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Research Article

The effect of foliar fertilization with normal and nano sulfur and the interaction between them in some vegetative characteristics, plant pigments content and dry weight of the shoot system of two varieties of leek plans *Allium ampeloprasum* L.

Zain alabdeen ALMOUSSWI*, Dhafir A. JAMEEL
Department of Biology, College of Education, University of Al-Qadisiyah, Iraq.
*Email: amzain1985@gmail.com

Abstract
This study was conducted to determine the effect of foliar fertilization with normal and nano-sulfur fertilizer and the interaction in the characteristics of vegetative growth and plant pigments for two varieties of leek (local and imported). Two levels of normal sulfur fertilizer (1 and 2g.L^{-1}) were used and two levels of sulfur nano-fertilizer (1 and 2mg. L^{-1}). The experiment was applied using Split split– Block design in complete randomized block with three factors and three replicates. Significant differences were recorded between the levels of fertilizer used for growth traits (plant height, number of leaves, leaf area, leaf width, total chlorophyll content, and carotenoids content). The local leek recorded the highest average values of traits (plant height 32.71cm, number of leaves 11.95 leaves. $plant^{-1}$, leaf area 166.50cm^2, total chlorophyll content 1.426mg.g^{-1} fresh weight) compared with the imported leek, which recorded the following values as 29.71cm, 8.79 leaves.$plant^{-1}$, 145.14 cm^2, $plant^{-1}$, and 1.294mg.g^{-1} fresh weight, respectively. There was no significant increase in the average leaf width between both the local, which recorded 1.77cm^2, and the imported variety, which recorded 1.62cm^2. The average content of carotenoids recorded a significant decrease of 0.509mg.g^{-1} fresh weight for the local variety and 0.464mg.g^{-1} fresh weight for the imported variety.

Keywords: *Pseudomonas aeruginosa*, Antibiotic resistance gene, Ruminant, DNA.
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Introduction

The leek, *Allium ampeloprasum* L. is one of the vegetable crops of the Amaryllidaceae family. The Mediterranean Basin (southern Europe, and North Africa to Western Asia) is believed to be its origin. It has also been introduced in other world regions, such as North and South America and Australia (Nehdi et al. 2020; Bokov et al. 2022). Leeks are widely cultivated for consumption as vegetables, culinary herbs, spices, ornamentals, and aromatic plants and are known to have a specific odor and sharp taste. The whole plant or some parts are either cooked or consumed fresh (Shelke et al. 2020). The leek has various beneficial effects on human health, such as antioxidant, antimicrobial and antineoplastic activity, effectiveness against diabetes and inflammation, and its remnants (Koca & Tasci 2016; Ansari et al. 2022). These are mainly attributed to the various chemical components in leeks, such as dietary fiber, sulfur-containing compounds, saponins, vitamins, chemical elements, and polyphenols (Nehdi et al. 2020; Huldani et al. 2022).

Nano-fertilization is one of the methods used in agriculture to improve crop growth, increase nutrient efficiency, and reduce fertilizer waste and cost. It contributes to increased crop growth. Nano-fertilizers provide more space for various metabolic reactions in plants, which increases the rate of photosynthesis and crop productivity and prevents biotic and abiotic stress (AL-Tameemi et al. 2019). Reduction of the size of the material to the nanoscale leads to an increase in the surface mass ratio of the particles, and as a result, an abundant amount of nutrient ions is absorbed slowly and steadily for a long period. The increased efficiency of the product may encourage farmers to use the product with enhanced profitability (Kumar et al. 2019).

The land plays an important role in plant metabolism, and it is necessary for the synthesis of plant proteins, amino acids, some vitamins, and enzymes. Most sulfur-containing compound fertilizers contain nitrogen highlighting the close association between these two elements. Sulfur is a part of an enzyme necessary for nitrogen absorption. Its deficiency could heavily hinder nitrogen metabolism, i.e. its presence and nitrogen enables sulfur to form the amino acids necessary for protein synthesis. It is also found in fatty acids and vitamins and significantly affects the quality, taste, and aroma of crops (Narayan et al. 2022).

Foliar fertilization is defined as supplying the plant with its needs of nutrients (macro and micro) through the shoot system instead of the root, by spraying the shoot system, which can absorb these elements through the gaps spreading on the surfaces of the upper and lower leaf. Studies have shown that all nutrients that are absorbed by the roots can be absorbed also by the stems and leaves and are more rapidly and efficiently absorbed than in the root fertilizing, especially when the soil conditions are not suitable for absorption such as soil pH, loss and washing (Jasim & Obaid 2018). Based on the above-mentioned background, this study was conducted to determine the effect of foliar fertilization with normal and nano-sulfur fertilizer and the interaction in the characteristics of vegetative growth and plant pigments for two varieties of leek (local and imported, Syrian variety).

Materials and methods

The cultivation experiment was carried out in a private nursery in Al-Diwaniyah Governorate during the planting season 2020-2021 on 1/10/2020 using plastic pots for planting seeds, and the capacity of each one was 10 kg/soil. The experiment was performed based on Split–Block Design in Complete Randomized Block with three factors and three replicates. The vitality of the seeds of the local and imported varieties was tested by taking 100 seeds and placing them in a petri dish with a diameter of 15 cm containing two filtration papers. 10 cm^3 of distilled water were added and the germination percentages were calculated. The germination percentage was (98%) after ten days. Opaque plastic pots were used, each one has a capacity of 10 kg, for cultivation, they were filled with 6 km of sandy alluvial soil with known characteristics. Normal sulfur fertilizer was prepared at levels of 0, 1 and 2g /liter, by dissolving the required amount of sulfur in distilled water and completing the volume down to 1 liter to get the above two levels. The nano sulfur fertilizer of the US – Nano Company, with the following characteristics (particle size: 47 nanometers, purity: 99.99, color: light yellow) was prepared through direct dissolution in distilled water according to the instructions on the usage sheet. Concentrations of pre-prepared materials (normal and nano sulfur fertilizer) were added only twice according to the earlier mentioned concentrations by spraying on the shoot system in the morning until it got wet completely using hand sprayers. Several drops of dishwashing liquids were added to the spray solutions because of its adhesive properties, taking into account all the necessary precautions and measures to prevent overlapping between one treatment and another in the addition process. The measurements of vegetative growth and concentrations of plant shoots were carried out in the full maturity stage, by taking a random sample of a group of plants for each treatment. The following characteristics were measured.

Table 1. Show effect of treatment of normal and nano sulfur fertilizer and the interaction between them on plant height (cm).

Sulfur fertilization (B)	Class A		Average effect of sulfur
	local	importer	
Comparison	29.11	26.17	27.64
Nano ($1mg.L^{-1}$)	32.17	29.67	30.92
Nano ($2mg.L^{-1}$)	33.17	30.50	31.84
normal ($1g.L^{-1}$)	31.50	27.83	29.67
normal ($2g.L^{-1}$)	31.67	29.33	30.50
Nano ($1mg.L^{-1}$) + Normal ($1g.L^{-1}$)	34.17	31.83	33.00
Nano ($2mg.L^{-1}$) + Normal ($2g.L^{-1}$)	37.50	32.67	35.09
average class effect	32.76	29.71	
LSD 0.05	A=2.441	B=1.311	AB=1.123

Table 2. Effect of treatment of normal and nano sulfur fertilizer and the interaction between them on the number of leaves (leaf. $plant^{-1}$).

Sulfur fertilization (B)	Class A		Average effect of sulfur
	local	imported	
Comparison	10.67	8.00	9.34
Nano ($1mg.L^{-1}$)	11.50	8.67	10.09
Nano ($2mg.L^{-1}$)	12.67	9.00	10.84
normal ($1g.L^{-1}$)	11.00	8.00	9.50
normal ($2g.L^{-1}$)	11.30	8.33	9.82
Nano ($1mg.L^{-1}$) + Normal ($1g.L^{-1}$)	13.00	9.20	11.10
Nano ($2mg.L^{-1}$) + Normal ($2g.L^{-1}$)	13.50	10.33	11.92
average class effect	8.79	11.95	
LSD 0.05	A=2.02	B=0.53	AB=0.3530

Plant height (cm): The plant height was measured from the contact site with the soil surface to the top of the plant using tape for all plants in one replicate and for all treatments.

Diameter of the leg (mm): The stem diameter was measured using a Vernier caliper from the stem area near the soil.

Number of leaves per plant: The number of leaves was calculated for one plant in each replicate.

Leaf area (cm^2): The leaf area (cm^2) was calculated for three leaves taken randomly from each pot, based on the experiment parameters using the following equation (McKee 1964)

Leaf area cm^2 = 1.25 x (3.143) x paper length (cm) x width (cm)

Determination of plant pigments: Determination of the total chlorophyll content (mg/gm fresh weight): The chlorophyll concentration was estimated based on Arnon (1949). For this purpose, 100mg of fresh plant leaves was taken and crushed in $10cm^3$ of acetone at a concentration of 80% by a ceramic mortar, then centrifuged at a rate of 3000rpm 5 min. Thereafter, the filtrate was taken and placed in a volumetric flask. The volume was completed to $20cm^3$ by adding acetone at a concentration of 80%, and the absorbance of the solution was estimated at the wavelength range of 663 and 645nm using a spectrophotometer according to the following equation:

mg– Chlorophyll a / mg tissue = [12.7(D663)] – [2.69(D645)] XV(100XW) mg–Chlorophyll b / mg tissue = [22.9(D645)] – [4.68(D645)] XV(100XW) mg–Chlorophyll) / mg tissue =[20.2(D645)] +[18.2(D663)] XV(100XW)

Where V = final volume of the filtrate (cm^3), D = optical density of the chlorophyll extract and W = fresh weight (g).

Determination of carotenoids: The carotenoids were estimated at a wavelength of 480nm according to Davies (1965) and were calculated using following equation: Optical density at wavelength (480) x volume of total solution x 1000

Table 3. Effect treatment of normal and nano sulfur fertilizer and the interaction between them on the total leaf area (cm^2. Plant-1).

Sulfur fertilization (B)	Class A		Average effect of sulfur
	local	imported	
Comparison	133.04	114.39	123.72
Nano (1mg.L^{-1})	169.87	151.06	160.47
Nano (2mg.L^{-1})	179.97	157.85	168.91
normal (1g.L^{-1})	140.65	124.51	132.58
normal (2g.L^{-1})	168.48	141.96	155.22
Nano (1mg.L^{-1}) + Normal (1g.L^{-1})	182.41	158.59	170.50
Nano (2mg.L^{-1}) + Normal (2g.L^{-1})	191.11	167.60	179.36
average class effect	166.50	145.14	
LSD 0.05	A=12.398	B=10.044	AB=11.353

Total carotene (mg/100g) =

$$\frac{\text{Optical density at wavelength (480)x volume of total solution x 1000}}{\text{100 x 2500}} \text{ x 10}$$

Percentage of dry matter of the shoot system: Three plants were taken from each replicate and each treatment. They were cleared well from dust using distilled water, and the wet plant parts were weighed using a scale (Precisa XB 22 OA). Consequently, each part was dried in the air first, then placed individually in perforated paper bags and placed in the Gallan Kamp electric oven at a temperature of 70°C for 48 hours (until the weight stabilized). Then they were weighed using a sensitive scale. The dry weight was estimated as follows:

$$\text{Percentage of the model} = \frac{\text{Dry sample weight}}{\text{Fresh sample weight}} \text{ x 100}$$

Results

Plant height: The results showed that the local leek (32.76cm) was significantly higher than the imported ones (29.71cm). The foliar fertilization with sulfur achieved significant results in all treatments compared to the control one (27.64cm). In addition, the treatment with nano sulfur for both varieties had better results than normal sulfur, but the increase was significant only in the 2mg. L^{-1} treatment, as the average plant height reached 31.84cm compared to 29.6 and 30.50cm of normal sulfur treatments, respectively. However, the treatments of nano-sulfur with normal fertilizer recorded the highest averages of plant height (35.09cm) when treated with nano-sulfur (2mg.L^{-1}) + normal (2g.L^{-1}). The Nano Sulfur + normal (2mg.L^{-1}) + Ordinary (2g.L^{-1}) achieved the highest average plant height in the current study (37.50cm) with a significant difference from all the interaction coefficients, including the control treatments for both local and imported varieties with the least significant mean for the trait, which reached 29.11 and 26.17cm, respectively (Table 1).

The number of leaves: The local leek had significantly higher leaves than the imported variety in the number of leaves (11.95 vs. 8.79 leaves. $plant^{-1}$) (Table 2). All treatments recorded higher averages for the number of leaves than the control (9.34 leaves.$plant^{-1}$), except the treatment with both concentrations of normal sulfur (1 and 2g.L^{-1}) that had 9.50 and 9.82 leaves.$plant^{-1}$, respectively.

The treatment with nano-sulfur + normal at both concentrations had a higher number of leaves compared to the treatment with nano-sulfur at both concentrations. The treatment with nano-sulfur (2mg.L^{-1}) + normal (2g.L^{-1}) recorded the highest mean number of leaves, (11.92 leaves. $plant^{-1}$) compared to others. The bilateral significant interaction between the plant variety and sulfur fertilization showed that the treatments of the local variety recorded significantly higher results than the imported variety. The treatments that included the nano-sulfur + normal mixture hsd the highest averages of the leaves in both varieties with the increase in the concentration of sulfur, followed by the treatments of nano-sulfur and then the normal sulfur (Table 2).

Total leaf area: The results showed that the local variety has a better response to fertilization (Table 3). It also recorded a significantly higher average total

Table 4. Effect treatment of normal and nano sulfur fertilizer and the interaction between them on leaf width (cm).

Sulfur fertilization (B)	Class A		Average effect of sulfur
	local	imported	
Comparison	1.66	1.50	1.58
Nano (1mg.L^{-1})	1.73	1.63	1.68
Nano (2mg.L^{-1})	1.80	1.65	1.73
normal (1g.L^{-1})	1.69	1.59	1.64
normal (2g.L^{-1})	1.72	1.61	1.67
Nano (1mg.L^{-1}) + Normal (1g.L^{-1})	1.87	1.66	1.77
Nano (2mg.L^{-1}) + Normal (2 g. L^{-1})	1.91	1.67	1.79
average class effect	1.77	1.62	
LSD 0.05	A=0.17	B=0.13	AB=0.15

Table 5. Effect of treatment of normal and nano sulfur fertilizer and the interaction between them on the total chlorophyll content (mg. g^{-1} fresh weight).

Sulfur fertilization (B)	Class A		Average effect of sulfur
	local	imported	
Comparison	1.215	1.047	1.131
Nano (1mg.L^{-1})	1.381	1.340	1.361
Nano (2mg.L^{-1})	1.430	1.379	1.405
normal (1g.L^{-1})	1.274	1.213	1.243
normal (2g.L^{-1})	1.371	1.291	1.331
Nano (1mg.L^{-1}) + Normal (1g.L^{-1})	1.449	1.386	1.418
Nano (2mg.L^{-1}) + Normal (2g.L^{-1})	1.860	1.399	1.629
average class effect	1.426	1.294	
LSD 0.05	A=0.0038	B=0.0071	AB=0.1010

leaf area of 166.50cm^2. Plant^{-1} compared to that of the Syrian variety (145.14cm^2.plant^{-1}). Due to the significant effect of sulfur treatment, all treatments haf significantly higher averages for leaf area than the control (123.72cm^2.plant^{-1}), except for normal sulfur treatment (1gm.L^{-1}), in which the increase was not significant, (132.58 cm^2. plant^{-1}). Based on the results, the treatment with nano-fertilizer at both concentrations were higher than the treatment of normal sulfur at 1g.L^{-1}. The normal and nano sulfur treatment of a concentration of 2mg.L^{-1} + 2g.L^{-1} had the highest average leaf area (179.36cm^2. plant^{-1}) than other treatments, but the treatment with normal and nano sulfur with a concentration of 1mg.L^{-1} + 1g.L^{-1} which was not significant.

The results of the interaction between the two varieties of plant and fertilization showed that the treatments of the local variety were significantly higher than the imported ones. In addition, the treatments that included a mixture of nano and normal sulfur at the highest concentrations recorded a significantly higher average leaf area (191.11cm^2) than the rest of the treatments, except for the treatment of a mixture of nano and normal sulfur at a concentration of 1mg.L^{-1} + 1g.L^{-1} (182.41cm^2).

Leaf width: The results regarding the leaf width showed that the local variety has more responsive than the imported variety, but not significant (Table 4). The increase in the average leaf width of the local variety was 1.77cm^2 compared with 1.62cm^2 for the imported variety. The results also indicate a significant effect of sulfur treatment. The average increase in the treated leaf width was 2mg. L^{-1} recorded 1.73cm^2 compared to the control treatment (1.5cm^2). In addition, the treatments of normal sulfur did not show a significant increase in the average width of the leaf at both concentrations, which were 1.64 and 1.67cm^2, respectively. Furthermore, the treatment with normal and nano sulfur with both concentrations had the highest significant leaf mean compared to the rest of the treatments. The increase was directly proportional to the increase in

Table 6. Effect of treatment of normal and nano sulfur fertilizer and the interaction between them on the content of carotenoids (mg. g^{-1} fresh weight).

Sulfur fertilization (B)	Class A		Average effect of sulfur
	local	imported	
Comparison	0.649	0.535	0.592
Nano (1mg.L^{-1})	0.476	0.470	0.473
Nano (2mg.L^{-1})	0.457	0.427	0.442
normal (1g.L^{-1})	0.600	0.528	0.564
normal (2g.L^{-1})	0.535	0.496	0.516
Nano (1mg.L^{-1}) + Normal (1g.L^{-1})	0.437	0.398	0.418
Nano (2mg.L^{-1}) + Normal (2g.L^{-1})	0.411	0.392	0.402
average class effect	0.509	0.464	
LSD 0.05	A=0.035	B=0.19	AB=0.238

Table 7. Effect of treatment of normal and nano sulfur fertilizer and the interaction between them on dry weight (gm).

Sulfur fertilization (B)	Class A		Average effect of sulfur
	local	imported	
Comparison	10.23	8.80	9.52
Nano (1mg.L^{-1})	13.07	11.62	12.35
Nano (2mg.L^{-1})	13.84	12.14	12.99
normal (1 g. L^{-1})	10.82	9.58	10.20
normal (2g.L^{-1})	12.96	10.92	11.94
Nano (1mg.L^{-1}) + Normal (1g.L^{-1})	14.03	12.20	13.12
Nano (2mg.L^{-1}) + Normal (2g.L^{-1})	14.70	12.89	13.80
average class effect	12.81	11.16	
LSD 0.05	A=0.0443	B=0.0829	AB=0.1173

concentration. The results of the significant interaction between the two varieties of plant and sulfur fertilization showed that the treatments of the local variety recorded a significantly higher at 2mg.L^{-1} (1.80cm^2) compared to the control treatment (1.66 cm^2). The treatments that included a nano and normal fertilizer mixture recorded the highest leaf width of 1.87 and 1.91cm^2 for treatments 1mg.L^{-1} + 1g.L^{-1} and 2mg. L $^{-1}$ + 2g.L^{-1}, respectively. In the imported variety, the treatment mixture with normal and nano fertilizers with both concentrations was significantly higher than the rest of the treatments and the control one with 1.58cm^2.

Total chlorophyll content: The results revealed that the plant's total chlorophyll content had the highest response in the local variety, (1.426mg.g^{-1} fresh weight) compared with the imported variety (1.294mg.g^{-1} fresh weight) (Table 5). The results in the same table indicate sulfur fertilization treatments. The results show that the treatment with nano + normal sulfur and only at both concentrations had significant better results.

The increase in the plant chlorophyll content was directly proportional to the increase in concentration, as the highest significant average of total chlorophyll was recorded in the 2mg.L^{-1} nano + 2g.L^{-1} normal treatment (1.629mg.g^{-1} fresh weight) while 1mg.L^{-1} nano + 1g.L^{-1} normal treatment recorded an average for total chlorophyll of 1.41mg.g^{-1} fresh weight. The rest of the treatments, whether the treatment with nano-fertilizer with both concentrations or the treatment with regular fertilizer with its two concentrations, recorded an increase that was not significant compared to the control treatment (1.131mg.g^{-1} fresh weight). The results of interaction between the two factors show that the treatments of the local variety had higher to their counterparts of the Syrian variety in terms of total chlorophyll content, with the highest value of total chlorophyll when treated with the highest concentration of the mixture of nano and normal fertilizer (1.860mg.g^{-1} fresh weight) compared with the rest of the treatments and the two control treatments for both local and Syrian varieties which reached 1.215 and 1.047mg.g^{-1} fresh weight, respectively.

Total carotenoid content: The plant content of carotenoids had a significant decrease between the local and imported variety, as the highest decrease was recorded for the local variety (0.509mg.g^{-1} fresh weight) compared to the imported variety (0.464mg.g^{-1} fresh weight) (Table 6). The majority of the treatments recorded a significant decrease in the average content of carotenoids, and the highest decrease was in the treatment with normal and nano fertilizers, as the highest average of carotenoids was for 2mg.L^{-1} nano + 2g.L^{-1} nano treatment (0.402mg.g^{-1} fresh weight) and for 1mg.L^{-1} nano + 1g^{-1} normal treatment as 0.418mg.g^{-1} fresh weight. The lowest decrease was recorded for the two treatments of normal fertilizer, which was 0.564 and 0.516mg.$g.^{-1}$ fresh weight for the two treatments of 1and 2g.L^{-1}, respectively. The bilateral significant interaction between the two varieties of the plant and the sulfur treatment showed that the treatments of the Syrian variety have a lower significant decrease than the local variety. The highest rate of decrease was recorded for the imported variety when treated with a mixture of nano and normal fertilizer with concentrations of 0.392mg.g^{-1} fresh weight, while the local variety had 0.411mg.g^{-1} fresh weight at the same concentrations.

Effect of the treatment of ordinary and nano sulfur fertilizer and the interaction between them on the percentage % of dry matter for the shoot system: the local variety of leek was significantly superior in the total dry weight of the plant (12.81g) to the imported variety with the least significant average of 11.16g. With regard to the significant effect of sulfur fertilization only, all treatments recorded a higher average of the dry weight of the plant than it was in the control treatment as 9.52g. However, the highest average was fertilization with nano sulfur (2mg.L-1) + normal (2g.L^{-1}). The dry weight of the plant was 13.80g, with significant superiority over all other sulfur fertilization treatments (Table 7).

The bilateral significant interaction between the plant variety and sulfur fertilization showed that the treatments of the imported variety were significantly higher than their counterparts from the local variety, including the control treatments. The nano-sulfur mixture + normal treatments had the highest averages of the dry weight of the plant in both varieties by increasing the concentration of sulfur, followed by the treatments of nano-sulfur and then the treatments of normal sulfur in the same order (Table 7).

Discussion

The results elucidate that the foliar spraying of normal and nano sulfur fertilizer and the interaction between them leads to a significant increase in the vegetative growth characteristics of the two leek varieties. The increase in plant height, leaves number, leaf area and leaf width under the effect of ordinary sulfur are due to the action of sulfur, as its absorption by the plant and the increase of its concentration within the plant tissues establish a balance in food processing in the tissues of the leaf, which further contributes to increasing the vegetative growth of the plant (Buchelt et al. 2020). The increase in vegetative growth may be explained by the effect of sulfur, which causes an increase in cell division and expansion, since a rapid elongation occurs after treatment with sulfur, accompanied by an increase in the number of dividing cells in the sub-meristem area moving later to the apical meristem area (Przygocka et al. 2020; Ansari et al. 2022).

The effect of nano-sulfur fertilizer on vegetative growth characteristics could be due to the increase in the absorption of nano-sulfur, which causes a rise in available nutrients in sufficient concentrations. Hence, nano-fertilizer particles possess a large surface area, increasing biochemical reactions and other enzymatic reactions that increase cell divisions. Furthermore, nanoparticles inhibit or reduce the formation of free radicals, which reduces oxidative damage and delays aging, thus increasing the plasticity of cell walls which are important in cell elongation and expansion; this is reflected in the increase in plant height and surface area (Morteza et al. 2013). Moreover, nano-fertilizers play a role in increasing the hormonal content of the plant, especially gibberellic acid, which is necessary for increasing cell division of the subapical region of the apical meristem (Tiwari et al. 2014; Bokov et al. 2022). The results agree with the findings of Solanki et al. (2020), Gashaw et al. (2021) and Huldani et al. (2022).

Regarding the application of nano and ordinary sulfur fertilizer on the two varieties of the study plant, it was found that ordinary sulfur played a role in increasing the plant's chlorophyll, although the increase was not significant. During the oxidation, reduction, and energy transfer processes, sulfur also plays a role in decreasing the degree of soil reaction and increasing the concentration of available nitrogen, thus increasing the concentration of nitrogen in the leaves. The latter is one of the components of the porphyrins group present in chlorophyll pigment composition, and these results agree with the results of (Rawat et al. 2017; Mohammed & Qasim 2021). Sulfur nano fertilizer also affects the plant's chlorophyll content. The effect may be because sulfur is part of carbon compounds, found in two amino acids, and is a precursor for many coenzymes and vitamins essential for metabolism (Taiz & Zeiger 2002). Nanoparticles can also improve plant growth by increasing the efficiency of chemical energy production in the photosynthesis system and thus improving plant growth and biomass production; many studies have shown that the application of nano fertilizers led to an increase in the content of photosynthetic pigments when using correct and appropriate concentrations of sulfur nano fertilizer SNP. Various sulfur compounds play an antioxidant role or modulate the antioxidant defense system. Among them is glutathione (GSH), a powerful antioxidant, especially against peroxidation of chloroplast membranes (Najafi et al. 2020). The current study results agree with Dana et al. (2018).

References

AL-Tameemi, A.J.; AL-Aloosy, Y.A.M. & Jumaa, S. S. 2019. Nano Fertilizers and Optimum Crop Productivity: A Review. Plant Archives 19: 552-554.

Ansari, M.J.; Jasim, S.A.; Taban, T.Z.; Bokov, D.O.; Shalaby, M.N.; Al-Gazally, M.E. & Khatami, M. 2022. Anticancer drug-loading capacity of green synthesized porous magnetic iron nanocarrier and cytotoxic effects against human cancer cell line. Journal of Cluster Science 1-11.

Arnon, D.I. 1949. Plant Physiology. (Cited by Mediner, H. 1984). Class Experiments in Plant Physiology. Londen. George Allen and Cenwin.

Buchelt, A.C.; Teixeira, G.C.M.; Oliveira, K.S.; Rocha, A. M.S.; de Mello Prado, R. & Caione, G. 2020. Silicon contribution via nutrient solution in forage plants to mitigate nitrogen, potassium, calcium, magnesium, and sulfur deficiency. Journal of Soil Science and Plant Nutrition 20(3): 1532-1548.

Dana, E.; Taha, A. & Afkar, E. 2018. Green synthesis of iron nanoparticles by *Acacia nilotica* L. pods extract and its catalytic, adsorption, and antibacterial activities. Applied Sciences 8: 192.

Davies, D.H. 1965. *Analysis of Carotenoid Pigments*. In: T.W. Goodwin (ed). Academic Press, London. pp: 489-532.

Olegovich Bokov, D.; Jalil, A.T.; Alsultany, F.H.; Mahmoud, M.Z.; Suksatan, W.; Chupradit, S. & Delir Kheirollahi Nezhad, P. 2022. Ir-decorated gallium nitride nanotubes as a chemical sensor for recognition of mesalamine drug: a DFT study. Molecular Simulation 1-10.

Gashaw, B. 2021. Evaluation of Different Rates of NPS on Growth and Yield Performances of Garlic (*Allium sativum* L.) in Cheha District, Gurage Zone, Ethiopia. International Journal of Agronomy 2021.

Huldani, H.; Jasim, S.A.; Bokov, D.O.; Abdelbasset, W.K.; Shalaby, M.N.; Thangavelu, L. & Qasim, M.T. 2022. Application of extracellular vesicles derived from mesenchymal stem cells as potential therapeutic tools in autoimmune and rheumatic diseases. International Immunopharmacology 106: 108634.

Jasim, A.H. & Obaid, A.S. 2018. Effect of foliar fertilizers spray, boron and its interaction on dry seeds yield of broad bean (*Vicia faba* L.) and some of its specific characteristics. 2nd conference of Babylon and Razi

University, 2013, Kermanshah, Iran.

Koca, I. & Tasci, B. 2016. Mineral composition of leek. In A.F. Gokce (Ed.), Acta Horticulturae № 1143, VII International Symposium on Edible Alliaceae. Nigde: International Society for Horticultural Science. pp: 147-152

Kumar, P.; Lai, L.; Battaglia, M.L.; Kumar, S.; Owens, V.; Fike, J.; Galbraith, J.; Hong, C.O.; Farris, R. & Crawford, R. 2019. Impacts of nitrogen fertilization rate and landscape position on select soil properties in switch grass field at four sites in the USA. Catena 20 180: 183-193.

McKee, G.W. 1964. A coefficient for computing leaf area in hybrid corn. Agronomy Journal 56(2): 240-241.

Morteza, E.; Moaveni, P.; Farahani, H.A. & Kiyani, M. 2013. Study of photosynthetic pigments changes of maize (*Zea mays* L.) under nano micro nutrients spraying at various growth stages. Springer Plus 2: 247-249.

Najafi, S.; Razavi, S.M.; Khoshkam, M. & Asadi, A. 2020. Effects of green synthesis of sulfur nanoparticles from *Cinnamomum zeylanicum* barks on physiological and biochemical factors of Lettuce (*Lactuca sativa* L.). Physiology and Molecular Biology of Plants 26(5): 1055-1066.

Narayan, O.P.; Kumar, P.; Yadav, B.; Dua, M. & Johri, A.K. 2022. Sulfur nutrition and its role in plant growth and development. Plant Signaling and Behavior 2030082.

Nehdi, I.A.; Sbihi, H.M.; Tan, C.P.; Al-Resayes, S.I.; Rashid, U.; Al-Misned, F.A. & El-Serehy, H.A. 2020. Chemical Composition, Oxidative Stability, and Antioxidant Activity of *Allium ampeloprasum* L. (Wild Leek) Seed Oil. Journal of Oleo Science ess19298.

Przygocka-Cyna, K.; Barłóg, P.; Grzebisz, W. & Spiżewski, T. 2020. Onion (*Allium cepa* L.) yield and growth dynamics response to in-season patterns of nitrogen and sulfur uptake. Agronomy 10(8): 1146.

Rawat, M.; Nayan, R.; Negi, B.; Zaidi, M.G.H. & Arora, S. 2017. Physio-biochemical basis of iron-sulfide nanoparticle induced growth and seed yield enhancement in *B. juncea.* Plant Physiology and Biochemistry 118: 274-284.

Shelke, P.A.; Rafiq, S.M.; Bhavesh, C.; Rafiq, S.I.; Swapnil, P. & Mushtaq, R. 2020. Leek (*Allium ampeloprasum* L.). In: *Antioxidants in Vegetables and Nuts-Properties and Health Benefits*. Springer, Singapore. pp: 309-331.

Solanki, S.S.; Chaurasiya, A.; Mudgal, A.; Mishra, A. & Singh, A.K. 2020. Effect of soil application of sulphur, farm yard manure and vermicompost on soil fertility, growth and yield of garlic (*Allium sativum* L.). International Journal of Chemical Studies 8(1): 1370-1373.

Taiz, L. & Zeiger, E. 2002. Photosynthesis: physiological and ecological considerations. Plant Physiology 9: 172-174.

Tiwari, D.K.; Dasgupta-Schubert, N.; Villaseor-Cendejas, L.M.; Villegas, J.; Carreto-Montoya, L. & Borjas-Garca, S.E. 2014. Interfacing carbon nanotubes (CNT) with plants: Enhancement of growth, water and ionic nutrient uptake in maize (*Zea mays*) and implications for nanoagriculture. Applied Nanoscience 4: 577-591.

Zainab I.M. & Maytham T.Q. 2021. Hormonal profile of men during infertility. Biochemical and Cellular Archives 21: 2895-2898.