

## Response of Barley Crop Growth to Concentrations and Number of Sprays of NPK Nano-Compound Fertilizer

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### ARTICLE INFO

**Received:** November 1, 2022

**Accepted:** December 6, 2022

**Volume:** 2

**Issue:** 4

### KEYWORDS

Nano-Fertilizer, growth indicators, Barley, NPK

### ABSTRACT

This study was conducted in Al-Alam district - Tikrit during the agricultural season 2021-2022, to study the efficiency of spraying Nano-fertilizers on the growth indicators of barley plants grown in plastic pots. In this study, the NPK fertilizer was used after converting it into nanoparticles. Statistical analysis was conducted at ( $P \leq 0.05$ ) and the results were as follows: The interaction between the different concentrations of NPK fertilizer in Nano form and the number of sprays during the growing season significantly affected the vegetative traits, as the interaction between the concentration 2gm/L and spraying twice during the growing season gave the highest plant height, root length, shoot weight, root weight, number of leaves/plant, and the highest leaf area/plant were (84.58 cm, 55.0 cm, 1.18 gm, 1.71 gm and 56.88 cm<sup>2</sup>), respectively. The interaction between the concentrations of Nano-fertilizer and the number of applications had a significant effect on the plant content of chlorophyll in its three types, as the concentration of 2 gm/L and spraying twice gave the highest content of chlorophyll a, b and total chlorophyll reached (94.74, 68.18 and 168.88)  $\mu\text{gm/gm}$  weight. Straight leaves.

### 1. Introduction

Barley, *Hordeum vulgare* L., is one of the oldest cultivated grains, and to date it is one of the most widespread cereal crops, crop yield and quality are of great importance to farmers due to current consumer interest in nutrition and health, improving the quality and quantity of barley may help restore the status of barley in the human diet system (Janmohammadi et al., 2016). Barley is one of the most drought-tolerant small grains and is a major crop in Mediterranean countries (Forster et al., 2004). It has a high nutritional value, as it can be used with wheat in the baking industry, and globally barley ranks fourth in grain crops after wheat, rice and maize (Verma et al., 2021). The area cultivated with barley in Iraq during the year 2020 amounted to approximately 4.528 million dunums, and the productivity reached about 1.756 million tons, with an average yield of 387.8 kg/ dunum (Central Statistical Organization, 2021).

Population growth led to an increase in the demand for food resources, which prompted agricultural development to be more economical and efficient, as well as modern trends in environmental safety from pollution, through finding modern technologies to reduce the excessive use of chemical fertilizers, reduce nutrient losses in fertilization and increase yield (Ram et al., 2017). Sustainable agriculture focused on reducing the use of common chemical fertilizers, and adopting new fertilizers that do not have a negative impact on the environment and human health (Parizad et al., 2017).

Nanotechnology is one of the important solutions proposed to increase agricultural production, and more food can be produced at lower costs while reducing energy consumption and environmental pollution (AL-Ramadi et al., 2016). Nanotechnology offers a wide scope for new applications in biotechnology, agriculture, and the fertilizer industry. Nanoparticles possess special physical and chemical properties due to their high surface area, alternative natural resources can be used to make Nano fertilizers to reduce environmental pollution and provide safety and health for humans, as well as reduced economic costs from using chemical fertilizers. (Mahmoud et al., 2017).

Nano-fertilizers are a new generation of synthetic fertilizers that contain readily available nutrients in the nanoscale. Nano-fertilizers are highly preferred due to their efficiency and environmental friendliness compared to conventional chemical fertilizers (Janmohammadi et al., 2016). Nanotechnology-based fertilizers can be more soluble or more reactive than their

conventional counterparts (Rameshaiah and Jpallavi, 2015). The use of Nano fertilizers may improve the solubility and dispersion of insoluble nutrients in soil, reduce soil nutrient fixation and increase bioavailability (Naderi and Danesh-Shahraki, 2013). Nano-synthesized fertilizers can be easily absorbed by plants and may exhibit a long effective duration of nutrient supply in the soil or plant (Rameshaiah and Jpallavi, 2015). The current study aims to evaluate the response of the vegetative growth characteristics of barley grown in pots to different concentrations and the number of sprays of NPK

## 2. Methodology

The study was conducted in the Biology Department Laboratories/ College of Education for Women/ Tikrit University, with the aim of studying the effect of Nano fertilizer in the traits of the yield component and seed content of elements and basic chemical compounds of the barley plant H. Volger. In the study, the certified variety (Hadhur), a local black barley, was obtained from the Agricultural Research Department of the Ministry of Agriculture in Baghdad. The soil brought from the Al-Aali area to the Al-Alam District/ Salah Al-Din Governorate, at a depth of 0-30 cm, and dried up and blessed and spared the sieve of diameter its holes are 2 mm.

Preparing pots and planting seeds: 18-liter water bottles with a diameter of 24 cm were reused as plastic pots that hold 17 kg of soil, filled with previously prepared soil, and the seeds of local black barley (Hadhur) were sown on 5/11/2021, as ten seeds were sown in per pot, and the germination rate reached 98%. The dilution was made to five plants per pot, 20 days after planting, in order to give suitable conditions for the plants. Crop service operations were carried out, including irrigation and pest control, as needed. The plants were harvested on 26/4/2022 after reaching the stage Full maturity.

Preparation of Nano-fertilizer: The balanced NPK fertilizer was brought in at a concentration of 20-20-20 from the Agricultural Office in Al-Alam district, and it was ground and sifted with a Nano-sieve in the laboratory of the Biology Department/ College of Education for Women, and the fertilizer was dissolved according to the required concentrations, where 2 gm of fertilizer was dissolved powder and sieved in 1 liter of water to obtain a high concentration of 2 gm / liter, and by diluting it, other concentrations were prepared.

Studied treatments: The study treatments included three concentrations of NPK Nano fertilizer: (0.5, 1, and 2 gm/L) at two levels. The first level included spraying the plants with the three concentrations only once after 50 days of planting on 12/25/2021, and this level was divided into Two groups for each concentration, where the plants of the first group were taken after the completion of the vegetative growth stage and before the stage of expelling the spikes, and measurements of vegetative traits were carried out on them, and the second group was left until the complete growth of the plants was completed. While the second level included spraying the plants with the three concentrations twice, the first spray after 50 days of planting on 12/25/2021, and the second spray after 85 days of planting on 1/2/2022, in addition to the comparison treatment (without spraying), which was divided into two groups. The first was harvested after the completion of the vegetative growth stage, and the second was left until the end. Table (1) shows the treatments used in the study.

Table (1): Treatments used in the study.

No.	Treatments
1	without spraying
2	Spraying once at a conc. of 0.5 gm after 50 days of planting
3	Spraying once at a conc. of 1 gm after 50 days of planting
4	Spraying once at a conc. of 2 gm after 50 days of planting
5	Spray twice at a concentration of 0.5 gm
6	Spray twice at a concentration of 1 gm
7	Spray twice at a concentration of 2 gm

Experimental design: Two experiments were carried out according to The Randomized Complete Block Design (RCBD), where the first experiment was simple and included the first four treatments from Table (1), whose plants were harvested at the end of the vegetative growth stage. While the second experiment was factorial, it included two factors, the first was the number of sprays and the second was the concentration of fertilizer, and it included all the seven treatments shown in Table (1), in which plants were left until the completion of their life cycle completely, and the treatments were distributed on pots by three replications for each treatment.

The studied characteristics: The five plants were taken from each experimental unit, and the following growth characteristics were measured:

1- Plant height (cm): according to the height of the plant from its connection with the ground up to its highest point using a ruler.

2- The length of the root system (cm): taken using a ruler.

3- The wet weight of the vegetative and root system (gm): - Taking the wet weight of the vegetative and root groups separately, by weighing them immediately after removing the plant from the soil and cleaning it from dust.

4- The dry weight of the shoot and root system (gm): The plants were dried for each treatment using an oven at a temperature of 75 °C for 48 hours, then the final weight was taken after drying for each of the shoot and root system of the plant using a sensitive scale.

5- The number of leaves.

6- The leaf area of the whole plant (cm<sup>2</sup>): The leaf area was estimated as described by Shaheen (1987) using the following equation:

$$\text{Leaf area (cm}^2\text{)} = \text{total weight of the paper} \times \frac{\text{area of the small section of the paper}}{\text{Small section weight}}$$

After finding the area of one leaf, the total leaf area of the plant was calculated using the following equation:

$$\text{Total leaf area / plant} = \text{number of leaves per plant} \times \text{area of one leaf (cm}^2\text{)}$$

7- Chlorophyll content ( $\mu\text{gm/ gm fresh weight}$ ): Determination of chlorophyll in the leaf tissues of plants according to the method described by (Arnon, 1949).

Statistical analysis: After collecting data on the studied traits, it was entered into the computer and organized using the Microsoft Office Excel program, then it was analyzed statistically and the different averages were compared using the Statistical Analysis System (SAS) according to the experimental design used as explained by Al-Zubaidi and Al-Jubouri (2016).

### 3. Results and Discussion

1- Plant height (cm): Table (2) shows that the plant height characteristic increased significantly with the increase in the concentration of NPK compared to the control treatment, except for the concentration of 0.5 gm/L in the vegetative growth stage, as it did not differ significantly from the control treatment according to the Duncan test results, at a probability level of 5%, while the concentration of 2 gm/ L achieved the highest mean of 44.33 cm, without a significant difference from the other concentrations. As for the full growth stage, we note with regard to the average concentrations, the significant effect of increasing the concentration, as the concentration exceeded 2 gm/ L in achieving the highest significant plant height of 78.81 cm, compared to the lowest plant height of 63.15 cm at a concentration of 0.5 gm/ L. The number of sprays also had a significant effect on the plant height, by recording the highest rate of height when spraying twice, which reached 77.29 cm compared to spraying once, which reached 64.92 cm. For the interaction between the concentrations and the number of sprays, the plant height increased significantly for all interactions by increasing the concentration and spraying compared to the control treatment, as the interaction of the concentration of 2 gm/ L with spraying twice achieved the highest significant plant height of 84.58 cm, an increase of 38.84% compared to the control treatment, which recorded 51.73 cm.

Table 2: Mean effect of concentrations and number of sprays with NPK Nano fertilizer on plant height (cm).

The growth stages and sprays Concentration (gm/L)	The vegetative growth stage	The full growth stage		Mean of Concentration
		One spray	Two sprays	
Control	39.17 b	51.73 g		
0.5	42 ab	57.82 f	68.47 d	63.15 c
1	42.67 a	63.90 e	78.81 b	71.35 b
2	44.33 a	73.03 c	84.58 a	78.81 a
Mean of spraying	-	64.92 b	77.29 a	

Means with the same letter are not significantly different.

2- Root system length (cm): Table (3) shows that the characteristic of root system length during the vegetative growth stage increased significantly with the increase in fertilizer concentration compared to the control treatment, except for the concentration of 0.5 gm/L in the vegetative growth stage, which did not differ significantly from the control treatment, at a probability level of 5%, while the concentration of 2 gm/L achieved the highest significant mean, which reached 72.3 cm.

As for the full growth stage, we note with regard to the average concentrations, the significant effect of increasing the concentration in the size of the root system, as the concentration exceeded 2 gm / L in achieving the highest length of the root system of 53.67 cm compared to the lowest length of 41.84 cm at a concentration of 0.5 gm/ L. The number of sprays also had a significant effect on the plant height, by recording the highest average root length when sprayed twice, which reached 51.56 cm, compared to a single spray, which reached 43.89 cm. For the interaction between the concentrations and the number of sprays, the length of the root system increased significantly for all interactions by increasing the concentration and spraying compared to the control treatment, as the interaction of concentration 2 gm/ L with spraying twice achieved the highest average length of the root system reached 55.00 cm, an increase of 39.4% compared to the control treatment, which recorded 33.33 cm.

Table 3: Mean effect of concentrations and number of sprays with NPK Nano fertilizer on root system length (cm).

The growth stages and sprays Concentration (gm/L)	The vegetative growth stage	The full growth stage		Mean of Concentration
		One spray	Two sprays	
Control	42.97 c	33.33 d		
0.5	53.77 bc	37.67 cd	46.00 b	41.84 b
1	61.2 ab	41.67 bc	53.67 a	47.67 a
2	72.3 a	52.33 a	55.00 a	53.67 a
Mean of spraying	-	43.89 b	51.56 a	

Means with the same letter are not significantly different.

3- The dry weight of the shoot (gm): The results of the effect of foliar spraying with NPK Nano-fertilizer and the number of times of spraying on the weight of the shoot during the two stages of vegetative growth and full growth appear in Table (4), which showed a significant response by increasing the fertilizer concentration compared to the control treatment, except for the concentration of 0.5 gm/L in the vegetative growth stage, as it did not differ significantly from the control treatment, while the concentration of 2 gm/L achieved the highest mean of 0.12 gm.

As for the full growth stage, we notice with regard to the average concentrations that there is a significant response with an increase in concentration, as the concentration exceeded 2 gm/ L in achieving the highest dry weight of the shoot amounted to 1.07 gm, compared to the lowest weight of 0.87 gm at a concentration of 0.5 gm/ L. The number of sprays also had a significant effect on the weight of the vegetative, by recording the highest weight when sprayed twice, which amounted to 1.035 gm, compared to a single spraying of 0.88 gm. For the interaction between the concentrations and the number of sprays, the dry weight of the shoots increased significantly for all the interactions with the increase in concentration and spraying, compared to the control treatment.

Table (4): The average effect of concentrations and the number of sprays with NPK Nano fertilizer on the dry weight of shoots (gm).

The growth stages and sprays Concentration (gm/L)	The vegetative growth stage	The full growth stage		Mean of Concentration
		One spray	Two sprays	
Control	0.06 b	0.66 c		
0.5	0.07 b	0.83 bc	0.91 b	0.87 b
1	0.09 ab	0.86 bc	1.015 ab	0.94 ab
2	0.12 a	0.96 ab	1.18 a	1.07 a
Mean of spraying	-	0.88 b	1.035 a	

Means with the same letter are not significantly different.

4- Dry weight of the root system (gm): Table (5) shows the significant response to the weight of the root system in the vegetative growth stage with an increase in the concentration of NPK compared to the control treatment, except for the concentration of 0.5 gm/ L, as it did not differ significantly from the control treatment according to results of the averages test are at a probability level of 5%, while the concentration of 2 gm/ L achieved the highest mean of 0.36 g without significant difference from the concentration of 1 gm/ L.

In the stage of full growth, with regard to the average concentrations, there was a significant effect of increasing the concentration, as the concentration exceeded 2 gm/ L in achieving the highest significant root weight of 1.37 gm, compared to the lowest root weight of 0.65 gm at a concentration of 0.5 gm/ L. The number of sprays also had a significant effect on the plant height, by recording the highest rate of height when spraying twice, which amounted to 1.28 gm, compared to spraying once, which amounted to 0.68 gm. For the interaction between the concentrations and the number of sprays, the weight of the roots increased significantly for all the interactions by increasing the concentration and spraying compared to the control treatment, as the interaction of the concentration of 2 gm/ L with spraying twice achieved the highest weight of the root total, which reached 1.71 gm, an increase of 87.72% compared to the control treatment, which recorded 0.21 gm.

Table 5: Mean effect of concentrations and number of sprays with NPK Nano fertilizer on root dry weight (gm).

The growth stages and sprays Concentration (gm/L)	The vegetative growth stage	The full growth stage		Mean of Concentration
		One spray	Two sprays	
Control	0.16 b	0.21 d		
0.5	0.21 b	0.38 d	0.91 bc	0.65 c
1	0.30 a	0.63 cd	1.22 b	0.93 b
2	0.36 a	1.02 bc	1.71 a	1.37 a
Mean of spraying	-	0.68 b	1.28 a	

Means with the same letter are not significantly different.

5- Number of leaves per plant: Table (6) shows that the characteristic of the number of leaves per plant increased significantly with the increase in the concentration of Nano fertilizer compared to the control treatment, except for the concentration of 0.5 gm/ L in the vegetative growth stage, as it did not differ significantly from the control treatment according to the results of the Duncan test at the level of Probability 5%, while the concentration of 2 gm/ L achieved the highest mean of 14 leaf/ plant.

In the full growth stage, the concentrations effect rates showed a significant increase in the number of leaves of the plant with an increase in the concentration of NPK, as the concentration exceeded 2 gm/ L in achieving the highest number of leaves, which reached 5.17 leaves, compared to the lowest number of leaves, which reached 4.50 leaves at a concentration of 0.5 gm/ L. The number of sprays also affected significantly the number of leaves of the plant by recording the highest rate when spraying twice, which reached 5 leaves, compared to spraying once, which amounted to 4.55 leaves. For the interaction between the concentrations and the number of sprays, the plant height increased significantly for all the interactions by increasing the concentration and spraying compared to the control treatment, as the interaction of the concentration 2 gm/ L with spraying twice achieved the highest number of leaves in the plant significantly, reaching 5.33 leaves, an increase of 24.95% compared to the control treatment, which recorded 4 leaves.

Table (6): Mean effect of concentrations and number of sprays with NPK Nano fertilizer on the number of leaves per plant.

The growth stages and sprays Concentration (gm/L)	The vegetative growth stage	The full growth stage		Mean of Concentration
		One spray	Two sprays	
Control	6.33 b	4.00 c		
0.5	8 b	4.33 bc	4.67 b	4.50 b
1	10 ab	4.33 bc	5.00 ab	4.67 ab
2	14 a	5.00 ab	5.33 a	5.17 a
Mean of spraying	-	4.55 b	5.00 a	

Means with the same letter are not significantly different.

6- Plant leaf area (cm<sup>2</sup>): Table (7) shows the results of the effect of the concentration and the number of spraying times with NPK on the leaf area of barley plant, which increased significantly with the increase in fertilizer concentration compared to the control treatment, except for the concentration of 0.5 gm/ L in the vegetative growth stage, as it did not differ significantly from the control treatment at the level of probability 5%, while the concentration of 2 gm/ L achieved the highest significant mean, which reached 73.65 cm<sup>2</sup>.

During the full growth stage, the concentration rates showed a significant effect by increasing the concentration of Nano-fertilizer, as the concentration exceeded 2 gm/ L in achieving the highest leaf area of the plant significantly amounted to 49.91 cm<sup>2</sup> compared to the lowest leaf area of 29.46 cm<sup>2</sup> at a concentration of 0.5 gm/ L. The number of sprays also affected significantly in the leaf area of the plant by recording the highest rate when spraying twice, which amounted to 46.99 cm<sup>2</sup> compared to spraying once, which amounted to 32.24 cm<sup>2</sup>. For the interaction between the concentrations and the number of sprays, the leaf area increased significantly in most of the interactions by increasing the concentration and spraying compared to the control treatment, except for the interactions of concentrations of 0.5 and 1 gm/ L with spraying once, as the interaction concentration of 2 gm/L with spraying twice achieved a significantly higher leaf area of 56.88 cm<sup>2</sup>, with an increase of 49.1% compared to the control treatment, which recorded 23.39 cm<sup>2</sup>.

Table (7): Mean effect of concentrations and number of sprays with NPK Nano fertilizer on leaf area (cm<sup>2</sup>) of plants.

The growth stages and sprays Concentration (gm/L)	The vegetative growth stage	The full growth stage		Mean of Concentration
		One spray	Two sprays	
Control	28.03 c	23.39 d		
0.5	34.99 c	24.92 cd	33.99 c	29.46 c
1	54.07 b	28.88 cd	50.09 ab	39.48 b
2	73.65 a	42.93 b	56.88 a	49.91 a
Mean of spraying	-	32.24 b	46.99 a	

Means with the same letter are not significantly different.

7- Chlorophyll concentration (µgm/ 100 gm fresh weight): Table (9) shows the average effect of NPK Nano fertilizer concentration on the plant content of chlorophyll a and b and total chlorophyll a+b in the vegetative growth stage, which showed the response of the three types of chlorophyll and a significant increase in its levels, by increasing the concentration of fertilizer compared to the control treatment, except for the concentration of 0.5 gm/L, which did not differ significantly from the control treatment according to the results of the Duncan test at the level of probability of 5%, while the concentration of 2 gm/L achieved the highest significant mean, which amounted to 95.74, 68.14, and 163.88 µgm/ gm fresh weight.

Table 8: Mean effect of concentrations of NPK Nano fertilizer on the characteristic of chlorophyll content (µgm/ gm fresh weight).

Concentrations of fertilizer (gm/ L)	Chlorophyll content (µgm/ gm fresh weight)		
	a	b	a+b
Control	68.17 c	27.15 c	95.32 c
0.5	68.97 c	28.49 c	97.46 c
1	73.46 b	35.13 b	108.59 b
2	95.74 a	68.14 a	163.88 a

Means with the same letter are not significantly different.

The results of tables (2-8) showed the superiority of the high concentration of NPK Nano fertilizer and two sprayings, and the interaction between them, in raising the averages of all the studied growth characteristics, foliar spraying of NPK Nano fertilizer increased plant height, root length, dry weight of vegetative, root system, number of leaves and leaf area, and this agrees with Abdel-Aziz et al. (2018) who found that NPK increased leaf growth in wheat, which was It can be obtained by increasing the availability of nutrients through the easy penetration of NPK through leaf stomata. This response may be attributed to the fact that the treatment with Nano fertilizer led to cell wall metabolism, expansion, division, development and plant growth (Jassim, 2014). The reason for the superiority of the spraying treatment at 2 gm/ L and the frequency of spraying is that the addition of Nano-fertilizer as a spray on the vegetative system has contributed to providing it in sufficient quantities as a result of its absorption by the stomata, its translocation through the cell membranes and its rapid assimilation, which contributed to the formation and division of cells (Eleyan et al., 2018; Al-Shammari, 2021). Muhammad (2021) stated that the characteristic of plant height was more responsive to spraying with NPK Nano fertilizer, and this may have achieved a state of balance by providing amounts of nitrogen, phosphorus and potassium commensurate with the needs of plants at the stage of cell growth and elongation.

The increase in leafy area is attributed to the fact that fertilizers made with nanotechnology increase the effectiveness of the photosynthesis process, regulate oxidative metabolism, and improve the water system in the vegetative growth stage, which is reflected in plant growth and development, and this is positively reflected in the leafy area of the plant (Al-Mousawi, 2020; Al-Shammari, 2021). The interaction between the concentration and the number of times of spraying had a positive role for Nano fertilizer in increasing the efficiency of the photosynthesis process and regulating the transfer of its products to areas of need in the plant with high efficiency, which led to an increase in its leaf area (Burhan and Ahmed, 2019). While the increase in the concentration of chlorophyll in its three types is due to the increase in the absorption of nutrients, especially nitrogen, which has a role in increasing the rates of carbon fixation, thus increasing the ability of the plant to supply the carbon structures required for the life structure with the chlorophyll molecule (Rezaei and Abbasi, 2014). As the foliar spraying of the main nutrients, especially nitrogen, which is one of the components of the porphyrin ring, which is one of the main components of the green pigment molecule in plants (Al-Obaidi, 2021). The NPK compound fertilizer also has a positive effect in filling the plant's need for the major mineral elements necessary for photosynthesis, respiration and metabolic processes that increase absorption by the plant, which has a major role in the process of cell division and elongation, and then increasing the size of the roots, which contributes to the absorption efficiency. Nutrients that increase shoot growth (Taiz and Zaiger, 2010).

The increase in the leaf area shown in Table (7) is a response to the positive effect resulting from the addition of Nano-fertilizer and the frequency of spraying in improving the level of vegetative growth of the plant, due to the role of the constituent elements of the fertilizer in a number of different metabolic processes, stimulating growth and encouraging cell walls to grow and elongate, as nitrogen promotes plant growth, which leads to a rise in CO<sub>2</sub> due to increased carbon uptake by increasing leaf area (Kumar, 2011). Also, the use of phosphorus at the required level has led to an increase in the effective area of the leaves, which has led to the enhancement of nutrient fixation and thus the effect on increasing the total area of the leaf, the reason for the increase in the leaf area may also be due to the role of potassium in increasing absorption and raising bloating pressure, which increases the absorption of water and nutrients, which leads to an increase in leaf area (Kumar et al., 2014).

The effect of NPK Nano fertilizer and its repeated spraying positively on increasing the rate of photosynthesis through its ability to transfer nutrients and its ease of movement and penetration of large groups of nutrients that can be absorbed by the roots and that penetrate into the plant, as the benefit of using these fertilizers is their effective effect in enhancing Efficiency of nutrients and preventing their loss from the soil by volatilization and leaching and their lack of readiness for sedimentation because their solubility is according to the plant's needs, preventing the loss of nutrients from the soil and increasing the activity of some microorganisms in the soil (DeRosa et al., 2010).

The increase in the concentration of chlorophyll may be attributed to the synergistic effect of nitrogen and phosphorus in the biosynthetic processes and the formation of the pyruvate unit that participates in building the chlorophyll molecule. Nitrogen is one of the essential nutrients in increasing photosynthesis, and it is an important essential part of the enzymes and amino acids that form the protein system, the foliar spraying of nitrogen-containing fertilizer increases the efficiency of the photosynthesis process, and thus increases the accumulation of carbohydrates in the plant. Phosphorus plays an important role in building amino acids, chloroplasts, and proteins, or this may be attributed to the role of potassium, which contributes to the activation of a number of enzymes responsible for the synthesis of chlorophyll, which helps in the formation of chloroplasts and its role in activating enzymes responsible for the manufacture of carbohydrates and energy, which leads to an improvement in The nutritional status of the plant, as potassium is known for its high ability to open and close stomata, which leads to an increase in the efficiency of photosynthesis, cell division, leaf growth and encouragement of vegetative growth, thus increasing some chemical characteristics such as carbohydrates and chlorophyll in the plant (Muhammad, 2021).

## 5. Conclusion

We conclude from the foregoing that there are differences between the concentrations of NPK Nano fertilizer used during the vegetative growth phase for the growth characteristics of the vegetative and root system, and the results also showed a clear response to increasing the concentration of NPK Nano fertilizer in improving all the studied traits, as the repetition of spraying with Nano fertilizer improved the rates of all the studied traits, and the interaction between high concentrations of Nano-fertilizer and frequency of spraying enhanced vegetative growth. Thus, this study recommends the use of NPK Nano fertilizer at a concentration of 2 gm/L, and the application of the process of spraying fertilizer in two full batches, and the use of higher concentrations of Nano fertilizer NPK to learn more about the role of this fertilizer in raising the performance of the studied characteristics, and expanding the use of other types of Nano fertilizers, and conducting studies using other characteristics and criteria and tracking the physiological effects of these fertilizers.

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