Plant Archives Vol. 20 Supplement 1, 2020 pp. 975-982 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF NANOPARTICLES, ORDINARY IRON OXIDE FERTILIZERS AND THEIR LEVELS AND COMPOST ON THE *SORGHUM BICOLOR* L. GROWTH

Alyaa Abdullah Jawad[1,2] and Muhammed Abid Al-Rubei[1]

[1]Ministry of Agriculture, Iraq.
[2]Soil and Water Resources Department, College of Agricultural Engineering Sciences, University of Baghdad, Iraq.

Abstract

A pot experiment was carried out in the plastic shade house on one of the agricultural farms / College of Agriculture / University of Baghdad, to determine the effect of nanoparticles and ordinary iron oxide fertilizers and their levels and compost on the *Sorghum bicolor* L. growth, using calcareous soil with a texture of loamy sand soil. The experiment included three levels of iron (0, 12, 18) kg Fe.h^{-1} added in the form of nanoparticles and ordinary iron oxide and two levels of palm fronds compost are without the addition of (C_0) and add (25) mega gm.h^{-1} (C_1). The Complete Randomized Design (CRD) was adopted in this study, and the pot was planted with *Sorghum bicolor* L. seeds, Inkath cultivar in the autumn season (2017), as well as, suitable moisture content were maintained for all treatments during the 112 days of the experiment. The results of the study showed the superiority of the nanoparticles iron oxide fertilizer (N.F) over the ordinary fertilizer of iron oxide (O.F). Where the percentages of increases in the Nano fertilizer in the fruit heads emergence stage amounted to (10.57, 6.01, 7.14 and 12.96%) for each of the available iron concentrations in soil, leaf area, shoot and root dry weight, respectively. As well as, the second level of 18 kg Fe.h^{-1} of iron oxide Nano fertilizer (L_2) was superior and gave a percentage of increases in the fruit heads emergence stage reached (47.73, 12.15, 12.75 and 31.98%) for each of the available iron concentrations in soil, leaf area, shoot and root dry weight, respectively, compared to the level of comparison (L_0). The interaction between the levels of addition and compost gave a percentage of increases for ($L_2.C_1$) treatment at the fruit heads emergence stage amounted to 79.47, 12.62, 35.63, 36.65 and 108.59%) for each of available iron concentrations in soil, plant height, leaf area, shoot and root dry weight, respectively, compared with the comparison treatment ($L_0.C_0$). While the triple interaction between iron sources levels and compost gave percentages of increases in (N.F.$L_2.C_1$) treatments at the fruit heads emergence stage of (93.44, 15.2, 42.92, 44.26 and 125.88%) for each of available iron concentrations in soil, plant height, leaf area, shoot and root dry weight, respectively, compared with the comparison treatment (O.F.$L_0.C_0$).

Key words : Nanoparticles, Ordinary Iron, *Sorghum bicolor* L.

Introduction

Sorghum bicolor L. is the world's most important crops because of its extensive use as a grain, fodder and industrial crops, where the cultivated area in Iraq was estimated to 2.5 thousand hectares with an average productivity of 1.428 mega gm.h^{-1} (central Statistical Organization, information's Technology, 2012). Nanotechnology refers to the study of the basic principles of compounds and molecules, that do not exceed their measurement 100 nm (Solomon *et al.,* 2007). This technology is based on reducing the part to a volume of one billionth of a meter, (Hossei and Eghtedar 2012) pointed out that the world's source production of Nanoparticles sources reached 103 mega gm in 2004, and is increasing continuously annually. Therefore, its playing an important role in the economic development of developing countries in the agricultural field. Nano productions are not limited in agriculture, but also in a wide field of sciences such as medicine, engineering and food (Mozafari *et al.,* 2008). The use of Nano fertilizers is still on the experiments scale in Iraq, but a number of countries neighboring Iraq have made significant strides in the use of this technology, including Iran, Saudi Arabia, Jordan and Egypt. The use of organic matter is an agricultural practices that can reduce the excessive use of mineral fertilizers that its production costs, through the use of organic waste from different sources (human, animal, plant) where the organic fertilization is the cornerstone that must be laid to increase soil fertility and reduce environmental pollution resulting from wasteful use of chemical fertilizers. As well as, its positive impact on many soil properties, especially chemical, physical and biological, which reflects on the activities of the ecosystem significantly, and the organic soil material is a reservoir of Bioenergy and a source of macronutrients and stimulate the activity of the number of enzymes and microorganisms (Baldock and Nelson, 2000 Al- Kilabi, 2018). Moreover, the results of (Al-Mustafa *et al.,* 2001) showed a significant increase in the dry matter content of iron for the *Sorghum bicolor* L. when adding FeEDDHA fertilizer at the level of 10 and 20 mg Fe kg^{-1}soil, the dry matter yield increased by 34% and 60% from both levels respectively, compared to non-fertilized treatment. Furthermore, (Ali and Sharqi 2010) found a significant increase in *Sorghum bicolor* L. leaves content of iron, when leaf fertilization with zinc and iron, with the continued spraying of iron, where the level of 2 $gm.L^{-1}$ of (feso4.7H_2O) gave the highest rate of iron concentration in leaves at 82.88 $mg.kg^{-1}$ dry matter. Finally, (Pariona *et al.,* 2016) pointed out that the use of iron granular nanoparticles by spraying on the *Sorghum bicolor* L. leaves with five concentrations (0, 1, 2, 4 and 6) $gm.L^{-1}$. Which Resulted in a significant increase directly proportioned with increasing concentration in leaf height and length, chlorophyll, root and shoot dry weight, and the weight of 1000 seeds compared to comparison treatment.

Materials and Methods

A pot experiment was carried out in the plastic shade house on one of the agricultural farms, College of Agriculture, University of Baghdad, to determine the effect of nanoparticle iron oxide fertilizer and compost on the readiness of iron and phosphorus in the soil, the iron preparation efficiency for plant and the *Sorghum bicolor* L. growth. Surface soil samples were collected at a depth of (0-30) cm from the same location that mentioned above and mixed to form a composite sample, then air dried and passed through a sieve of 4mm diameter. In order to determine some chemical and physical soil properties and to conduct laboratory analysis, the soil was passed through a sieve with a diameter of (2mm), and some chemical and physical properties were estimated as shown in Table 1. A 15 soil particles that passed through the sieve (4) mm was weighed for each pot, where plastic pot of 20 kg capacity was used, and the pots were planted with *Sorghum bicolor* L. seeds (Inkath cultivar) for the autumn season 2018 by 7 seeds per one pot and was reduced to one plant after a week of germination. The experiment continued until the beginning of the fruit heads emergence stage and the corn Sesamia cretica Led. was controlled by Diazion pesticide when the plants had four leaves, and two weeks after the first

Table 1: Some physical and chemical properties of soil study.

Properties		Value	Unit
(1:1) Electrical Conductivity (EC)		2.70	$Ds.m^{-1}$
(1:1) PH value		7.10	-
Cation Exchange Capacity (CEC)		26.1	Cent. Charge. Kg^{-1}soil
Organic matter (OM)		11.90	$mg.kg^{-1}$soil
Carbonate minerals			
Gypsum		2.30	
Dissolved cation ions	Ca^{2+}	8.06	m $mol.L^{-1}$
	Mg^{2+}	2.282	
	Na^{+}	3.39	
	K^{+}	0.621	
Dissolved negative ions	HCO_3^-	3.10	
	SO_4^{2-}	2.63	
	Cl^-	4.964	
	CO_3^{2-}	Nil	
Available elements	NH_4^++NO_3^-	50.14	$mg.kg^{-1}$soil
	Phosphorus	10.2	
	Potassium	150.4	
	iron	5.12	
	Manganese	8.43	
Soil separators	sand	550.53	$gm.kg^{-1}$soil
	Silt	425.42	
	Clay	24.08	
Texture		loamy sand	
Available water		18.2	%
Bulk density		1.38	$Mg.m^3$

addition, while the weed control was done manually. Pots were irrigated immediately after planting and the moisture was maintained whenever needed. Furthermore, the experiment was carried out according to Complete Randomized Design CRD, which included 36 treatments (2 × 3 × 2 × 3) with three replicates R1, R2, and R3, including the comparison treatment that represents the soil treatment only, as well as, the treatments were randomly distributed until the total units became 36 experimental units.

Nitrogen, phosphorus and potassium fertilizers were added at a constant level for all treatments, where the Nitrogen was added in the form of urea (N, 46%) by a level of 240 $kgN.ha^{-1}$ in two batches, the first at planting stage and the second after 30 days of germination. Potassium fertilizer was added in the form of potassium sulfate (K, 42%) at the level of 120 $kg.ha^{-1}$ and was added in two equal batches, the half before planting and mixed with soil and the other half after 30 days of germination. The phosphate fertilizer was added in the form of triple super phosphate (P 21%) at the level of 80 kg ha^{-1} in two batches, the first when planting and the second after 30 days of germination. The levels of added iron in the form of ordinary ferric fertilizer Fe_2O_3 (0, 12 and 18) kg $Fe.ha^{-1}$ (Ali 2012), while the levels of nanoparticles ferric fertilizer Fe_2O_3 (0, 12 and 18) kg $Fe.ha^{-1}$, and the levels of palm fronds compost (0,25) $Mg.ha^{-1}$ were added at once batch and mixed with soil. The plant leaf area was calculated using the method followed by (Liang *et al.,*1973) according to the following equation: LA= L × W × 0.75, where: LA leaf area (cm^2), L leaf length (cm) and W maximum leaf width (cm) and 0.75 was constant. The average plant height for each treatment was calculated from the soil contact area to the fruit heads (Sahoki, 1990). The shoot dry weight was calculated after separating shoot from the root of the plant in each treatment and washing it with water, then with distilled water and air dried, then cut-off and placed in paper bags and then in an electric oven at (65) °C for 48 hours. Furthermore, the dry matter yield per one plant was also calculated. Finally, the root dry weight was also calculated after isolating root from the soil for each treatment and washed with water, then with distilled water and air dried, and then placed in paper bags and then in an electric oven at 65 ° C for 48 hours. The dry matter yield per one root was calculated, and the iron was estimated for both of dry shoot and root, as the iron was estimated using Atomic Absorption) device as explained by (Haynes 1980).

Results and discussion

Growth indicators

Plant height

Table 2 shows that the addition of N.F fertilizer resulted in an increase in plant height for the fruit heads emergence stage by 2.33% compared with O.F treatment. The plant height increased significantly by increasing the levels of iron addition (L_1 and L_2), while there were no significant differences between the levels of addition. The increases of fruit heads emergence stage reached 3.25 and 4.65%, respectively, compared to the comparison treatment (L_0), and the organic fertilization (compost) (C_1) was significantly affected in increasing the plant height by an increasing of 7.64% compared with comparison treatment (C_0). All bilateral interactions were significantly affected on increasing plant height. Where the bilateral interaction between the iron sources and compost gave the highest rate for (N.F.C_1) treatment of 154.67cm, with an increase of 10.13% compared to the comparison treatment (O.F.C_0), which reached 140.44 cm. Moreover, the interaction between the iron levels and compost achieved the highest rate reached 156.17 cm and with an increase of 12.62% compared to the comparison treatment, which gave an average of 138.67 cm.

The triple interaction between iron sources and its levels and compost showed a significant increase in plant height. Where the treatment (N.F.L_2C_1) gave the highest rate of plant height, which reached 159.0 cm and did not differ significantly from the treatment (N.F.$L_{1.}C_1$) with an increase amounted to 15.22% compared to the comparison treatment (O.F.L_0.C_0) that gave 138.0 cm for the fruit heads emergence stage. All the bilateral interactions and the triple interaction achieved an increase in the plant height resulted from the role of the nanoparticles and ordinary iron oxide with the increases of addition levels. This was because of the effective role of iron in the process of cell division, which involved in the formation of several cytochrome and ferredoxin compounds that involved in the most important plant processes photosynthesis and respiration. This increases the plant effectiveness for the nutrient absorption in addition to the role of iron in increasing the nutrients absorption N and K, which lead to a significant role in the process of photosynthesis and then increase the height. These findings were consistent with (Khazraji, 2011; Tamimi and Alotafi, 2015), where Iron plays an intermediate and central role in the chlorophyll formation, although it does not enter into its composition. As well as, its enters in the cytochrome formation that had a great importance in the carbon representation and the

Table 2: Effect of nanoparticles, ordinary iron oxide fertilizers, and their levels and compost on plant height for the fruit heads emergence stage (cm) of *Sorghum bicolor* L.

Compost $mg.h^{-1}$	Iron sources	Iron levels kg $Fe.h^{-1}$ (0) L_0	(12) L_1	(18) L_2	Average effect F×C
(0) C_0	O.F	138.00	141.33	142.00	140.44
	N.F	139.33	144.33	146.67	143.44
(25) C_1	O.F	148.00	151.33	153.33	150.89
N.F	149.00	156.00	159.00	154.67	
$L.S.D_{0.05}$		4.53			2.61
Compost $mg.h^{-1}$		Iron levels kg $Fe.h^{-1}$			Average effect C
		(0) L_0	(12) L_1	(18) L_2	
(0) C_0		138.67	142.83	144.33	141.94
(25) C_1		148.50	153.67	156.17	152.78
$L.S.D_{0.05}$		3.20			1.85
Iron sources		Iron levels kg $Fe.h^{-1}$			Average effect F
		L_0(0)	(12) L_1	(18) L_2	
O.F		143.00	146.33	147.67	145.67
N.F		144.17	150.17	152.83	149.06
$L.S.D_{0.05}$		3.20			1.85
Average effect F		143.58	148.25	150.25	147.36
$L.S.D_{0.05}$		2.26			

Table 3: Effect of nanoparticles, ordinary iron oxide fertilizers, and their levels and compost on leaf area (cm^2) for the fruit heads emergence stage of *Sorghum bicolor* L.

Compost $mg.h^{-1}$	Iron sources	Iron levels kg $Fe.h^{-1}$ (0) L_0	(12) L_1	(18) L_2	Average effect F×C
(0) C_0	O.F	268.4	282.3	293.4	281.4
	N.F	275.1	310.9	317.1	301.0
(25) C_1	O.F	324.7	343.9	353.5	340.7
	N.F	333.3	358.1	383.6	358.3
$L.S.D_{0.05}$		35.99 kg $Fe.h^{-1}$			20.78
Compost $mg.h^{-1}$		Iron levels kg $Fe.h^{-1}$			Average effect C
		(0) L_0	(12) L_1	(18) L_2	
(0) C_0		271.7	296.6	305.3	291.2
(25) C_1		329.0	351.0	368.5	349.5
$L.S.D_{0.05}$				25.45	14.69
Iron sources		Iron levels kg $Fe.h^{-1}$			Average effect F
		L_0(0)	(12) L_1	(18) L_2	
O.F		296.5	313.1	323.4	311.0
N.F		304.2	334.5	350.4	329.7
$L.S.D_{0.05}$		25.45	14.69		
Average effect F		300.4	323.8	336.9	320.37
$L.S.D_{0.05}$		18.00			

respiration processes, it also plays a central role in converting the dissolved nitrogen in the leaves into a protein, which has a major role in protecting chlorophyll from extreme sunlight. In addition to that, iron induces the opening and closing process of stomata in the leaves, which increases the transpiration process and thus increases the nutrients absorbed by the roots. The addition of processed iron oxide fertilizer according to nanotechnology had the greatest percentage in increasing the plant lengths compared to the processed iron oxide according to the traditional methods. Since the Nano fertilizer may provide more surface area for the different metabolic reactions in the plant, which increases the rate of photosynthesis and promotes the demand for nutrients. As well as, the iron nanoparticles promotes seed germination and the photosynthesis in the plant, which increases the cell division in the plant and the plant height, and these results are consistent with (Parvin *et al.,* 2018 and Rambabu *et al.,* 2018) and (Montenegro *et al.,* 2013). Nano fertilizers are important tools in the agriculture sector to improve crop growth averages through increased productivity and quality improvement. (Singh *et al.,* 2017). The increase in plant lengths is also due to compost addition, which improves the physical and chemical properties of the soil. In addition, when the organic fertilizer decomposes, it results in sufficient amount of nutrients that improve plant growth and development, which are positively reflected in plant height. These results are consistent with (Choudhary and Kumar, 2013; Al- Saadoun and Al-Obeidi, 2014) findings.

Leaves area

Table 3 shows a significant increase in leaf area when adding (N.F) fertilizer for the fruit heads emergence stage by an increase of 6.01% compared to the addition of (O.F). Moreover, all the addition levels of iron were affected significantly, as the leaf area increased with the increasing of addition levels (L_1 and L_2) amounted to 7.79 and 12.15% respectively, compared to the comparison treatment (L_0). As well as, compost was affected significantly by increasing the leaf area amounted to 20.0% compared to the comparison treatment (C_0). All treatments of bilateral interaction were significant for the fruit heads emergence stage in increasing the leaf area, where bilateral interaction treatment between iron sources and compost gave the highest average of the leaf area for treatment ($F.C_1.N$). Which gave at the fruit heads emergence stage the highest leaf area by 358.3 cm ^{2}, compared to the lowest value of the comparison treatment 281.4 cm^2. The interaction between iron levels and compost gave the highest average leaf area of treatment (L_2C_1) reached 368.5 cm^2 with an increase of 35.63% compared to the lowest average leaf area of the comparison treatment (L_0C_0) of 271.7 cm^2. While the bilateral interaction between iron levels and sources, the treatment (F. L_2. N) gave the highest average leaf area of 350.04 cm^2 with an increase of 18.18% compared to the lowest average for treatment ($O.F.L_0$) that gave 296.5 cm^2 for the fruit heads emergence stage.

The triple interaction between the iron levels, sources and compost achieved the highest average in the leaf area of the triple interaction treatment ($N.F.L_{2.}C_1$), which was 383.6 cm^2, with an increase of 42.92% compared with the lowest average of treatment ($O.F.L_{0.}C_0$) amounted to 268.4 cm^2. All bilateral interactions between the iron sources and levels and between the compost and iron levels, as well as the triple interaction between the iron sources and levels and compost, resulted in an increase in the leaf area. The increase was attributed to the role of nanoparticles and ordinary iron oxide with increasing the addition levels and compost and their interacted role and what these fertilizers contents of important nutrients for the plant. It gives an opportunity to accumulate these nutrients and materials manufactured by the carbon representation process, such as carbohydrates and proteins in plant tissues, which are components of dry matter in the plant and increases its concentration that leads to increase the growth indicators of the plant. As well as, the role of iron in participating in the formation of chlorophyll molecules in the plant, in addition to its role in cell division and participation in biological processes. Furthermore, it works to raise the leaves efficiency in the (photosynthesis process), then the leaf growth is increased, these results are consistent with (Tamimi *et al.,* 2015 ; Al-Tamimi *et al.,* 2014) findings. The addition of nanoparticles iron oxide fertilizer resulted in an increase in the leaf area by a larger percentage compared to the ordinary iron oxide fertilizer. That's because the Nano fertilizer has a large surface area that helps it to enter the plant cells easily, which increases the process of various metabolic reactions and production of secondary metabolites in the plant and increase the stomata efficiency. This is positively reflected in the increase of CO_2 that entering to the leaves, thus increasing in the photosynthesis process (Yasmeen *et al.,* 2018), this lead to increasing the leaf area and these results are consistent with (Mohammadi *et al.,* 2016; Elizabath; *et al.,* 2017 ; Kandil and Elanchezhian *et al.,* 2017). The increase in the leaf area was due to the addition of organic fertilizer (Compost) because of its contents on the major and minor nutrients needed by the plant as a balanced and continuous form. In addition to its role in improving many of the physical, chemical, fertility and biological soil properties, which contributes to increase the readiness of the necessary nutrients. Therefore, its increase the absorption of essential nutrients, especially phosphorus, which enters or contributes to the manufacture of nutrients and then positively reflected in the growth of the plant by increasing the leaf area of the plant cm^2.

Shoot dry weight (g)

Table 4 indicates a significant effect of adding (N.F) fertilizer on the plant dry weight to increase by 7.14% compared with the addition of ordinary iron oxide fertilizer. The plant dry weight also increased significantly by increasing the addition levels of ($L_{1,}$ L_2) by 8.22 and 12.75%, respectively, compared to the level (L_0). The addition of compost significantly increased the plant dry weight by 21.49% compared to the comparison treatment (C_0). All the bilateral interactions showed a significant increase in plant dry weight, and between iron sources and compost achieved the highest dry weight value for the treatment ($N.F.C_1$) which reached 52.99 g, with an increase of 94.60% compared with the lowest value of the treatment ($O.F.C_0$), which amounted to 40.71 g. In addition, the interaction between iron levels and compost achieved the highest value of the treatment (L_2C_1) by 53.73 g, with an increase of 36.65% compared to the lowest average of the interaction treatment (L_0C_0) of 39.32 g. The effect of bilateral interaction between iron levels and their sources was significant by giving the highest dry weight value of the plant ($N.F.L_2$) by 51.42 g, with an increase of 19.39% compared to the lowest value of treatment ($O.F.L_0$) of 43.07 g. The triple interaction between iron sources, levels and compost showed a significant increase in the plant dry weight, where the treatment ($N.F.L_2.C_1$) achieve the highest value, which was not significantly different from the treatment ($N.F.L_1C_1$) that reached 56.19g with an increase of 44.26% compared with the treatment ($O.F.L_0.C_0$) that gave the lowest value for plant dry weight, which reached 38.95g. All the triple and bilateral interactions led to a significant increase in the shoot dry weight, where the increase was attributed to the role of iron in increasing the amount of chlorophyll in the leaves and thus increasing

Table 4: Effect of nanoparticles, ordinary iron oxide fertilizers, and their levels and compost on shoot dry weight (gm) of *Sorghum bicolor* L.

Compost mg.h^{-1}	**Iron sources**	**Iron levels kg Fe.h^{-1}**			**Average effect F×C**
		(0) L_0	**(12) L_1**	**(18) L_2**	
(0) C_0	O.F	38.95	40.27	42.90	40.71
	N.F	39.69	44.75	46.65	43.69
(25) C_1	O.F	47.19	50.17	51.26	49.54
	N.F	48.89	53.90	56.19	52.99
L.S.D$_{0.05}$	2.58	1.49			
Compost mg.h^{-1}		Iron levels kg Fe.h^{-1}			Average effect C
		(0) L_0	(12) L_1	(18) L_2	
(0) C_0		39.32	42.51	44.77	42.20
(25) C_1		48.04	52.03	53.73	51.27
L.S.D$_{0.05}$			1.82	1.05	
Iron sources		Iron levels kg Fe.h^{-1}			Average effect F
		L_0(0)	(12) L_1	(18) L_2	
O.F		43.07	45.22	47.08	45.12
N.F		44.29	49.32	51.42	48.34
L.S.D$_{0.05}$		1.82	1.05		
Average effect F		43.68	47.27	49.25	46.73
L.S.D$_{0.05}$		1.29			

Table 5: Effect of nanoparticles, ordinary iron oxide fertilizers, and their levels and compost on root dry weight (gm) of *Sorghum bicolor* L.

Compost mg.h^{-1}	**Iron sources**	**Iron levels kg Fe.h^{-1}**			**Average effect F×C**
		(0) L_0	**(12) L_1**	**(18) L_2**	
(0) C_0	O.F	7.42	8.31	9.78	8.50
	N.F	7.72	10.30	11.97	10.00
(25) C_1	O.F	12.53	13.35	14.81	13.56
	N.F	12.72	15.28	16.76	14.92
L.S.D$_{0.05}$	1.28	0.74			
Compost mg.h^{-1}		Iron levels kg Fe.h^{-1}			Average effect C
		(0) L_0	(12) L_1	(18) L_2	
(0) C_0		7.57	9.31	10.87	9.25
(25) C_1		12.62	14.32	15.79	14.24
L.S.D$_{0.05}$			0.90	0.52	
Iron sources		Iron levels kg Fe.h^{-1}			Average effect F
		L_0(0)	(12) L_1	(18) L_2	
O.F		9.97	10.83	12.30	11.03
N.F		10.22	12.79	14.36	12.46
L.S.D$_{0.05}$		1.82	0.52		
Average effect F		10.10	11.81	13.33	11.75
L.S.D$_{0.05}$		0.64			

the absorption of major and minor nutrients. This has a positive effect on increasing photosynthesis, thus accumulating proteins and carbohydrates, which reflected in increasing the plant dry weight, these results are consistent with (Ali and Sharqi, 2010; Mayali, 2017) findings. The addition of manufactured iron according to nanotechnology was significantly higher in this trait with the addition of iron manufactured by traditional methods, because the Nano fertilizers of iron are characterized by high absorption speed due to its small size and high surface area. As well as, the unique advantages of being easy to penetrate into cells and to activate many enzymes within the plant because of the metabolic process activity and increased photosynthesis averages, which led to the increase the plant dry weight and these results, are consistent with (Rezaeei *et al.,* 2014; Bakhtiari *et al.,* 2015). The addition of compost fertilizer has improved the physical, chemical, fertility and biological soil properties, and thus increase the readiness of the necessary major and minor nutrients for plant growth, in addition to what it add of nutrient elements. Thus, it becomes ready for absorption by the plant throughout the growth period, which leads to conversion into amino acids and then to protein compounds and carbohydrates, which is reflected on the dry matter collecting in the plant, these results are consistent with (Al-Maghrabi, 2016; Al-Zaidi, 2017).

Root dry weight (g)

The results of table 5 showed that all addition levels of nanoparticles, ordinary iron and compost had a significant effected on increasing root dry weight. As, the addition of (N.F) fertilizer was significantly affected by an increase of 12.96% compared to the treatment (O.F), and all the addition levels of iron have also been affected significantly. The root dry weight increased with the increase of addition levels (L_1 and L_2) where the percentage of increase amounted to 16.93 and 31.98% respectively, compared to the comparison treatment (L_0). Moreover, the addition of compost (C_1) led to a significant increase in root dry weight by an increase of 53.95% compared to the comparison treatment (C_0). All the bilateral interactions showed a significant difference in increasing the root dry weight, where the bilateral interaction treatment between iron sources and compost was superior by achieving the highest average for treatment ($F.C_1.N$) that reached 14.92 g, with an increase of 75.53% compared with the lowest value of ($O.F.C_0$) that reached 8.50 g. While the effect of interaction between the iron levels and compost achieved the highest average for the interaction treatment (L_2C_1) of 15.79 g, with an increase of 108.59% compared to the lowest average of (L_0C_0) by 7.57 g. The effect of bilateral interaction between iron levels and its sources was significant by giving the highest average of root dry weight for the treatment ($N.F.L_2$) of 14.36 g, with an increase of 44.03% compared with the lowest value of ($O.F.L_0$) by 9.97 g. The effect of triple interaction between iron sources, levels and compost was significant in increasing the root dry weight, as the treatment ($N.F.L_2.C_1$) achieved the highest average of 16.76 g, with an increase of 125.88% compared with the treatment of ($O.F.\ L_0.C_0$), which gave the lowest average of root dry weight by 7.42g.

The addition of Nano iron has led to increase the root weight because of its effective role in regulating hormones and enzymes and increasing the reactions speed that leading to increase the production of root growth substances, which was reflected in the increase the root dry weight and these results are consistent with (Gui *et al*., 2015; Karunakaran *et al.,* 2017). As well as, the addition of compost has improved water and tropical characteristics as a result of improved soil construction and reduced soil Bulk density. It helped to increase the spread of roots and their penetration and extension in the soil, which led to increasing the movement of nutrients from the soil to the root, increasing the root and thus increasing the root dry weight. The results are consistent with (Abbas and Aati, 2007).

References

ALMustafa,W.A.A.E.Abdallah and A.M. Falatah (2001). Assessment of five extractants for their ability to predict iron uptake and response of sorghum grown in calcareous soil. *Commun. soil Sci. Plant Anal.*, **32:** 907-919.

Al-Tamimi, M.S., H.Z. Fahdawi and S.S. Mahmoud (2014). Effect of Leaf Nutrition with Iron and Zinc on Some Vegetative Characteristics and Biological Harvest of Wheat Plant, Parents 99. *Euphrates Journal for Agricultural Sciences*, **6 (4):** 233-240.

Al-Tamimi, M.S. and A.S. Al-Wataifi (2015). Effect of Iron and Zinc Spraying on Some Vegetative Attributes and Buckwheat Grain. *Babylon Journal / Pure and Applied Sciences*, **3(1):** 392-399.

Al-Khazraji, O.A.R.O. (2011). Effect of Potassium Fertilizer Levels Added to Soil and Iron Spray in Yellow Corn Growth, Master Thesis, Al-Anbar University.

Ali, N.S. (2012). The guide in plant nutrition. Written by Allen in Parker and David J. Willem, Ministry of Higher Education and Scientific Research. faculty of Agriculture. University of Baghdad.

Ali, F.M. and H.S.E. (2010). Effect of foliar fertilization with zinc and iron on growth and yield of *Sorghum bicolor*s L. and zinc and iron content of leaves and seeds. *Anbar Journal of Agricultural Sciences*, **8(4):** 139-151.

Abbas, M.K. and A.S.A. (2007). Growth and development of the root total of maize plant in different soil poles treated with crushed cornmeal. *Anbar Journal for Agricultural Sciences*, **5(2):** 12-19.

Central Statistical Organization and Information Technology, 2012.

Bakhtiari, M., M.O. Payam and S. Behzad (2015). The Effect of Iron Nanoparticles Spraying Time and Concentration on wheat. *Biological Forum -An International Journal,* **7(1):** 679-683.

Baldock, J.A. and P.N. Nelson (2000). Soil Organic Matter. In M.E Sumner. HandBook of Soil Science.CRC Press pp 18-38.

Choudhary, V.K. and P.S. Kumar (2013). Maize production, economics and soil productivity under different organic source of nutrients in eastern Himalayan region, India. *Int. J. of Plant Prod.*,**7(2):**167-186.

Elizabath, A.B, V.P. Misra, M. Vipin and T. Thomas (2017). Effect of different concentrations of iron oxide and zinc oxide nanoparticles on growth and yield of carrot (*Daucuscarota* L.). *Journal of Pharmacognosy and Phytochemistry*, **6(4):** 1266-1269.

Hao, C. (2018). Metal based nanoparticles in agricultural system: behavior, transport, and interaction with plants. *Chemical Speciation & Bioavailability*, **30(1):** 123-134.

Haynes, R.J. (1980). A Comparison two modified kjeidhal digestion techniques for multi element plant analysis with conventional wet and dry ashing methods. *Commune in soil Sci. plant analysis*, **11:** 459-467.

Karunakaran, G., M. Jagathambal, N. Van Minh, E. Kolesnikov, A. Gusev, O.V. Zakharova, E.V. Scripnikova, E.D. Vishnyakova and D. Kuznetsov (2017). Green Synthesized Iron Oxide Nanoparticles: A Nano-Nutrient for the Growth and Enhancement of Flax (*Linumusitatissimum* L.). *Plant, International Scholarly and Scientific Research and Innovation*, **11(4):** 289-293.

Kelabi, J.E.M. (2018). The role of mycorrhizates and various phosphate sources and compost in the readiness of phosphorus and copper in soil and the growth and yield of maize, PhD thesis, University of Baghdad, College of Agriculture.

Liang, G.H, C.C. Chu, N.S. Reddy, S.S. Lin and A.D. Dayton (1973). Leat blade areas of grain sorghum varities and hybrids. *Agron. J.*, **65:** 456-459.

Mozafari, M., C. Johnson, S. Hatziantoniou and D. Demetzos

(2008). Nanoliposomes and their applications in food nanotechnology. *J. of Liposome Res*., **18:** 309-327.

Mohammadi, M.J., T. Amanzadeh, N. Sabaghnia and S. Dashti (2016). Impact of foliar application of nano micronutrient fertilizers and titanium dioxide nanoparticles on the growth and yield components of barley under supplemental irrigation. *Acta agriculturae Slovenica*, **107(2):** 265-276.

Moroccan, N.M.H. (2016). Effect of organic and mineral fertilization on some soil properties and sorghum plant content of some nutrients. *Alexandria Journal for Scientific Exchange*, **37(1):** 146-157.

Mayali, A.M. (2017). Response of white maize crop to spraying in different concentrations of iron and zinc. Master Thesis, College of Agriculture, Muthanna University.

Pariona, N., I.M. Arturo, H.M. Hdz-Garcý, L.A. Cruz and H. Valdes (2016). Effects of hematite and ferrihydrite nanoparticles on germination and growth of maize seedlings. *Saudi Journal of Biological Sciences*, In Press, Corrected Proof-Note to users.

Parvin, O.N., M.T. Shafi, Y. Rikta and A. Kamal (2018). Facile synthesis of iron oxide anoparticle and synergistic effect of iron nanoparticle in the presence sunlight for the degradation of DOM from textile wastewater. *Applied Water Science*,**73(8):** 1-11.

Rezaeei, M., M. Daneshvar and A.H. Shirani (2014). Effect of iron nano chelated fertilizers foliar application on three wheat cultivars In Khorramabad climatic conditions. *Scientific Journal of Crop Science*, **3(2):** 9-16.

Sharifi, R., K. Mohammadi and A. Rokhzadi (2016). Effect of seed priming and foliar application with micronutrients on quality of forage corn (*Zeamays* L.). *Environmental and Experimental Biology*,**14:**151-156.

Singh, M.D., G. Chirag, P. Prakash, M.H. Mohan, G. Prakasha and K.Vishwajith (2017). Nano-Fertilizers is a New Way to Increase Nutrients Use Efficiency in Crop Production. *International Journal of Agriculture Sciences*, **9(7):** 3831-3833.

Solomon, S., M. Bahadory, A. Jeyarajasingam, S. Rutkowsky and C. Boritz (2007). *Synthesis and study of silver nanoparticles of Chem. Edu*., **2(84):** 322-325.

Walpola, B.and M. Yoon (2012). Prospectus of phosphate solubilizing microorganisms and phosphorus availability in agricultural soils: A review. *African J. of Microbiology Res*., **6(37):** 6600-6605.

Sahoki, M.M. (1990). Yellow corn produced and improved. Ministry of Higher Education and Scientific Research. Baghdad University.

Saadoun, S.N.A. and M.M. Obeidi (2014). *Zea mays* L. response to organic fertilization pert Humus under different irrigation periods. *Anbar Journal of Agricultural Sciences*, **12(2):** 246-256.

Yasmeen, F. (2018). Differential effects of copper and iron nanoparticles on wheat shoot proteomics. *Biochem. Anal. Biochem*., **7:** DOI: 10.4172/2161-1009-C2-021.

Zaidi, J.A.M. (2017). Effect of Potassium and Organic Fertilizer on Potassium Formation of Rhizosphere and Outside Soil and Growth of *Maize* L. (*Zea mays* L.), Master Thesis, College of Agriculture, University of Qadisiyah.