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The impact of nano Fe-chelate, Fe-EDDHA Non-nano and FeSO4 on the growth and physiological index in lettuce (*Lactuca sativa* L.) varieties grown in NFT

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Abstract

It is one of the micronutrients Fe, there is enough for plant growth and chlorophyll formation it is necessary. Element for many physiological processes, including the manufacture of chlorophyll and the biochemical reactions of oxidation and reduction, photosynthesis, respiration and enzyme systems is essential. In this regard, this study examines the impact of Nano Fe-chelate, Fe-EDDHA Non-Nano and FeSO4 on some indices of growth and the amount of chlorophyll a, b and total chlorophyll, Varieties Ovak Leaf Green, Ovak Leaf Violet, Betarige and Ayserg N.F.T grown lettuce in a factorial randomized complete block design with three replications deals. The results suggest that changes in the performance of all averages and indices physiological treatments studied were significant at the one percent level and the number of traits, there were significant differences. So that the maximum mass of the whole plant and shoot fresh mass Ovak Leaf green respectively 253.33 and 216.28 mg, respectively. Fe fertilizers significant effect on chlorophyll a, b and total chlorophyll "a". Nano Fe-chelate fertilizer plant than other treatments led to an increase in the amount of chlorophyll "b" and total chlorophyll was. According to the test results to improve the performance of Nano Fe-chelated 9% and Ovak Leaf green varieties grown in NFT system is advisable.

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Introduction

The total world population of 6 billion people is estimated that about 50 percent are based in Asia. Much of the population lives in developing countries and most trouble growing food shortage due to unfavorable environmental conditions or political instability face while the developed countries are faced with an abundance of food resources. Such a way that developing countries can cope with a shortage of food supplies, to increase the performance of agricultural products, particularly by reducing the damage caused by living agents (pests and plant diseases) and is non-living. Nanotechnology is the ability to create change in the areas of health, textiles, materials, energy and information and communication technology is good. The first report on the application of nanotechnology in agriculture in 2003 was published by the Ministry of Agriculture America (Schoen *et al.*, 2003). It is known that nanotechnology has revolutionized the entire industry and fundamental changes in the production, storage, processing, packaging and transport of agricultural products and will eventually consume them. By definition, any agricultural product and food in one of the stages of production, storage, processing, packaging and transport it from one of the achievements of nanotechnology are used, so-called nano-food (Schoen *et al.*, 2003). In the realm of agriculture, nanotechnology, leading to dramatic changes in the use of natural resources, energy and water, recycling and reuses them as possible and will reduce waste and pollution (Peyvandi *et al.*, 2010).

Hydroponics is a method of generating power plant roots in places other than dirt. It may produce a variety of organic and non-organic substances used for plant nutrition. Today, the science of hydroponics in greenhouse vegetable production on a commercial scale is used throughout the world. The benefits include: A) Eliminate some of the problems associated with soil cultivation, such as poor soil structure, poor water penetration in the soil, uneven texture, water weeds and pathogens. B) Automated hydroponic culture, the addition of some factors, such as chemical fertilizers can be controlled by the computer and human error is attributable to the decrease (Naseri, 2013). N.F.T is a hydroponic growing system of systems. These systems provide a constant flow of nutrient solution so that no timing is needed to pump submerged. Nutrient solution into the growing tray (usually a tube) is pumped onto the plant roots can then be returned to the supplier. Aside from the weather usually is not used in any development environment, which will reduce the cost of growth medium after each harvest. Usually, small plastic baskets are kept in the plant roots are suspended in a nutrient solution. Are very sensitive to power outages and pump failures. The soluble material flow stops when the roots are dried quickly (Naseri, 2013).

Iron (Fe) is a key component of this research is that there are two groups of proteins: A) Cytochrome proteins that includes several cytochrome oxidase, Catalase, peroxidase, hemoglobin log legume root nodules are seen. B) Proteins in processes such as metabolism and photosynthesis, sulfate to sulfite reductase, are involved in respiration and nitrogen fixation (proteins, Fe & S) and The most famous is Ferredoxin to be noted that the Fe do not exist in the structure of chlorophyll. It plays an important role in the synthesis and activation of enzymes and RNA synthesis plays an important role and the effect of Fe deficiency severely reduced photosynthesis and respiration process does not work. It is believed that "Fe" is involved in protein synthesis and growth of the root end systems and the lack of nitrate in plants that accumulate due Ferredoxin. Fe deficiency prevents the development of chloroplasts in the leaves of all plant species are. It is one of the micronutrients Fe, there is enough for plant growth and chlorophyll formation it is necessary. This element is one of the essential elements of the low-energy and low mobility in the plant. Among all plants Micronutrients are most needed part of catalytic Fe oxidation and the reduction of many enzymes and is required for

chlorophyll synthesis (Taiz & Zeiger, 2002). This element is involved in 75% of the chlorophyll structure. It is an absorbable form of Fe^{2+}.Respiration of sugars for energy to grow, to contribute (Jafarnia *et al*., 2007). Many physiological and biochemical processes of Fe for the manufacture of chlorophyll, redox reactions, photosynthesis, respiration and enzyme systems is essential. Some chemical and physical properties of soils, including alkaline pH, low organic matter, consuming too much phosphorous fertilizer, power plants affected by Fe and reduced its level (Ronaghi *et al*., 2002). In this regard, this study examines the effect of Nano Fe-chelate 9%, $FeSO_4$ and Fe-EDDHA on the growth and chlorophyll content of a, b and total chlorophyll, Varieties Ovak Leaf green, Ovak Leaf Violet, Betarige and Ayserg lettuce in N.F.T system deals.

Materials and methods

The materials used

The experiments designed to compare the effect of Nano Fe-chelate 9%, Fe-EDDHA and $FeSO_4$ on the growth parameters including total plant mass, shoot fresh mass, root fresh mass, dry mass and chlorophyll content of a, b and total chlorophyll Four varieties of lettuce (Ovak Leaf Green, Ovak Leaf Violet, Betarige and Ayserg) in N.F.T hydroponics system in a greenhouse located in the city of Bam (Kerman Province in Iran) in a factorial completely randomized design with three replications. Lettuce from seed planting to harvesting period lasted for seventy days. October fifteenth seed trays of seedlings were planted in a bed of peat moss and twenty days after transplanting into pots containing mineral cartridge was transferred to rooting occurs after rooting pots containing N.F.T channels transmitted lettuce for a period of 40-50 days, the plant used to make the nutrient solution was careless. Treatments with Fe through food dissolved separately in three separate plants were given. Treatments consisted of 1) Nano Fe-chelated 9% 2) $FeSO_4$ 3) Fe-EDDHA separate each nutrient and the barrels were added to a 200 ml. It should be noted that the same nutrient solution for each system according to the formula in Table (1) were made and all nutrient solutions were replaced every week.

Table 1. Nutrient compounds used in the experiments.

Type of element	The chemical composition	The concentration used Ml/200L
Macro elements	Potassium dihydrogen phosphate (KH_2PO4)	200
	Potassium nitrate (KNO_3)	800
	Calcium nitrate [$Ca(NO3)_2$, $4H_2O$]	460
	Magnesium sulfate ($MgSO_4$, $7H_2O$)	268
Micro elements	Boric acid (H_3BO_3)	200
	Manganese chloride ($MnCL_2$, $4H_2O$)	
	Zinc sulfate ($CuSO_4$, $5H_2O$)	
	Copper sulfate ($CuSO_4$, 5H2O)	
	Molybdate acid ($H2MoO_4$, H2O)	
Treatments Fe	Nano Fe-chelated 9%	200
	$FeSO_4$	200
	Fe-EDDHA	200

How pigment measure photosynthetic (chlorophyll content)

To measure chlorophyll a, b Lichtenthaler and Wellburn using (1983) The use of methanol extracts of leaf tissue was extracted. Frozen leaves it to size 0.2 g fresh mass in a mortar and pestle on worn over the ice to prevent chlorophyll degradation and at the same time 25 ml of methanol was added to it. The

resulting samples were subjected to overnight in the refrigerator. The resulting samples were subjected to overnight in the refrigerator. Then subjected to centrifugation at a speed of 2000 RPM for 7 min and the temperature was 21 degrees net and using a spectrophotometer at wavelengths of 666 and 653 and 470 nm the amount of chlorophyll "a" and "b" in the upper solution was measured and calculated using the following formula:

Chl a = 15.65A666- 7.34A653
Chl b = 27.05A653 – 11.21 A666

How to measure vegetative and reproductive traits of lettuce

Lettuce from seed planting to the harvesting period of 70 days and duration of treatments was 30 days. Lettuce growth traits measured in fresh and dry mass of shoot and root dry mass, respectively. It shoots and roots at harvest measured separately and then were transferred to the drying oven. Plant tissues for 48 h at 72 °C and then massed. The leaf area using leaf area meter Model C_1 202 was determined. To calculate the dry mass, including leaves, stems and roots in an oven at 72 °C for 72 h and placed and then massed separately. Analysis of data obtained from the experiment using software MSTATC and mean comparison using Duncan multiple range test using SPSS software levels 1 and 5%, respectively. EXCEL software was used to draw the relevant diagrams.

Results

Plant fresh mass

The results of the analysis of variance determined the effect of fertilizers, interaction between the variety and fertilizer and variety of total plant fresh masses was significant at the one percent level (Table, 2). The maximum mass of the whole plant 242.04 g of Nano Fe-chelate 9% fertilizer was compared to the Fe-EDDHA fertilizer and $FeSO_4$, respectively 11 and 32.4 percent, respectively (Table, 3). Most mass Ovak Leaf Green (253.33 g) and the lowest figure Ayserg (177.69 g) were obtained (Table, 3). There was no statistical difference between the number of Ovak Leaf Violet and Betarige. Total fresh mass of plant varieties, Ovak Leaf Green higher than Ayserg the equivalent 29.8 percent respectively. Duncan showed a statistical comparison method the highest mass of lettuce plants to nano Fe-chelated 9% fertilizer, Ovak Leaf Green diagram equivalent to 298.66 g and the lowest fertilizer, $FeSO_4$ and Ovak Leaf Violet varieties of 93.68 g, respectively (Diagram, 1).

Table 2. Analysis of variance on plant fresh and dry mass (PFM, PDM), and shoot and root fresh mass (SFM, RFM) of lettuce plants.

		Mean squares			
Sources changes	df	PFM	SFM	RFM	PDM
Fertilizer	2	19137.392**	14467.49**	540.756**	151.15**
Variety	3	10178.289**	7928.781**	52.193**	45.059**
Fertilizer in varieties	6	4686.565**	3303.761**	247.168**	21.421**
Error	24	113.067	185.656	4.567	4.250
Total	35				
Coefficient of Variation		5.16%	7.96%	6.16%	15.06%

*, ** and ns, respectively: Significance level of one percent, five percent and not significant.

Table 3. Comparison of fertilizer and Variety effects on lettuce growth in test conditions.

	PFM (g)	SFM (g)	RFM (g)	PDM (g)
Fertilizer				

Nano Fe- chelate	242.04 [a]	200.45 [a]	41.58 [a]	17.23 [a]
Fe-EDDHA	215.31 [b]	182.93 [b]	36.82 [b]	13.60 [b]
$FeSO_4$	163.49 [c]	133.49 [c]	28.33 [c]	10.13 [c]
Variety				
Ovak Leaf Green	253.33[a]	216.28 [a]	36.83 [a]	15.46 [a]
Ovak Leaf Violet	194.89[b]	158.63 [b]	36.25 [a]	15.56 [a]
Betarige	199.87[b]	162.66 [b]	37.22 [a]	12.58 [b]
Ayserg	177.69[c]	151.59 [b]	32.01 [b]	11.02 [b]

Similar letters in each column indicate no significant difference.

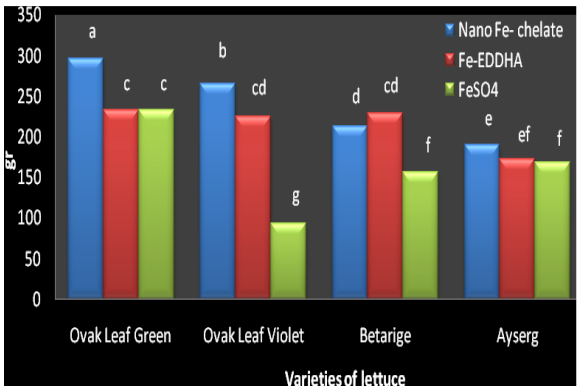

Fig. 1. Interaction of fertilizer on plant fresh mass of lettuce varieties in terms of Tests.

Shoot fresh mass

According to the analysis of variance (Table 2) was determined by the interaction effect of fertilizer and manure, and lettuce varieties on shoot fresh mass was significant at the one percent level. The comparison showed the greatest shoot fresh mass of nano Fe-chelated fertilizer 200.45 g and the lowest $FeSO_4$ fertilizer 133.49 g. This increase is equivalent to 31.8%, respectively (Table 3). Shoot fresh mass between Ovak Leaf Violet varieties, Betarige and Ayserg no statistically significant difference. Maximum shoots fresh mass of Ovak Leaf Green digits (216.28 g) and the lowest mass to variety Ayserg 151.59 g (Table 3). Ovak Leaf Green variety higher than an equivalent increase Ayserg 29.9 percent. Comparison of Average maximum shoots fresh mass of the nano Fe-chelated 9% fertilizer and Ovak Leaf Green amount equivalent to 261.65 grams and the lowest $FeSO_4$ fertilizer and varieties of Ovak Leaf Violet 77.66 mg was observed (Diagram, 2).

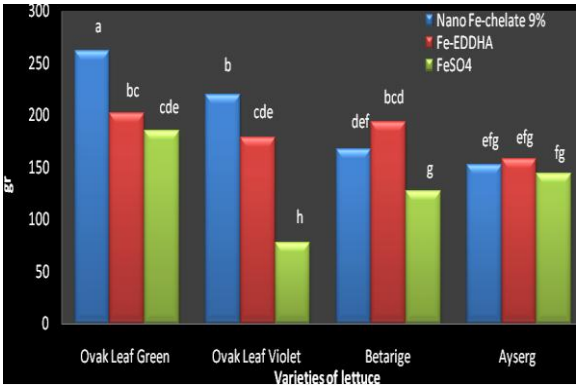

Fig. 2. Interaction of fertilizer on shoot fresh mass of lettuce varieties in terms of Tests.

Root fresh mass

Analysis of variance showed that the effect of fertilizer, variety and variety interaction effect of fertilizer on a percentage of the fresh mass of roots was significant (Table, 2). The comparison showed the greatest mass-related lettuce root Nano Fe-chelate 9% fertilizer (41.58 g) and the lowest fertilizer, $FeSo_4$ (28.33 g), respectively. Increase in fresh mass of lettuce roots in the compost, Nano Fe-chelated fertilizer than Fe-EDDHA or $FeSo_4$ respectively 11.4 and 31.8 respectively (Table 3). The highest fresh mass of roots Betarige digits (37.22 g) and the lowest variety Ayserg (32.01 g), respectively. Ovak Leaf Green between varieties Ovak Leaf Violet and Betarige no statistically significant difference was observed (Table, 3). The highest mean fresh mass of

root Fe-EDDHA fertilizer and Ovak Leaf Violet figure equivalent to 46.42 g, respectively, with no statistical difference between the treated Nano Fe fertilizer. The lowest root fresh mass of $FeSO_4$ fertilizer and varieties of Ovak Leaf Violet 16.02 g, respectively (Diagram, 3).

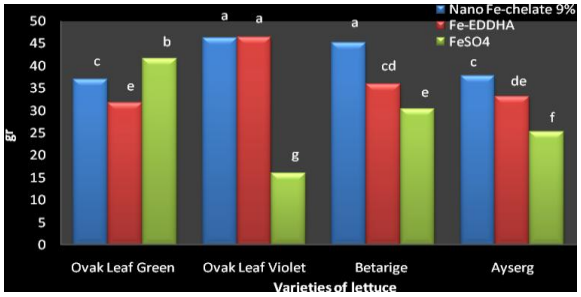

Fig. 3. Interaction of fertilizer on root fresh mass of lettuce varieties tested.

Plant dry mass

The results of the analysis of variance revealed that the effect of fertilizer, variety and interaction effects of fertilizer on the plant dry mass of lettuce variety was significant at the one percent level (Table, 2). The comparison showed that the use of nano Fe-chelated fertilizer plant dry mass (17.23 g) was obtained and the lowest $FeSO_4$ equivalent to 10.13 g, respectively (Table 3). The increase in plant dry mass, equivalent to 41.2 respectively. The highest levels of plant dry mass of Ovak Leaf Violet digits (15.56 g) were obtained with a variety of Ovak Leaf Green no statistical difference was observed (Table, 3). Comparison of means was determined by the interactions between nano Fe-chelated fertilizer plant dry mass of most varieties of Ovak Leaf Violet 22.18 g was observed (Diagram, 4).

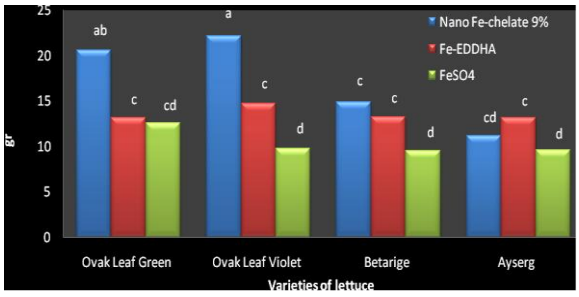

Fig. 4. Interaction of fertilizer on lettuce varieties and plant dry mass in test conditions.

Chlorophyll a

According to the results of analysis of variance determined the effect of fertilizers, Varieties, fertilizer and variety interaction was significant at the one percent level of chlorophyll "a" (Table, 4). The application had no significant effect on chlorophyll "a" so that the interaction of fertilizer and variety mean chlorophyll "a" levels indicate the highest amount of chlorophyll in the Fe-EDDHA fertilizer equivalent to 13.33 and the lowest $FeSo_4$ equivalent to 7.26 mg/g (Table, 5). Nano Fe-chelate 9%, Fe-EDDHA fertilizer application relative to and $FeSo_4$, respectively 4.5 and 45.5% increase in chlorophyll "a" was lettuce (Table, 5). Lettuce varieties of chlorophyll "a" and chlorophyll "a" maximum rate of application of Nano Fe-chelated 9% and Ovak Leaf Violet figure of 18.01 mg/g, respectively (Diagram, 5). No direct role of Fe in chlorophyll structure, but there is enough Fe improves chlorophyll in plants and plant chlorophyll status can affect the rate of photosynthesis (Peyvandi *et al*., 2010).

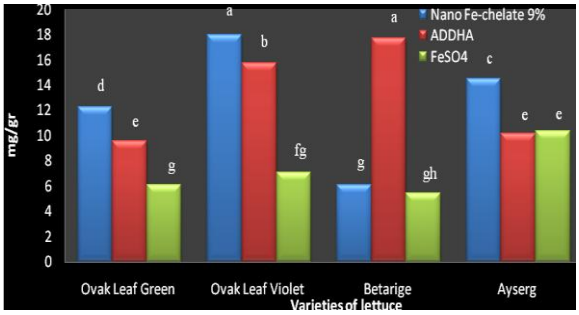

Fig. 5. Interaction of fertilizer on lettuce varieties on chlorophyll an in terms of testing.

Chlorophyll b

The results of the analysis of variance revealed the interaction effect of fertilizer and manure, and lettuce on a percentage variety on the amount of chlorophyll "b" was significant (Table, 4). Most of chlorophyll "b" from application of nano Fe-chelate 9% (16.04 mg/g) and lowest fertilizer, $FeSo_4$ equivalent to 7.29 mg/g, respectively (Table, 5). This increase is equivalent to 54.4%, respectively. The highest amount of chlorophyll "b" and the lowest variety in the Ovak Leaf Violet variety, Btarya variety was observed (Diagram, 6). Compared with respect to the application and the number of interactions were

identified the highest chlorophyll "b" using Nano Fe-chelated fertilizer and varieties of Ovak Leaf Violet 35.87 mg/g, respectively (Diagram, 6). In a study by Peyvandi *et al* (2010) the effect of nano Fe-chelated with Fe-chelate on growth and activity of antioxidant enzymes was savory, as a result, use of Fe-chelates at low concentrations and increases in serum concentrations of Fe-Nano is chl "a". Application of Fe-Nano particles at all concentrations chl "b" effective in increasing the quantity of Fe-chelate concentration (Peyvandi *et al.*, 2010). In this experiment, nano Fe-chelated fertilizer use will increase chlorophyll "b".

Table 4. Analysis of variance in experimental studies of plant pigments.

		Mean squares		
Sources changes	df	Chl a	Chl b	Total chl
Fertilizer	2	134.146**	253.511**	197.139^{ns}
Variety	3	34.529**	295.321**	229.818**
Fertilizer in varieties	6	51.862**	187.105**	145.531^{ns}
Error	24	0.424	0.559	0.434
Total	35			
Coefficient of Variation		5.91%	6.99%	7.28%

*, ** and ns, respectively: Significance level of one percent, five percent and not significant.

Table 5. Comparison of the effects of fertilizer and plant pigment lettuce varieties on test conditions.

	Chl a (mg/gr)	Chl b (mg/gr)	Total chl (mg/gr)
Fertilizer			
Nano Fe- chelate	12.73 ^{b}	16.04 ^{a}	14.14 ^{a}
Fe-EDDHA	13.33 ^{a}	9.21 ^{b}	8.12 ^{b}
$FeSO_4$	7.26 ^{c}	7.29 ^{c}	6.43 ^{c}
Variety			
Ovak Leaf Green	9.35 ^{c}	7.52 ^{c}	6.63 ^{c}
Ovak Leaf Violet	13.62 ^{a}	18.34 ^{a}	16.18 ^{a}
Betarige	9.77 ^{c}	5.41 ^{d}	4.77 ^{d}
Ayserg	11.68 ^{d}	12.11 ^{b}	10.68 ^{b}

Similar letters in each column indicate no significant difference.

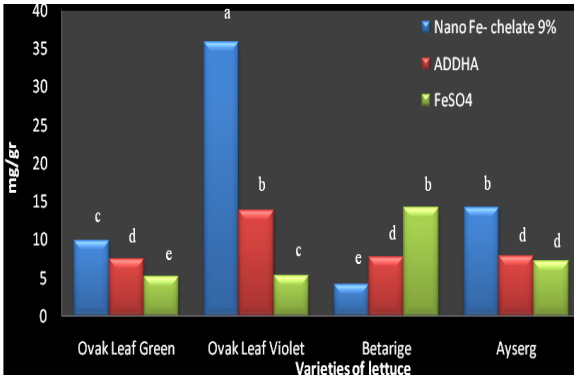

Fig. 6. Interaction of fertilizer on lettuce varieties on chlorophyll b in terms of testing.

Total chlorophyll

According to the analysis of data revealed the effect of fertilizer and varied on the total chlorophyll content of lettuce plants was not significant, but those interactions were significant at the one percent level (Table, 4). Comparison revealed the highest total chlorophyll content of the application of Nano Fe-chelate 9% (14.14 mg/g) and the lowest rate of

fertilizer application $FeSo_4$ equivalent to 6.43 mg, respectively (Table, 5). This increase is equivalent to 54.5%, respectively. The highest total chlorophyll of Ovak Leaf Violet and minimum number of digits Betarige respectively (Diagram, 7). The highest total chlorophyll interaction of Nano Fe-chelated fertilizer and varieties of Ovak Leaf Violet 64.31 mg/g, respectively (Diagram, 7). The role of Fe in oxidative and reducing processes and the capacity change is due to electron transport this is a very important role in plant metabolism. Fe is necessary for protein synthesis and since the major role of iron in chlorophyll synthesis is associated proteins chlorophyll deficiency fails, which is why it is yellow due to iron deficiency occurs (Vankhadeh, 2002). It has been reported that foliar Fe, zn and Mn alone or in combination with each other to increase cotton production, this increase resulted from an increase in the amount of chlorophyll and carotenoid of leaves and plant height. The test results of Peyvandi *et al* (2010) on the effect of Nano Fe-chelated with Fe-chelate on growth and antioxidant enzyme activities Savory has done, therefore, expressed Fe-chelated and nano Fe-chelated fertilizer reduction increases the total chlorophyll "a" and "b". These results are in agreement with experiment.

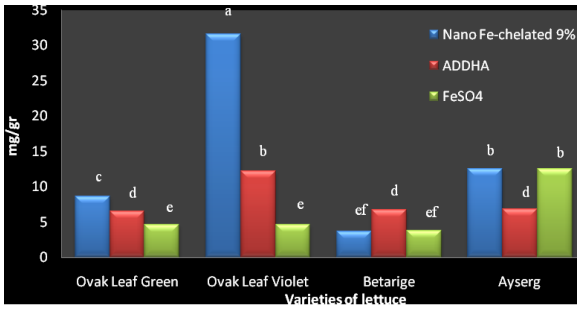

Fig. 7. Interaction of fertilizer on total chlorophyll in lettuce varieties tested.

Discussion

Analysis of variance results indicated, effects of fertilizer, variety and interaction of fertilizer and plant physiological characteristics of lettuce variety were significant at the one percent level and Nano Fe-chelated fertilizer was the highest yield increase of about 31.8% of the show. Koksal *et al* (1999) in one study, Fe-chelated as a foliar spray was applied to a variety of pear and Fe deficiency eliminated and the total yield amounted to 47% and 120% to increase the Fe concentration in the leaves. An Ovak Leaf Violet variety of no statistical differences between Ovak Leaf Violet and Betarige observe. Wet mass of the whole plant, root and Ovak Leaf Green variety of Ayserg less than 29.8 percent respectively. Ovak Leaf Green variety higher than an equivalent increase Ayserg 29.9 percent. Also Ovak Leaf Green varieties of Ovak Leaf Violet and Betarige also found no statistical difference and the highest root fresh mass of Fe-EDDHA fertilizer and Ovak Leaf Violet varieties obtained with nano Fe fertilizer treatments had no significant difference. The highest amount of plant dry mass was calculated from the number Ovak Leaf Violet with Ovak Leaf Green figure showed no statistical difference. Mean changes in all parameters studied physiological and performance of treatments was significant at the 1% level. Changes in fresh mass, dry mass of roots, such that the presence of nano Fe-chelated fertilizer had a significant increase compared with the other treatments. According to the comparison of lettuce varieties were determined, the number of traits and there is a tremendous difference so that the maximum mass of the whole plant and shoot fresh mass Ovak Leaf Green respectively 253.33 and 216.28 g, respectively (Dig. 1 and 2). In terms of plant dry mass, there was no statistical difference between the figures Ovak Leaf Violet and Ovak Leaf Green (Figure 4). One of the essential microelements which plays an important role in increasing the production and quality of the product is Fe. It reduces the performance and quality products will decrease Fe absorption. This element is a major component of plant enzyme systems such as cytochrome oxidase (electron transfer) and cytochrome (end-stage respiratory) is. A Ferredoxiniron, a protein component of the assimilatory sulfate and nitrogen for nitrate reduction and energy production (NADP) is necessary (Tabatabai, 2008). Some micronutrients such as zinc and Fe are essential for plant growth and physiological processes such as photosynthesis, growth hormones are involved in the formation of chlorophyll and can be deficiencies cause nutrient

imbalances in plants and ultimately reduce the quantity and quality of the product (Bron *et al*., 2003). In this experiment, the use of fertilizers, nano Fe-chelate observed in lettuce plants leads to increased levels of chlorophyll "b" and total chlorophyll was. Also, Ovak Leaf Violet digits highest chlorophyll a, b and total chlorophyll accounted for. Metal irons such as Fe, Zn, Cu, Mn and Mg as a cofactor for many antioxidant enzymes involved in the construction and studies Cakmak (2002) indicate that the trace element deficiency under stress decreased activity of antioxidant enzymes and thus increase the susceptibility of plants to environmental stresses. Baybordi (2004) The effect of Fe, Mn, Zn and copper in reducing salinity stress said.

Use of fertilizers nano Fe-chelate and Ovak Leaf Green yield figure 298.66 g, maximum performance at the NFT hydroponics system was tested and also the highest total chlorophyll content of the application of nano Fe-chelate 9% (14.14 mg/g) and the lowest rate of fertilizer application $FeSo_4$ equivalent to 6.43 mg/g, respectively, this suggests that replacing Fe fertilizer produced with nanotechnology and other common Fe fertilizers to improve plant growth and quality of lettuce is.

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