Effect of iron nanoparticles and yeast suspension on the phenotypic trials and chemical content of Daucus carota plant

Zena Abdulkadhim Oudah
College of Science, University of Al-Qadisiyah, Iraq

Intedhar Abbas Marhoon
College of Science, University of Al-Qadisiyah, Iraq, Intedhar.abbas@qu.edu.iq

Abstract

The experiment was applied in the College of Science, University of Al-Qadisiyah. The aim of study was to investigate the effect of foliar spraying with iron nanoparticles and dry yeast extract on some phenotypic trails and chemical content of carrot plant roots Daucus carota. The experiment was designed as a factorial experiment with two factors; the first was iron nanoparticles at concentrations (0, 50, and 100) mg/L, and dry yeast extract at concentrations (0, 2, 4, 6) gm/L. They have sprayed twice on the plant. In this study, root length (cm), percentage of dry matter to total rootstock, carotenoids content, percentage of proteins and carbohydrates, and percentage of calcium have been investigated. The results have been showed that spraying the plants with iron at a concentration (100 mg/L) led to a significant increase in all the studied traits, as the highest root length recorded 14.23 cm, the highest percentage of dry matter was 3.82%, the content of carotenoids was (1.62), the percentage of proteins was 12.03%, and the percentage of carbohydrates was 19.73%, calcium was 1.75%, compared to the control treatment. The effect of yeast suspension concentrations had a significant effect on all studied root traits and chemical content, especially at a concentration of 6 g/L. The interactions between iron nanoparticles and yeast suspension also had a significant effect on increasing the studied traits.

Keywords: *iron nanoparticles, dry yeast, carotenoids, proteins, Daucus carota.*

INTRODUCTION

The D. carota is one of the most important genera that belong to the Apiaceae family. It is considered one of the winter crops, and it is grown in all provinces of the country. It is an annual herbaceous plant with a compressed stem and short internodes. The leaves begin to appear 15 days after germination (Heywood, 2007). The carrots are rich in nutrients and have many health benefits. It has high content of carotenoids, phenolic compounds, polyacetylenes, and vitamins. Carrots are of economic importance among root vegetables due to their high vitamin A content, rich in bioactive compounds including carotenoids and beta-carotene, a good source of thiamine, protein, calcium, and riboflavin (Sharma et al., 2020).

This plant contains chemicals that have antioxidant and anti-cancer properties. It has been proven that carrots have anti-diabetic properties, cholesterol and cardiovascular diseases, lowering high blood pressure, protecting the liver, wound healing, anti-bacterial, anti-fungal, and anti-inflammatory. It has also rich in molybdenum (Mishra, 2022). Recently, the composition of nanoparticles has a fundamental role in life applications, including agricultural including the use of nano-fertilizers in agriculture, which caused an increase in agricultural productivity and to reducing the use of other fertilizers (Khan et al., 2017). The technology of using nano-fertilizers instead of traditional fertilizers is one of the modern and influential technologies in agriculture. This leads to improving agricultural production with less damage to environmental systems. It is one of the safe technologies that work to provide healthy food and a sustainable environment, and nano-fertilizers have a major role in Improving plant growth and protecting plants from most environmental stresses (DeRosa et al., 2010).

Valdez et al. (2018) have been used iron with an extract of some plants to manufacture nanoparticles. It was observed that these particles had a positive effect on seed germination, plant growth, the ability to photosynthesize, and the levels of biomolecules and antioxidants of Vigna radiata (Rani et al., 2020). Salarpour et al. (2013) have been used nano iron on the cress plant Lepidium sativum. They have indicated a significant difference in the plant height. It has reached 33 cm at a concentration of 5 g /L. Also, treat the Zea mays plants with nanoiron at a concentration of 2 g/L, the chlorophyll content of the leaves increased significantly compared to the control treatment (Fathi et al., 2017). When the Zea mays was sprayed with nanoiron, it resulted in an increase in the chlorophyll content, as it recorded 3.8 mg/ g, compared to the control treatment, which has recorded 0.3 mg/ g (Roozbahani, and Mohammadkhani, 2017).

In agriculture, the increasing concern for the environment has led to find alternative fertilizers that are more environmentally friendly. One of the most important means to develop plant nutrition and organic fertilization is the use of yeast extract (Saccharomyces cerevisiae), which is environmentally safe, cheap and economically feasible. It has proven effective on many crops by improving and increasing growth trails and yield (Thierry et al., 2014). Dawod et al, (2013) have been explained that use the solution of yeast was on soybeans Glycine max increased the dry matter by 82.7%, and the weight of the seeds has increased 90.6%. In a study of the effect of adding yeast on the growth, productivity and nutritional value of two types of lettuce (Lactuca sativa) grown in a hydroponics system, the results have been showed that yeast cells gather around the root cells of lettuce, then enter the cells and lead to an increase in the nutritional value of the plant in addition to increasing productivity (Abdul Ameer and Hussain, 2022).

Abed Nasser, (2019) has been reported that the positive effect of a dry yeast solution on the studied plants, which recorded significant differences in leaves properties, compared to the control treatment. The highest number of leaflets, leaf area, total chlorophyll content, stem length, inner nodes length and number of nodes were recorded in plants treated by spraying and inject around the roots at a dose of (10) g/L. Therefore, The aim of study was to investigate the effect of foliar spraying with different concentrations of nano-iron fertilizer and yeast suspension and the interaction between them on the trials of vegetative and root growth, the chemical content and the active substance of the local variety carrot plant D. carota.

Materials and Methods

This study was applied in College of Science/ University of Al-Qadisiyah during the season 2022-2023. The aim of study was to investigate the effect of foliar spraying with different concentrations of nano-iron fertilizer and yeast suspension and the interaction between them on the trials of vegetative and root growth, the chemical content and the active substance of the local variety carrot plant. Pots (30 cm in diameter) containing a mix of clay soil with peat moss was used in a ratio of (2:1). The seeds of the local variety were planted on 15/10/2022, ten seeds in each pot, and the pots were placed in the wooden canopy until the treatments were applied.

Two weeks after germination, the seedlings were reduced to only three. Foliar spraying treatments were applied with iron nanofertilizer at concentrations (50, 100) mg/L in addition to the control treatment (spraying with distilled water only), as well as spraying with yeast suspension (2, 4 and 6) g/L. The process of spraying the solutions was applied in the early morning until complete wetness. The foliar spraying operations were repeated using the same concentrations above, one month after the first spraying. Traits were measured three weeks after the last treatment including root length (cm) which was measured using a tape measure. The percentage of dry matter was estimated in the root system of three plants from each replicate for each treatment. It was well cleaned of dirt and soil using water, and then each was weighed using a sensitive scale. After that, the root parts were dried in the air first, then placed in perforated paper bags and left in the electric oven at 70°C for 48 hours (until the weight is proven). Then, they were weighed again using a sensitive scale. The dry weight was estimated as follows:

$$\text{The percentage of dry matter} = \frac{\text{Dry weight}}{\text{Soft weight}} \times 100$$

Estimation of the content of total carotenoids (mg/gm fresh weight) based on Lichtenthaler (1987) method. The content of total carotenoids in the root was estimated. One gram of fresh roots was taken and cut into small pieces and add 10 ml of acetone with a concentration of 80%, then crush it with a ceramic mortar. Then, the precipitate was separated from the filtrate using a centrifuge at a speed of 3000 rpm for 15 minutes. Using a spectrophotometer, the visible density of the filtrate was measured at a wavelength of 470 nm, and then the following equation was applied to calculate the value of carotenoids:

Total Carotenoid content (mg/g tissue) = A.Y (ml).106 / A1%1cm .100

A = optical density reading at a wavelength (470 nm)

Y = volume of the solution

A1% 1cm = Absorbance Coefficient for Carotenoids (2592)

Calcium concentration (%)

The percentage of calcium in roots was estimated according to Cresser and Parsons (1979) method. 5 ml of digested roots samples were taken and 95 ml of distilled water was added. Then, the absorbance using an atomic spectrometer at a wavelength of 422.7 nm, and using the standard curve, the calcium concentration was extracted, and then its percentage was estimated.

Estimation of the percentage of proteins

The percentage of protein was extracted from the roots by multiplying the percentage of nitrogen produced from the roots x 6.25 (Thachuk et al., 1977).

Determination of the carbohydrates percentage

The percentage of carbohydrates in the roots was estimated according to the Joslyn (1970) method, where 0.2 g of a dried and ground sample was weighed and (8 ml) of ethyl alcohol, concentration of 80% was added. It is placed in a water bath at a temperature of 60 °C for 30 minutes, then separate the filtrate from the precipitate using a centrifuge (Heva - Christ gumy) at a speed of 3000 revolutions/ minute for (15) minutes. The process was repeated twice in a row, and the filtrate was collected and the volume was completed to 25 by adding ethyl alcohol. Then, (1) ml was withdrawn from the extracted sample and (1) ml phenol and (5) ml sulfuric acid were added. After that, the absorbance was read at a wavelength of 650 nm using a spectrophotometer.

Statistical analysis

The experiment was designed as a factorial experiment with two factors, and the design was completely randomized. The rates were compared using the least significant design (LSD) value of 5%.

Results and Discussion

Table (1) has been indicated that the effect of the treatments on the average root length. It is clear that the treatment with nano-iron significantly increased the root length. It has reached the highest average root length (14.23 cm) when spraying with the highest concentration of nano-iron compared to the control treatment, while the use of (50 mg/l) of nanoparticles reordered no significant increase. The yeast suspension has been recorded a significant increase in the average root length with the increase in the concentration that used. The highest average root length was (14.76 cm) when the concentration was (6 g/L) of the yeast suspension. In the interactions, it was found that the interaction of the highest concentration of both study factors had a significant superiority in recording the highest average root length (15.26 cm) compared to the control treatment, which was (12.01 cm).

Table (1) the effect of iron nano-fertilizer and yeast suspension and the interaction between them on the average root length (cm) of carrot plants.

Nano-iron concentrations (mg/L)	yeast suspension concentrations (g/l)				Average of nano-Iron
	0	2	4	6	
0	12.01	13.47	13.50	14.00	13.25
50	12.11	12.99	13.75	15.01	13.47
100	13.33	13.55	14.76	15.26	14.23
Average of the yeast suspension	12.48	13.34	14.00	14.76	
LSD 0.05	Nano-iorn= 0.42		yeast suspension= 0.61		combined =1.04

Average of dry content to root total (%)

Table (2) has been showed that the effect of the factors under study and the combined between them on the percentage of dry content to the root system. It was found that spraying the plant with nano-iron caused significant effects in the percentage of dry content to the root system, reaching the highest percentage (3.82%) at the concentration (100 mg/l) compared to the control treatment. The treatment with yeast suspension also recorded a significant increase in the average percentage of dry content to the root system, the highest was (4.04%) when spraying at a concentration of (6 g/l) compared to the control treatment. With regard to the combined, the highest percentage of dry was (4.24%) when the combination of iron nanoparticles at a concentration of (100g/L) with (6g/L) of yeast suspension compared to the control treatment, which recorded a ratio of (2.96%) for dry content of the total root.

Table (2) the effect of nano-iron fertilizer and yeast suspension and the combined between them on the average dry percentage (%) of the root system of carrot plants.

Nano-iron concentrations (mg/L)	yeast suspension concentrations (g/l)				Average of nano-Iron
	0	2	4	6	
0	2.96	3.51	3.72	3.83	3.51
50	3.35	3.50	4.01	4.05	3.73
100	3.49	3.55	4.00	4.24	3.82
Average of the yeast suspension	3.27	3.52	3.91	4.04	
LSD 0.05	Nano-iorn= 0.15		yeast suspension= 0.21		combined =0.32

It is clear that the foliar spraying with nano-iron had a significant effect on increasing the content of total carotenoids in the root as it is recorded (1.56 mg/g). The same table also shows that spraying with a yeast suspension at a concentration of (6 gm/L) was significantly superior in total carotenoid content as it reached (1.68 mg/gm) (Table 3). The effect of the combined between the concentrations of the study factors, the highest average content of total carotenoids was (1.70 mg/g) when the two combinations consisted of an interaction with 6 g/L of yeast suspension with nano-iron at a concentration of (100 mg/L) and (50 mg/L). L), compared to the control treatment, which recorded (1.38 mg/g) of the average total carotenoids content.

Table (3) the effect of nano-iron fertilizer and yeast suspension and the combined between them on the average total carotenoids content (mg/g) in the root system of carrot plants.

Nano-iron concentrations (mg/L)	yeast suspension concentrations (g/l)				Average of nano-Iron
	0	2	4	6	
0	1.38	1.61	1.59	1.65	1.56
50	1.37	1.60	1.66	1.70	1.58
100	1.45	1.63	1.68	1.70	1.62
Average of the yeast suspension	1.40	1.61	1.64	1.68	
LSD 0.05	Nano-iorn= 0.02		yeast suspension= 0.04		combined =0.05

Protein percentage (%)

The results have been showed that the percentage of protein in the root has increased significantly under the influence of the study factors. The highest percentage of protein was achieved by using nano-iron at a concentration of (100 mg/L) which was (12.03%) compared to the control treatment (9.56%). The highest rate of protein was recorded when using a yeast suspension with a concentration of (6 gm/L), which amounted to (11.36%), compared to (10.25%) for the control treatment (Table 4). For the combined, most of them has been recorded a significant increase in the protein percentage compared to the control treatment, and the highest rate was (12.63%) when using 100 mg /L of nano-iron with 6 g/L of yeast suspension.

Table (4) the effect of iron-nano fertilizer and yeast suspension and the combined between them on the average percentage of proteins (%)

Nano-iron concentrations (mg/L)	yeast suspension concentrations (g/l)				Average of nano-Iron
	0	2	4	6	
0	9.44	9.56	9.50	9.75	9.56
50	10.31	9.88	10.38	11.69	10.57
100	11.00	12.00	12.50	12.63	12.03
Average of the yeast suspension	10.25	10.48	10.79	11.36	
LSD 0.05	Nano-iorn= 0.43		yeast suspension= 0.21		combined =1.02

For the percentage of carbohydrates, table (5) has been showed that the average percentage of carbohydrates in the root was significantly increased when treated with nano-iron and with both concentrations, and the highest average percentage of carbohydrates when using the concentration (100 mg / L) was (19.73%) compared to the control treatment. The same applies to the effect of spraying with yeast suspension, as it also increased the average percentage of carbohydrates in the root. In general, it reached the highest average percentage of carbohydrates (19.97%) when using a high concentration of yeast suspension. The use of nano-iron at a concentration of (100 mg/L) with 6 g/L of yeast suspension have been recorded the highest rate of carbohydrates in the root compared to the control treatment, which recorded (19.03%).

Table (5) the effect of iron-nano fertilizer and yeast suspension and the combined on the average percentage of carbohydrates (%)

Nano-iron concentrations (mg/L)	yeast suspension concentrations (g/l)				Average of nano-Iron
	0	2	4	6	
0	19.03	19.08	19.78	10.82	19.43
50	19.44	19.45	19.77	20.00	19.67
100	19.43	19.52	19.88	20.10	19.73
Average of the yeast suspension	19.30	19.35	19.81	10.97	
LSD 0.05	Nano-iorn= 0.11		yeast suspension= 0.09		combined =0.24

The results have been indicated that nano-iron had no significant effect on the percentage of calcium in the root system. However, all concentrations of yeast suspension increased the average percentage of calcium in the root, as the concentration (6 g/L) was able to record the highest average percentage of calcium, which reached (1.98%) compared to (1.46%) for the control treatment. The effect of the combined between the iron nanoparticles and the yeast suspension, it appeared that the interaction of the high concentration of both agents recorded the highest rate of calcium (2.12%) compared to the control treatment (1.46%).

Table (6) the effect of nano-iron fertilizer and yeast suspension and the combined on the average percentage of calcium (%)

Nano-iron concentrations (mg/L)	yeast suspension concentrations (g/l)				Average of nano-Iron
	0	2	4	6	
0	1.46	1.54	1.78	1.80	1.65
50	1.45	1.61	1.78	2.01	1.71
100	1.48	1.60	1.80	2.12	1.75
Average of the yeast suspension	1.46	1.58	1.79	1.98	
LSD 0.05	Nano-iorn= N.S		yeast suspension= 0.12		combined =0.21

The reason for this is that nano-composites possess unique qualitative trails such as their large surface area and small size of their particles, and as a result, their ability to be absorbed by plants increases. In addition, nano-fertilizers have high solubility in solvents, especially water. The small size of their particles and these trails contributes to increasing the penetration of nano-particles when sprayed on leaves (Sekhon, 2014; Zahedi etal, 2020).

Tanou et al. (2017) have been found that nano-composites provide more space for physiological processes within plants, the most important of which is an increase in the rate of photosynthesis within plants, which results in an increase in the growth rate of plants in general. Thus, an increase in the carbohydrates rate and the percentage of dry content of the plant. This is what was found in the results of the current study. The increase in the percentage of dry content of the root system may be due to the increase in the activity of the shoot system that increasing of nutrients and the supply of nutrients to the root, which leads to an increase in its weight. These results are agreed with Mohammadkhani and Roozbahani (2017) and Elanchezhian et al. (2017).

It was also clear from the results that treatment with nano-iron have increased the proportion of carbohydrates in the root system of the pear plant Pyrus communis, and this is agreed with Abou El Nasr et al. (2015). The reason for the effect of yeast suspension is due to the fact that it contains some minerals, proteins, carbohydrates, and vitamins. It is also an important source of melatonin, folic acid, and some hormones such as cytokinins, which stimulate division of plant cells and thus increase the vegetation of the plant, Ibrahim Dewedar, (2016) and Sacakli et al., (2013). Hormones also affect the activation of physiological activities, the formation of chlorophylls and helper pigments, and the produce of proteins and nucleic acids, and this will positively affect the effectiveness of the photosynthesis pathways, which will reflect positively on the vegetative and root characteristics of the plant (El-Desouky et al, 2007).

Conclusion

The study conclude that the results have been showed that spraying the plants with iron at a concentration (100 mg/L) led to a significant increase in all the studied traits, as the highest root length recorded 14.23 cm, the highest percentage of dry matter was 3.82%, the content of carotenoids was (1.62), the percentage of proteins was 12.03%, and the percentage of carbohydrates was 19.73%, calcium was 1.75%, compared to the control treatment.

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