analysis .Part 1and 2nd edt. Argon. Monagr. 9. ASA and SSSA. Madison, Wisconsin.

Li, G., Kronzucker, H. J., and Shi, W. (2016). The Response of the Root Apex in Plant Adaptation to Iron Heterogeneity in Soil. Frontiers in Plant Science, 7: 344.

Lavon, R., and Goldschmidt, E. E. (1999). Enzymatic methods for detection of mineral element deficiencies in citrus leaves: A mini-review. Journal of Plant Nutrition, 22(1):139-150.

Lindsay, W. L., and Norvell, W. A. (1978). Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Science Society of America Journal, 42(3):421-428.

Lindsay, W. L. (1979). Chemical equilibria in soils. John Wiley and Sons Ltd.

Lindsay, W. L., and Schwab, A. P. (1982). The chemistry of iron in soils and its availability to plants. Journal of Plant Nutrition, 5(4-7):821-840.

Lindsay, W.L. (1988). Solubility and redox equilibria of iron compounds in soils. C.F: **Stucki, J.W., Goodman, B.A., Schwertmann, U. (1988)**. Iron in soils and clay minerals. Reidel Publ. NATO, Dordrecht Pp. 37–60.

Lindsay, W.L. (1988). Solubility and redox equilibria of iron compounds in soils. C.F: **Stucki, J.W., Goodman, B.A., Schwertmann, U. (1988)**. Iron in soils and clay minerals. Reidel Publ. NATO, Dordrecht Pp. 37–60.

Lindsay, W. L. (1995). Chemical reactions in soils that affect iron availability to plants. A quantative approach. C.F**: J. Abadía. (ed.), (1995)**. Iron nutrition in soils and plants. Kluwer Academic Publishers Pp.7-14.

Loeppert, R. H. (1986). Reactions of iron and carbonates in calcareous soils. Journal of Plant Nutrition, 9(3-7):195-214.

Loeppert, R. H. and Iskeep, W. P. (1996). Iron methods of soil analysis, Part 3, chemical methods, C.F: Sparks, D. L., Page, A. L., Helmke, P. A., Loeppert, R. H., Soltanpour, P. N., Tabatabai, M. A., and Sumner, M. E. (1996). Methods of soil analysis. Part 3-Chemical methods. Soil Science Society of America Inc., Pp. 437-474.

Long, J. K., Bänziger, M., and Smith, M. E. (2004). Diallel analysis of grain iron and zinc density in southern African-adapted maize inbreds. Crop Science, 44(6):2019-2026.

Loop, E. A., and Finck, A. (1984). Total iron as a useful index of the Fe-status of crops. Journal of Plant Nutrition, 7(1-5):69-79.

Marschner, H. (1991). Symposium summary and future research areas. C.F: Chen, Y. and Hadar, Y. (1991). Iron Nutrition and Iron Interactions in Plants. Kluwer Academic Publishers, Dordrecht. Pp. 365–372.

Masalha, J., Kosegarten, H., Elmaci, Ö, and Mengel, K. (2000). The central role of microbial activity for iron acquisition in maize and sunflower. Biology and Fertility of Soils, 30(5-6):433-439.

Meena, R.S., Mathur, A.K. and Sharma, S.K. (2013). Determination of critical limit of iron for wheat in soils of sub-humid southern zone (IV-B) of Rajasthan. International Journal of Applied Agricultural and Horticultural Sciences.4 (3):291-302.

Mengel, K., Planker, R., and Hoffmann, B. (1994). Relationship between leaf apoplast pH and iron chlorosis of sunflower (*Helianthus annuus L.*).J. P.N, 17(6):1053-1065.

Mengel, K. (1995). Iron availability in plant tissues—iron chlorosis on calcareous soils. C.F J. Abadía (ed.), (1995).Iron nutrition in soils and plants. Kluwer Academic Publishers, Pp. 389-397. Springer Netherlands.

Mengel, K., Kirkby, E. A., Kosegarten, H. and Appel, T. (2001). Principles of Plant Nutrition. Kluwer Academic publishers.

Miller, G.W., Huang, I.J., Welkie, G.W and Pushnik, J.C. (1995). Function of iron in plants with special emphasis on chloroplasts and photosynthetic activity. In Iron Nutrition in Soils and Plants. Springer Netherlands, Pp. 19–28

Mohammad, SH. SH.A. (2006). Availability indices and physic-chemical behavior of Iron in calcareous soils. M.Sc. Thesis, Sulaimani Univ. Iraq.

Mohsin, H.A.A, (2013). Effect Different Levels of Chelated Iron on the Growth and yield of Wheat (*Triticum aestivum L.)* under Thi- Qar and Al-Muthanaa conditions. International Journal of Science and Research, 4(9):1741-1743.

Narimani, H., M.M. Rahimi, A. Ahmadikhah and B. Vaezi, (2010). Study on the Effects of foliar spray of micronutrient on yield and yield components of Durum wheat. Archives of Applied Science Research, 2(6): 168-176.

Noor Mohammadi, G., Siadat, A. and Kashani, A. (2008). Agronomy of Cereals. Publications of Shahid Chamran University of Ahwaz. P. 446.

Norvell, W. A. (1984). Comparison of chelating agents as extractants for metals in diverse soil materials. Soil Science Society of America Journal, 48(6):1285-1292.

O'Hallorans, J. M., Lindemann, W. C., and Steiner, R. (2005). Iron characterization in manure amended soils. Communications in Soil Science and Plant Analysis, 35(15-16): 2345-2356.

Olson, R. V., and Carlson, C. W. (1950). Iron chlorosis of sorghums and trees as related to extractable soil and iron manganese. Proceedings. Soil Science Society of America Journal, 14:109-112.

Reuter D. J., Robinson J. B., and Dutkiewicz C. (1997). Plant Analysis: An Interpretation Manual.Clayton, VIC:Commonwealth Scientific and Industrial Research Organisation Publishing.

Rezaei, A., (2007). Understanding of statistic and probability .Mashhad Nashr puplication.

Richards, L.A. (1954). Diagnosis and improvement of saline and alkali soils Agric. Hand book No. 60, USDA. Washington.

Robin, A., Vansuyt, G., Hinsinger, P., Meyer, J. M., Briat, J. F., and Lemanceau, P. (2008). Iron dynamics in the rhizosphere: consequences for plant health and nutrition. Advances in agronomy, 99: 183-225.

Römheld, V., and Marschner, H. (1986). Evidence for a specific uptake system for iron phytosiderophores in roots of grasses. Plant Physiology, 80 (1):175-180.

Rowell, D. L. (1996). Soil Science. Methods and Application. Reading Univ. UK.

Sakal, R., Singh, B. P., Sinha, R. B., Singh, S. P., and J ha, S. N. (1986). Availability of zinc, iron, copper and manganese in sub--Himalayan hill and forest soils as influenced by certain soil properties. Journal of Indian Society of Soil Science, 34(1):191-193.

SAS Institute, (2001). The SAS system for Windows, The SAS Inst. Cary, NC.

Schuffelen, A. C., Muller, A., and Van Schouwenburg, J. C. (1961). Quick tests for soil and plant analysis used by small laboratories. Netherlands Journal of Agricultural Science, 9, 1-16.

Schwertmann, U. (1988). Occurrence and formation of iron oxides in various Pedoenvironments. C.F: J.W. Stucke et al (ed). (1988) Iron in soils and clay minerals. NATO ASI series concentration 127.D.Reidel Public. Co.,Boston, Pp. 267-308.

Shahrokhi, N., Khourgami, A., Nasrollahi, H., and Shiran-Rad, A.H. (2012). The effect of Iron Sulfate Spraying on Yield and Some Qualitative Characteristics in Three Wheat Cultivars. Scholars Research Library Annals of Biological Research, 3(11): 5205-5210.

Shittu, O. S., Ogunwale, J. A., and Ayodele, O. J. (2010). Total and extractable Iron and manganese in soils developed on charnockite in ekiti state, Nigeria. International Journal of Water and soil Resources Research, 1:83-93.

Sims, J.T and Johnson, G.V. (1991). Micronutrient soil tests, C.F: Mortvedt, J.J., **Cox, F. R., Shuman L. M., and Welch, R. M. (2ndedt.), (1991).** Micronutrients in Agriculture. Soil Science Society of America Journal. 4: 427-476.

Singh, M. and. Dahiya, S. S (1975). Effect of calcium carbonate and iron on availability of iron in a light textured soil. Journal of Indian Society of Soil Science, 23: 247-252.

Singh, H. G., and Takkar, P. N. (1981). Evaluation of efficient soil test methods for Zn and their critical vales in salt-affects soils for rice. Communications in Soil Science and Plant Analysis, 12(4):383-406.

Soltanpour, P. A., and Schwab, A. P. (1977). A new soil test for simultaneous extraction of macro-and micro-nutrients in alkaline soils 1. Communications in Soil Science and Plant Analysis, 8(3):195-207.

Somani, L.L, and Kanthaliya, P.C. (2004). Soils and fertilizers at agallance, Agrotech publishing academy. H.S. off set printers New Delhi.

Sparks, D. L., Page, A. L., Helmke, P. A., Loeppert, R. H., Soltanpour, P. N., Tabatabai, M. A., and Sumner, M. E. (1996). Methods of soil analysis. Part 3-Chemical methods. Soil Science Society of America Inc.

Stucki, J.W., Goodman, B.A., Schwertmann, U. (1988). Iron in soils and clay minerals. Reidel Publ. NATO, Dordrecht, Pp. 37–60.

Tagliavini, M., and Rombolà, A. D. (2001). Iron deficiency and chlorosis in orchard and vineyard ecosystems. European Journal of Agronomy, 15(2): 71-92.

Tyner, E. H. (1947). The relation of corn yields to leaf nitrogen, phosphorus, and potassium content. Soil Science Society of America Journal, 11(C): 317-323.

Tupatkar, P., and Sonar, K. R. (1995). Effect of pyrite on release of Fe, P and S in a calcareous Inceptisol and yield of rice. Journal of Indian Society of Soil Science, 43(4): 696-698.

Ulrich, A. (1952). Physiological bases for assessing the nutritional requirements of plants. Annual Review of Plant Physiology, 3(1):207-228.

Wallace, A. and Wallace, G. A. (1992). Some of the problems concerning iron Nutrition of plants after four decades of synthetic chelating agents. Journal of Plant Nutrition 15: 1487–1508.

Wallace, A., Wallace, G. A., and Cha, J. W. (1992). Some modifications in trace metal toxicities and deficiencies in plants resulting from interactions with other elements and chelating agents--the special case of iron. Journal of Plant Nutrition, 15(10):1589-1598.

White, P. J., and Broadley, M. R. (2009). Bio fortification of crops with seven mineral elements often lacking in human diets–iron, zinc, copper, calcium, magnesium, selenium and iodine. New Phytologist, 182(1): 49-84.

Whitney, D. A. (1988). Micronutrient soil test zinc, iron, manganese and copper. Pp.20-22. C.F: W. C. Dahnke. (1990). Recommended chemical soil test Procedures for the North Central Region. North Dakota Agric. Exp. Stn. Bull, 499. Review.

Wolt, J. D. (1994). Soil solution chemistry: applications to environmental science and agriculture. John Wiley and Sons.

Zuo, Y., and Zhang, F. (2011). Soil and crop management strategies to prevent iron deficiency in crops. Plant and Soil, 339(1-2):83-95.

Appendix (1): Explained interaction effect of soil types and levels of iron on some growth characters of wheat plant

Soil No	Plant height(cm)					Leaf area(cm^2)					Number of Spike.pot^{-1}				
	0	2	4	6	8	0	2	4	6	8	0	2	4	6	8
1	63.83	62.85	65.33	59.50	61.50	35.11	33.08	38.57	33.64	33.92	18.66	14.66	13.00	13.66	15.00
2	60.33	64.50	61.83	64.33	67.16	22.56	22.61	36.89	36.24	23.58	27.66	28.33	26.66	31.33	**33.66**
3	66.83	67.16	66.16	67.16	69.00	29.27	37.14	25.02	36.25	28.88	16.00	17.00	15.33	16.33	13.66
4	62.16	64.50	65.00	65.83	66.00	35.38	34.03	33.81	33.27	41.69	12.00	11.66	16.66	13.66	17.00
5	69.667	66.66	64.50	68.33	65.00	27.28	27.59	28.28	24.83	23.83	17.33	16.33	28.66	15.00	13.66
6	66.50	64.70	61.50	64.14	66.66	34.70	38.69	33.76	33.10	37.69	18.33	14.33	13.66	16.66	16.00
7	46.16	**44.33**	51.66	48.00	50.00	26.70	**17.01**	29.68	24.04	17.35	**10.00**	10.33	12.33	11.00	12.66
8	66.00	68.16	64.50	69.16	66.00	34.58	30.15	31.30	32.77	40.01	24.00	14.33	12.33	17.66	18.33
9	58.50	55.66	58.66	52.33	50.50	21.38	24.03	26.43	28.96	21.49	13.00	12.33	15.00	13.66	10.33
10	61.00	62.50	64.50	59.00	60.00	29.21	34.36	29.37	27.36	22.31	16.66	12.66	13.33	13.00	14.66
11	70.33	68.00	70.167	69.50	**73.33**	30.07	33.32	30.32	29.33	25.35	24.66	26.66	24.33	26.33	24.33
12	72.50	66.00	66.33	68.66	66.66	47.26	41.92	41.93	39.38	37.66	24.66	30.00	30.33	27.00	27.00
13	55.33	57.83	60.00	61.16	57.66	26.00	29.93	23.11	26.46	26.95	17.00	16.00	20.66	20.33	18.33
14	59.50	61.16	62.33	58.16	62.33	30.10	27.47	31.38	32.80	33.21	14.33	11.33	13.66	14.00	17.00
15	68.00	64.83	61.16	53.66	63.00	35.01	24.85	25.71	31.12	31.30	15.00	12.66	13.00	12.33	12.66
16	72.00	65.50	65.16	67.83	66.66	27.48	26.29	27.72	32.55	**90.43**	23.33	24.33	17.00	21.33	16.66
17	58.50	59.16	53.167	65.50	61.50	26.61	28.81	22.54	26.28	35.65	20.00	25.33	14.33	21.66	21.33
18	66.66	60.50	54.66	65.83	63.20	38.01	26.02	21.89	32.71	37.26	31.00	21.33	13.33	24.66	23.66
19	64.66	63.66	60.66	67.83	66.50	28.26	29.23	32.57	32.87	34.49	23.00	27.33	22.00	25.66	21.00
20	56.83	64.00	66.66	55.00	56.83	32.48	30.38	25.75	28.90	26.96	14.33	17.66	19.33	21.00	10.33
Effect	**					**					**				

Appendix (1) continued

Soil No	No of seeds.pot^{-1}					Seed Wt. (g)					Wt. of dry matter (g)				
	0	2	4	6	8	0	2	4	6	8	0	2	4	6	8
1	384.00	312.66	252.33	313.66	280.00	13.45	9.92	8.68	10.99	9.78	42.99	31.97	27.13	33.08	30.06
2	506.66	451.33	377.33	416.00	583.66	16.97	16.78	10.61	17.26	18.80	58.95	66.93	49.46	**77.56**	77.35
3	359.33	315.33	323.00	346.33	313.66	13.97	11.45	12.03	14.90	12.57	40.09	38.49	35.53	40.33	34.14
4	235.66	252.33	292.33	500.66	343.00	5.64	8.58	12.29	18.25	11.90	22.92	26.42	32.08	26.39	38.01
5	361.00	583.33	433.00	408.66	305.33	16.32	15.21	23.08	15.23	11.37	40.06	42.09	68.00	38.52	35.62
6	358.66	357.33	274.66	356.00	352.33	9.99	13.27	7.76	10.31	10.80	36.51	37.07	32.07	34.44	31.81
7	**94.66**	114.66	165.33	116.00	113.00	**2.61**	3.11	4.44	3.24	3.14	**9.74**	9.81	15.45	11.80	13.51
8	485.66	441.00	331.66	485.66	430.33	17.44	17.96	11.68	19.12	17.51	55.94	46.33	31.93	51.26	38.98
9	276.00	293.33	284.00	204.33	156.00	8.08	7.71	8.13	6.77	4.64	22.35	20.63	23.84	19.04	14.08
10	270.33	210.33	260.00	195.33	213.66	8.08	6.46	6.48	6.94	5.77	27.92	22.81	20.40	21.84	18.58
11	723.33	695.66	700.33	761.00	724.00	**31.10**	21.55	26.23	24.87	27.62	72.47	68.85	73.75	68.36	69.52
12	412.66	362.66	329.66	293.66	331.00	11.52	13.52	12.26	11.39	14.72	58.68	57.44	54.13	56.45	54.05
13	219.66	276.00	392.00	357.66	218.66	6.13	9.27	12.01	10.85	4.97	24.68	33.91	42.73	39.63	31.04
14	205.00	168.66	192.33	158.33	227.66	6.33	5.81	6.09	4.77	7.69	20.50	18.36	19.41	15.84	25.28
15	300.00	243.00	302.66	200.00	167.66	10.78	8.15	10.44	6.33	5.28	34.31	27.58	32.97	18.77	21.78
16	718.00	**767.33**	305.33	540.00	326.33	29.08	27.96	11.25	20.89	15.03	73.03	76.60	53.73	61.37	44.97
17	235.66	570.66	235.66	407.00	365.66	7.73	17.04	7.83	11.36	10.96	34.25	57.97	41.93	46.75	48.21
18	574.00	448.33	293.33	599.66	594.66	21.14	18.46	8.77	20.89	18.94	75.70	53.36	25.35	62.77	55.08
19	197.00	408.66	255.33	148.33	255.33	7.29	12.06	4.66	11.76	7.63	37.96	58.47	39.58	46.10	41.06
20	194.33	266.00	342.33	246.00	162.00	7.58	9.02	12.31	8.58	5.47	22.84	30.42	40.48	30.23	16.32
Effect	**					**					**				

Appendix (1) continued

Soil No	Chlorophyll SPAD				
	0	2	4	6	8
1	36.40	45.50	35.63	32.43	35.00
2	45.50	46.93	43.90	41.93	46.20
3	37.96	40.63	37.00	40.00	38.63
4	38.96	36.10	38.20	39.30	38.50
5	36.93	36.70	36.36	36.83	37.40
6	38.46	40.03	39.63	39.60	40.20
7	38.02	39.86	39.10	37.70	36.60
8	41.93	37.13	37.20	39.30	40.16
9	40.03	40.76	41.16	39.46	37.40
10	42.86	41.03	40.90	40.36	40.50
11	39.40	37.50	31.30	36.70	34.46
12	44.60	44.83	43.73	43.23	43.23
13	32.66	32.73	34.66	**30.50**	32.10
14	42.86	37.93	37.93	37.73	38.60
15	42.53	35.33	32.40	37.33	32.70
16	37.53	38.46	39.36	37.40	38.63
17	38.80	39.16	36.50	40.63	40.53
18	**47.26**	42.73	38.46	42.76	41.66
19	41.06	41.26	43.66	46.66	42.96
20	37.90	38.06	39.16	36.70	39.00
Effect	**				

حكومة اقليم كوردستان

وزارة التعليم العالي والبحث الغلمي

جامعة السليمانية

فاكلتي العلوم الزراعية

تحديد الحد الحرج للحديد في ترب محافظة السليمانية المزروعة بالحنطة

رسالة مقدمة الى

مجلس فاكلتي العلوم الزراعية في جامعة السليمانية كجزء من متطلبات نيل درجة الماجستير في العلوم الزراعية

علوم التربة والمياه (خصوبة التربة)

من قبل

سازان فتحي شريف

بكالوريوس علم التربة-جامعة السليمانية -2001

دبلوم عالي (الريات التكميلية)- المحاصيل الحقلية- جامعة السليمانية 2009

بأشراف

أ.د.اكرم عثمان اسماعيل

2016 م

1437 ه

الخلاصة والاستنتاجات

شملت هذه الدراسة تجربة عاملية في السنادين لنبات الحنطة خلال موسم النمو الشتوي (2014-2015) وللفترة الواقعة ما بين 1\12\2014 الى 12\6\2015 بهدف تحديد الحد الحرج للحديد باستخدام ترب من (20) موقعا زراعيا وهي (قلياسان, بازيان , بكرة جو , سيروان , باينجان , حلبجة, كيلي, سيد صادق , كلار , كفري, بينجوين , قلعة دزة , رانية , جمجمال , دربنديخان, كاني بانكة, زركويز , طاسلوجة, دوكان و ماوت) في محافظة السليمانية. . اجريت التجربة في الحقول الزراعية التابعة لمركز البحوث الزراعية في بكرة جو ذات قراءة GPS 35°,32',134"N-45°,22',879"E .

اجريت تجربة عاميلة لدراسة تاثير (5) مستويات من الحديد المخلبي Fe-EDDHA,6%Fe (8,6,4,2,0) ملغم.Fe كغم$^{-1}$ تربة من (20) موقعا زراعيا باستخدام التصميم العشوائي الكامل بثلاث مكررات على النمو والانتاج والنوعية لنبات الحنطة و تحديد الحد الحرج للتربة ونبات الحنطة .

تمت زراعة بذور الحنطة *Triticum aestivum L.* في سنادين بلاستيكية سعتها (13) كغم، وتم ري النباتات عند الحاجة حسب الطريقة الوزنية، وتم حصاد النباتات في 2015/6/12.

يمكن تلخيص اهم النتائج بما يلي:

1. اعلى وادنى التراكيز البدائية للحديد في الترب كانت (3.96-1.66) ملغمFe.كغم$^{-1}$تربة ، في موقعي زركويز و طاسلوجة على التوالي.
2. سجل أعلى وزن جاف (77.5) غم سندانة$^{-1}$ في المعاملة أو المستوى (6) ملغمFe.كغم$^{-1}$تربة لموقع بازيان.
3. أثر موقع التربة معنويا (P≤0.01) على الوزن الجاف، وتم تسجيل أعلى قيمة في موقع (بينجوين) بمعدل (68.52)غم.سندانة$^{-1}$، في حين ادنى قيمة كانت لموقع (كيلي) بمعدل (11.97) غم.سندانة$^{-1}$.
4. اظهرت النتائج بانه بزيادة مستويات الحديد المضافة تاثير معنوي (P≤0.01) في تركيز الحديد في بذور الحنطة، اذ بلغت اعلى قيمة له (73.23) ملغمFe.كغم$^{-1}$تربة عند المستوى (6) ملغمFe.كغم$^{-1}$تربة ، وادنى قيمة كانت (62.14) ملغمFe.كغم$^{-1}$تربة سجلت عند (2) ملغمFe.كغم$^{-1}$تربة. كما كان لموقع التربة تأثيرا معنويا عند (P≤0.01) على تركيز الحديد في بذور الحنطة، حيث دونت اعلى قيمة

له (164.40) ملغمFe.كغم$^{-1}$تربة عند موقع (سيدصادق) ، وادنى قيمة كانت (16.23) ملغمFe.كغم$^{-1}$تربة لموقع (بينجوين). كما كان للتداخل بين مستويات الاضافة والمواقع أثرا معنويا عند ($P\leq0.01$) على تركيز الحديد في بذور الحنطة، حيث كانت اعلى قيمة (184.66) ملغمFe.كغم$^{-1}$تربة سجلت في المعاملة العاملية S_6Fe_8 في حين كانت ادنى قيمة (7.01) ملغمFe.كغم$^{-1}$تربة سجلت في المعاملة العاملية S_4Fe_6 .

5. اثر زيادة مستويات الحديد معنويا ($P\leq0.01$) على محتوى البروتين في بذور الحنطة، حيث سجلت اعلى قيمة (174.16) مكم كغم$^{-1}$ بذور عند المستوى (8) ملغمFe.كغم$^{-1}$تربة ، في حين سجلت أدنى قيمة (169.32) مكم كغم$^{-1}$ بذور في معاملة المقارنة ، كما كان لموقع التربة تأثيرا معنويا ($P\leq0.01$) على محتوى البروتين، حيث سجلت اعلى قيمة (201.33) مكم كغم$^{-1}$ بذور لموقع (قلعةدزة) ، و سجلت ادنى قيمة (131.52) مكم كغم$^{-1}$ بذور ^{1} لموقع (كلار) ، كما ان للتداخل بين مستويات الاضافة والمواقع أثرا معنويا عند ($P\leq0.01$) على محتوى البروتين، حيث كانت اعلى قيمة (205.90) مكم كغم$^{-1}$ بذور وادنى قيمة (119.50) مكم كغم$^{-1}$ بذور في المعاملة العاملية S_5Fe_0 .

6. اظهرت النتائج بانه بزيادة مستويات الحديد المضافة تاثير معنوي ($P\leq0.01$) فى تركيز الحديد في قش الحنطة، اذ بلغت اعلى قيمة له (51.03) ملغمFe.كغم$^{-1}$قش عند المستوى (4) ملغمFe.كغم$^{-1}$تربة ، وادنى قيمة كانت (39.86) ملغمFe.كغم$^{-1}$قش سجلت عندالكونترول. كما كان لموقع التربة تأثيرا معنويا عند ($P\leq0.01$) على تركيز الحديد في قش الحنطة، حيث دونت اعلى قيمة له (125.38) ملغمFe.كغم$^{-1}$قش عند موقع (كفري) ، وادنى قيمة كانت (12.56) ملغمFe.كغم$^{-1}$قش لموقع (كلار). كما كان للتداخل بين مستويات الاضافة والمواقع أثرا معنويا عند ($P\leq0.01$) على تركيز الحديد في قش الحنطة، حيث كانت اعلى قيمة (236.47) ملغمFe.كغم$^{-1}$قش سجلت في المعاملة العاملية $S_{13}Fe_2$ في حين كانت ادنى قيمة (11.02) ملغمFe.كغم$^{-1}$قش سجلت في المعاملة العاملية S_6Fe_1

7. اظهرت النتائج بانه بزيادة مستويات الحديد المضافة تاثير معنوي ($P\leq0.01$) فى تركيز الفسفور في قش الحنطة، اذ بلغت اعلى قيمة له (7.05) ملغمFe. غم$^{-1}$قش عند المستوى (6) ملغمFe.كغم$^{-1}$تربة ، وادنى قيمة كانت (2.08) ملغمFe غم$^{-1}$قش سجلت عند المستوى (2) ملغمFe.كغم$^{-1}$تربة، لكن لموقع التربة أثر معنويا ($P\leq0.01$) على تركيز الفسفور في قش الحنطة، حيث سجلت أعلى قيمة (4.53)

ملغم غم$^{-1}$ لموقع (دوكان) في حين سجلت أدنى قيمة لموقع (كيلي) وكانت (2.16) ملغم غم$^{-1}$. كما كان للتداخل بين مستويات الاضافة والمواقع أثرا معنويا عند ($P\leq0.01$) على تركيز الفسفور في قش الحنطة حيث سجلت أعلى قيمة (5.40) ملغم غم$^{-1}$ للمعاملة العاملية S_4Fe_3 بينما لوحظت أدنى قيمة (1.80) ملغم غم$^{-1}$ للمعاملة العاملية S_7Fe_0 .

8. بلغ مستوى الحد الحرج للحديد في التربة بالطريقة البيانية والحسابية (2.61 و2.5) ملغم Fe.كغم$^{-1}$ تربة على التوالي.
9. بلغ الحد الحرج للحديد لنبات الحنطة التي تم تقديرها بالطريقة البيانية والحسابية (46.55, 50.50) ملغم Fe.كغم$^{-1}$ نبات على التوالي.

حکومەتی هەرێمی کوردستان

وەزارەتی خوێندنی باڵا و توێژینەوەی زانستی

زانکۆی سلێمانی

فاکەڵتی زانستە کشتوکاڵیەکان

دیاریکردنی تخووبی شلۆقی ئاسن بۆ خاکی پارێزگای سلێمانی چاندراو بە گەنم

نامەیەکە

پێشکەش کراوە بە ئە نجومەنی فاکەڵتی زانستە کشتوکاڵیەکان لە زانکۆی سلێمانی وەك بەشێك لە

پێداویستیەکانی بە دەستهێنانی بڕوانامەی ماستەر لە زانستە کشتوکاڵیەکان –زانستی خاك و ئاو

(پیتداری خاك)

لە لایەن

سازان فتحی شریف

بەکالۆریوس –زانستی خاك -زانکۆی سلێمانی -٢٠٠١

دبلومی باڵا- بەروبومی کیلگەیی- زانکۆی سلێمانی -٢٠٠٩

بە سەر پەرشتی

پ.د.ئەکرەم عوسمان ئسماعیل

٢٠١٦ ز — ٢٧١٦ ك

پوختە و دەرئەنجامەکان

ئەم تویژینەوەیە لە وەرزی زستانەی (٢٠١٤-٢٠١٥) لەماوەی ١-١٢-٢٠١٤ تا ١٢-٦-٢٠١٥ ئەنجام درا ، بۆ دیاریکردنی تخووبی شلۆقی ئاسن لە ٢٠ خاکی ناوچەی کشتوکاڵی،(قلیاسان،بازیان،بەکرە جۆ ، سیروان ، باینجان ،هەلبجە، کێلێ ، سەید سادق، کەلار ،کفری ، پێنجوێن ، قەلادزە ،ڕانیە ، چەمچەماڵ ، دەربەندیخان، کانی پانکە ، زرگوێز ، تاسلوجە، دوکان و ماوەت) چاندراو بە گەنم لە کێڵگە کشتوکالیێەکانی سەر بە سەنتەری تۆژینەوەی کشتوکاڵی بەکرەجۆ لە پارێزگای سلێمانی. کە خوێندنەوەی (GPS) ە کەی 35°,32',134"N-45°,22',879"E بوو.

تۆێژینەوەکە لە ئینجانەدا ئەنجام درا لە کێڵگەکانی وێستگەی بەکرەجۆ سەر بە مەڵبەندی فەرمانگەی تویژینەوەکانی کشتوکاڵی سلێمانی . کە پێنج ئاستی جیاواز (8,6,4,2,0) ملگم بە کگم$^{-1}$ بە بەکارهێنانی Fe-EDDHA کەر بڕی ٦٪ ئاسنی تیدایە و ٢٠ خاکی جیاواز بەکارهێنرا بە مەبەستی زانینی کاریان لە سەر گەشەو جۆری گەنم و دیارکردنی ئاستی شلۆقی ئاسن بە بەکارهینانی نەخشەکاری هەرەمەکی فاکتوریاڵی تەواو بە سێ دوبارەبوونەوە.تۆوی گەنم لە جۆری *Triticum asetiv* چێنرا لە ئینجانە کە قەبارەکەی (١٣) کیلۆگرام یە خاکی تێکرا بوو. ئاودان کرا لە کاتی پێویست بە پێ ی ڕێگای کێشی . دورێنەئەنجامدرا لە ١٢\٦\٢٠١٥.

دەرئەنجامەکانی ئەم تویژینەوەیە لەم خالآنەی خوارەوەدا کورت کراوەتەوە:

١. بەهای ئاستی ئاسنی سەرەتایی خاك لە (3.96-1.66) ملگم.کگم$^{-1}$ خاك بوو، لە زرگوێز و تاسلوجە تۆمار کرا.

٢. بەرزترین کێشی وشکە مژاد (5 .77) گرام. ئینجانە$^{-1}$ بوو لە مامەڵەی پێکەوەیی (٦ ملگم. کگم$^{-1}$ خاك * بازیان) تۆمار کرا.

٣. شوێنەکان کاریگەری بەرچاویان هەبوو لە ژێر ئاستی ($P \leq 0.01$) لە سەر کێشی وشکە مژاد و بەرزترین بەها (٦٨,٥٢) گم.ئینجانە[-١] لە شوێنی (پێنجوێن) تۆمارکرا، وە نزمترین بەهاش (١١.٩٧) گم.ئینجانە[-١] لە شوێنی (کێلێ) تۆمار کرا.

٤. زیادکردنی ئاستی ئاسنی زیادکراو کاریگەری بەرچاویان هەبوو لەسەر ڕێژەی ئاسن لە بەرهەمی گەنم و بەرزترینی (73.23) ملگم کگم[-١] بوو لە ژێر ئاستی زیادکردنی ٦ مگم.Fe کگم[-١]خاك ، وە نزمترینی (62.14) مگم. کگم[-١] لەژێر ئاستی زیادکردنی ٢ مگم.Fe کگم[-١]خاك تۆمارکران. شوێنەکان کاریگەری بەرچاویان هەبوو لە سەر ڕێژەی ئاسن لە بەرهەمی گەنم و بەرزترین بەها (١٦٤.٤٠) ملگم.Fe کگم[-١] لە شوێنی سەیدسادق و نزمترین بەهاش (16.23) ملگم.Fe کگم[-١] لە شوێنی پێنجوێن تۆمار کران. زیادکردنی ئاستی ئاسنی زیادکراو و شوێنەکان بە یەکەوە کاریگەری بەرچاویان هەبوو لەسەر ڕێژەی ئاسن لە بەرهەمی گەنم و بەرزترین بەها (١٨٤.٦٦) ملگم.Fe کگم[-١] لەمامەڵەی پێکەوەیی S_6Fe_5 و نزمترین بەهاش (7.01) ملگم.Fe کگم[-١] لەمامەڵەی پێکەوەیی S_4Fe_4 تۆمار کران.

٥. زیاد کردنی ئاستەکانی ئاسن کاریگەری بەرچاویان هەبوو لە سەر ڕێژەی پرۆتین لە بەرهەمی گەنم و بەرزترین کێش (174.16) مگم .کگم[-١] لە ژێر ئاستی زیادکردنی (٨) مگم Fe.کگم[-١]، وە نزمترین بەهاش (169.32) مگم .کگم[-١] لە ژێر ئاستی بەراورد تۆمارکران. شوێنەکان کاریگەری بەرچاویان هەبوو لەسەر ڕێژەی پرۆتین لە بەرهەمی گەنم کە بەرزترین ڕێژە (201.33) مگم .کگم[-١] لە شوێنی ژمارە قەلادزە و نزمترین بەهاش (131.52) مگم .کگم[-١] لە شوێنی کەلار تۆمار کران. مامەڵەی پێکەوەیی ئاستی ئاسن و شوێنەکان کاریگەری بەرچاویان هەبوو لەسەر ڕێژەی پرۆتین لە بەرهەمی گەنم و بەرزترین بەها (205.90) مگم .کگم[-١] لەمامەڵەی پێکەوەیی $S_{12}Fe_5$ و نزمترین بەهاش (119.50) مگم .کگم[-١] لە S_5Fe_0 تۆمار کران.

٦. زیادکردنی ئاستی ئاسنی زیادکراو کاریگەری بەرچاویان هەبوو لەسەر ڕێژەی ئاسن لە کای گەنم، و بەرزترینی (51.03) ملگم کگم$^{-1}$ بوو لە ژێر ئاستی زیادکردنی 4 مگم.Fe کگم $^{-1}$خاك ، وە نزمترینی (39.86) مگم. کگم$^{-1}$ لە ژێر ئاستی بەراورد تۆمارکران. بەڵام گۆڕانی شوێنەکان کاریگەری بەرچاویان هەبوو، لەسەر ڕێژەی ئاسن لە کای گەنم کە بەرزترین بەها (125.38) ملگم کگم$^{-1}$ لە شوێنی کفری وە نزمترین بەهاش (12.56) ملگم کگم$^{-1}$ لە شوێنی کەلار تۆمار کران. زیادکردنی ئاستی ئاسنی زیادکراو و شوێنەکان بەیەکەوە کاریگەری بەرچاویان هەبوو لەسەر ڕێژەی ئاسن لە کای گەنم کە بەرزترین بەها (236.47) ملگم. کگم $^{-1}$ تۆمار کرا لەمامەڵەی پێکەوەیی $S_{13}Fe_2$ وە نزمترین بەهاش (11.02)) ملگم کگم $^{-1}$ لەمامەڵەی پێکەوەیی S_6Fe_1 تۆمار کران.

٧. زیاد کردنی ئاستی ئاسنی زیادکراو کاریگەری بەرچاویان هەبوو لەسەر ڕێژەی فسفۆر لە کای گەنم. و بەرزترینی (7.05) ملگم گم$^{-1}$ بوو لە ژێر ئاستی زیادکردنی 6 مگم.Fe کگم $^{-1}$خاك ، وە نزمترینی (2.08) مگم. گم$^{-1}$ لە ژێر ئاستی زیادکردنی 2 مگم.Fe کگم $^{-1}$خاك. گۆڕانی شوێنەکان کاریگەری بەرچاویان هەبوو لەسەر ڕێژەی فسفۆر کە بەرزترین بەها (٤.٥٣) ملگم گم$^{-1}$ لە شوێنی دوکان وە نزمترین بەهاش (٢.١٦) ملگم گم$^{-1}$ لە شوێنی کێلێ تۆمار کران. زیادکردنی ئاستی ئاسنی زیادکراو و گۆڕانی شوێنەکان بە یەکەوە کاریگەری بەرچاویان هەبوو لە سەر ڕێژەی فسفۆر لە کای گەنم و بەرزترین بەها (5.40) ملگم گم $^{-1}$ لەمامەڵەی پێکەوەیی S_4Fe_3 وە نزمترین بەهاش (1.80) ملگم گم $^{-1}$ لە مامەڵەی پێکەوەیی $S_{14}Fe_0$ تۆمار کران.

٨. تخووبی شلۆقی ئاسن لە پارێزگای سلێمانی دیاریکرا بە هەردوو ڕێگای ئەژمارکردن و گرافیکی کە (2.61 و 2.5) ملگم Fe کگم $^{-1}$خاك بوو یەك لە دوای یەك.

٩. تخووبی شلۆقی ئاسن لە ڕووەکی گەنم دیاریکرا بە هەردوو ڕێگای ئەژمارکردن و گرافیکی کە (46.55 و50.50) ملگم Fe کگم $^{-1}$ بوو یەك لە دوای یەك.