University of Thi-Qar Journal of agricultural research

Thi-Qar Journal of agricultural research

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 13, Issue 2 (2024) PP 135-142

https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v13i1.323*

The physiological relationship between the Nano-organic fertilizer Optimus plus and growth and yield of wheat (Ibaa 99)

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Abstract

To face the challenges of wheat crop production using modern technologies and to raise the rate of the production unit produced by using nanoparticles (Optimus plus fertilizer), know the focus, and choose its best spray date, which can improve the growth and total yield, a potting experiment was carried out during the agricultural season 2023-2024 using design RCBD by three replications. The amounts of nano-organic fertilizer were one of the primary factors (C) (1 (C1), 2 (C2), 3 (C3)) ml. L^{-1}, while The application of the nano-organic fertilizer was the second component (S) at the plant growth stages (Seedling (S1), Tillering (S2), Anthesis (S3)). The study's findings demonstrated significant physiological relationship of the amounts (C3) and the spray stage (S2) to wheat's development and yield (Ibaa 99), giving them the highest averages for most of the studied traits. The concentration (C3) supplied the greatest averages (plant height, chlorophyll content, flag leaf area, number of tillers, total grain yield) (104.67cm, 0.7544, 55.99cm^2, 429.0 tiller.m^{-2}, 8.171ton.ha^{-1}) respectively, while concentration (C1) gave the highest average weight of 1000 grains amounting to 45.81 g. Spraying stage (S2) was superior in the studied of the most traits (they were not significantly different from the spraying stage (S3)) (109.00 cm, 0.7656, 59.40 cm^2, 412.0 tiller.m^{-2}, 44.71 - 44.70 g, 7.911 - 7.502 ton.ha^{-1}), respectively, spraying stage (S1) produced the most grains per spike, which didn't much change from the spraying stage (S2) (67.1 - 66.0) grain.$spike^{-1}$. Interaction treatment (C3S2) excelled in giving it the highest average grain yield of 8.847, which was superior to the total grain yield of the study agents individually, which confirms the importance of the physiological relationship of nanoparticles (Optimus plus fertilizer) for the wheat growth and yield.

Keywords: Amino acids, Nano-organic fertilizer, Concentration, Spraying stage

Introduction

Due to its indispensible role in ensuring global food security for all peoples, as well as its ability to balance the essential ratio of proteins to carbohydrates for human needs, wheat is one of the most significant strategic crops on a local and global scale (Al-Mashhadany et al., 2022). Nanoparticles are a modern technology that has been widely used in various sciences, including agriculture, as they can be added to the soil to improve its physical, chemical and biological properties or sprayed on plants to enhance development and yield. Small size, effective surface area, high ability to dissolve, fast penetration into the plant, and ability to reach the region of influence are just a few of the peculiar and unusual characteristics of nanoparticles (Hussein, 2020). Paper feeding is one of the methods of fertilization that is a supplement to ground fertilization and It is one of the most widely used techniques for treating nutritional deficiency, organized and distributed in a homogeneous manner to the vegetative total of the plant, where paper feeding increases the percentage of nutrients inside the plant, especially when there is a rapid and sudden deficiency of these nutrients inside the plant, which reflects positively on the increase in growth indicators and the yield. One of the key elements that improves the effectiveness of using nanoparticles as a paper nutrition is determining the right time to spray them, and it also gives the appropriate opportunity for the plant to absorb the largest possible amount of these nutrients (Hassanein, 2020). There are many challenges facing us, including the increase in demand for

University of Thi-Qar Journal of agricultural research

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this crop due to the population increase in recent years, the decrease in the productivity of the area unit compared to global production, climate changes in addition to the deterioration of the quality of the product due to the lack of use of modern technologies, the service of the crop, soil and dehydration problems (Ministry of Agriculture, 2017). Therefore, the study aims to raise the rate of the production unit produced by using nanoparticles, know the focus and choose its best spray date, which can improve the growth and total yield.

MATERIALS AND METHODS

Study location

To face the challenges of wheat crop production using modern technologies and to raise the rate of the production unit produced by using nanoparticles (Optimus plus fertilizer), know the focus, and choose its best spray date, which can improve the growth and total yield, a potting experiment was carried out during the agricultural season 2023-2024 using design RCBD by three replications.

Study factors

The amounts of nano-organic fertilizer were one of the primary factors (C) (1 (C1), 2 (C2), 3 (C3)) ml. L^{-1}, while The application of the nano-organic fertilizer was the second component (S) at the plant growth stages (Seedling (S1), Tillering (S2), Anthesis (S3)). The Nano-organic fertilizer is a nano-composite manufactured by the Turkish company Izmir, containing 50% organic materials, 28% plant amino acids, 20% organic carbon, and 2% nitrogen. The wheat seeds, Ibaa 99, were planted in the soil of pots with a diameter of 30 cm and a size of 5 kg, with 10 seeds per pot. Fertilizer recommendations for N,P,K were used according to brochures prepared by the Ministry of Agriculture, in three stages (Tillering, Elongation, Booting).

Studied traits

Plant height, chlorophyll content (as determined by Manack et al., 2014) method, flag leaf area, number of tillers, number of grains per spike, weight of 1000 grains, and grain yield were among the characteristics that were examined. The harvesting process took place on April 25, 2024. Data were collected and analyzed according to the chosen design, and the means were compared at the 0.05 probability level by using the Genstat 18 program.

RESULTS AND DISCUSSION

plant height (cm)

Table (1) results show a significant impact on the Optimus plus nano-organic fertilizer concentrations, the spraying stages, and the interaction between them.

The concentration of 3 ml.L^{-1} (C3) gave the highest average plant height of 104.67 cm, which didn't differ significantly from the concentration of 2 ml.L^{-1} (C2), which gave 102.11 cm, compared to the concentration of 1 ml.L^{-1}, which gave the lowest average of 96.67 cm.

This may be due to the nano-organic fertilizer containing organic materials, amino acids, and nitrogen, which led to increasing the plant's vital activities, nutrient absorption, activating cell division, and producing growth hormones that encourage cell division and elongation, thus increasing the plant's height.

Alternatively, this could be explained by the significance of nanoparticles and their particular and unusual behavior and characteristics as a result of their small size and large surface area, which allow

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them to accelerate enzymatic activity and biochemical reactions by increasing the rate of absorption (Al-Yasri et al., 2019). This result agreed with Baqer, (2018).

The nano-organic fertilizer spraying stage (S2) excelled by giving the highest average plant height of 109.00 cm, while the spraying stage (S1) gave the lowest average of 89.22 cm. The superiority of this stage (S2) may be attributed to its coincidence with the progression of cell division and elongation and the increased growth of meristematic tissues, as a result of the availability of nutrients, which led to a clear growth in plant height (Fakhraden et al., 2019).

The C3S2 intervention treatment showed the highest average in plant height, of 111.33 cm, while the C1S1 intervention treatment presented the lowest average, of 85.67 cm. The increase in plant height in the S2 stage is due to the role of fertilizer concentration and increasing the availability of nitrogen, which is important by stimulating and creating auxin, which helps increase cell division and elongation (Fakhraden et al., 2019).

Table 1. The effects of different spraying stages and concentrations of nano-organic fertilizer on plant height (cm)

Concentration	**Spraying stage**			**Mean**
	S1	**S2**	**S3**	
C1	85.67	105.33	99.00	**96.67**
C2	90.33	110.33	105.67	**102.11**
C3	91.67	111.33	111.00	**104.67**
Means	**89.22**	**109.00**	**105.22**	
L.S.D$_{0.05}$	**Concentration**	**Spraying stage**	**Interaction**	
	2.767	**3.001**	**4.796**	

Chlorophyll content

The strong influence of the study parameters and their interactions was demonstrated by the results in Table (2).Concentration (C3) outperformed to assigning the highest average 0.7544, whilst concentration (C1) provided the poorest mean 0.6900. This superiority may be attributed to the increase in the fertilized concentration. Increasing the content of the chlorophyll is linked to the nitrogen freed from the nano-organic fertilizer, when nitrogen enters the process of producing chlorophyll and amino acids, which in turn enter the process of creating green plasids, which increases the chlorophyll content, on the other hand, increasing the concentration of the fertilizer may lead to increased permeability of cell membranes and thus increased absorption of important nutrients in building chlorophyll. This outcome was consistent with Amin et al., (2020).

The spraying stage (S2) provided the highest average of 0.7656, while the spraying stage (S1) provided the lowest average of 0.6767. this may be attributed to the role of the nano-organic fertilizer in effectively growing and matching the growth of the shoots and thus activating carbon metabolism, which is reflected in the increase and activation of chlorophyll. This result was agreed with Al-Fahdawy et al., (2020). C3S2 intervention treatment showed the highest average of 0.7833, while C1S1 intervention treatment showed the lowest average of 0.6400. C3 concentration had a role in encouraging the vegetable tissue containing chlorophyll in the S2 by increasing the optical acting process, which positively reflected the overall chlorophyll content in the plant.

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Table 2. The effects of different spraying stages and concentrations of nano-organic fertilizer on chlorophyll content

Concentration	Spraying stage			Mean
	S1	S2	S3	
C1	0.6400	0.7367	0.6933	**0.6900**
C2	0.6700	0.7767	0.7200	**0.7222**
C3	0.7200	0.7833	0.7600	**0.7544**
Means	**0.6767**	**0.7656**	**0.7244**	
L.S.D$_{0.05}$	**Concentration**	**Spraying stage**	**Interaction**	
	0.028	**0.033**	**0.049**	

Flag leaf area (cm^2)

The findings in Table (3) show that the spraying stages, the concentrations of the nano-organic fertilizer, and their interactions all have a noteworthy effect. The concentration (C3) provided the greatest average of the flag leaf area 55.99 cm^2, that didn't substantially deviate from the concentration (C2), that gave an average 54.51 cm^2 contrasted to the concentration (C1), that produced the lowest average 50.46 cm^2. The ingredients found in nano-organic enrichment (organic, amino and nitrogen acids) caused a rise in the plant's chlorophyll concentration (Table 2), thus increased absorption of nutrients, photosynthesis and the production of structural compounds (proteins, carbohydias, labida) that directly contribute to the growth of the plant in general and the flag leaf area particularly. This outcome was accepted Al-Kishy and Al-Hanidawi, (2020).

The spraying stage (S2) surpassing by providing the greatest average 59.40 cm^2, whilst the spraying stage (S1) provided the poorest mean 49.27 cm^2. Because the fertilizer is a source of nitrogen that the plant needs at all stages of growth, spraying it during the tillering stage greatly increases the area of the flag leaf, especially in the stage of the branches and the formation of the leaves, as well as the role of nitrogen that is important in carrying out many vital and physiological processes such as enlarging and dividing the cells, boosting the rate of photosynthesis efficiency, and absorbing the elements, and the growth of the flag leaf's area so reflects this. This outcome was accepted Al-Mashhadany et al., (2022). Interaction treatment C3S2 was given the greatest mean 62.56 cm^2, whilst C1S1 was given the minimum mean 46.42 cm^2.

Table 3. The effects of different spraying stages and concentrations of nano-organic fertilizer on flag leaf area (cm^2)

Concentration	Spraying stage			Mean
	S1	S2	S3	
C1	46.42	54.85	50.10	**50.46**
C2	50.12	60.80	52.60	**54.51**
C3	51.29	62.56	54.11	**55.99**
Means	**49.27**	**59.40**	**52.27**	
L.S.D$_{0.05}$	**Concentration**	**Spraying stage**	**Interaction**	
	3.963	**4.692**	**6.865**	

Number of tillers (tiller.m^{-2})

The findings presented in Table (4) demonstrated that the study components and their interactions had a noteworthy influence, as the concentration (C3) provided the highest average, which came to 429.0 tiller.m^{-2}, whilst the concentration (C1) provided the least average 335.9 tiller.m^{-2}. The plant absorbed more nutrients when the concentration of the nano-organic fertilizer was increased, which

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reflected positively on the increase in metabolic compounds and thus on the growth of the plant (Tables (1,2,3)) and thus increased the vegetative system and tillers of the plant, or possibly the fertilizer's beneficial effects on maintaining a higher number of tillers produced, which further raised the average number of tillers. The outcomes matched those of Hamedan and Jassim (2021).

Table (4) also makes it evident that the spraying stage (S2) was superior by giving it the greatest mean 412.1 tiller.m^{-2}, whilst the spraying stage (S1) provided the poorest mean 355.8 tiller.m^{-2}. It could be explained by the fact that at this point in time, the fertilizer was being sprayed at the same time as the vegetative system was growing and expanding. This allowed the plant to receive the organic acids, amino acids, and nutrients it needed, which in turn led to improved growth and more tillers on the plant. This outcome was in line with Mekhlif et al., (2020). The interference treatment C3S2 provided the highest average, which came to 477.3 tiller.m^{-2}, whilst the C1S1 provided the least average 320.0 tiller.m^{-2}. This superiority could be linked to the increased readiness and production of substances manufactured and absorbed by the plant during the tillering stage and the development of plant tissues. This outcome was consistent with Al-Mashhadany et al., (2022).

Table 4. The effects of different spraying stages and concentrations of nano-organic fertilizer on the number of sprays (tiller.m^{-2})

Concentration	**Spraying stage**			**Mean**
	S1	**S2**	**S3**	
C1	320.0	346.3	341.3	**335.9**
C2	354.3	412.7	378.7	**381.9**
C3	393.0	477.3	416.7	**429.0**
Means	**355.8**	**412.1**	**378.9**	
L.S.D$_{0.05}$	**Concentration**	**Spraying stage**	**Interaction**	
	20.19	**26.33**	**34.98**	

Number of grains per spike (grain. spike^{-1})

Table (5) indicates that this feature is significantly impacted by the phases at which the nano-organic fertilizer is sprayed as well as by the interaction alone. The spraying stage (S1) provided the greatest average 67.1 grain.spike^{-1}, This was not very different from the spraying stage (S2), that grant 66.0 grain.spike^{-1} compared to the stage (S3), that provided the poorest mean 58.0 grain.spike^{-1}. This could be explained by the function of the nano-organic fertilizer in stimulating physiological processes in the leaflet and tillering stages, which is considered the beginning of the stage of spike formation and development (starters and originators of the total number of spikes), which increases metabolic processes and making materials, The spike's increased grain content is indicative of this. This outcome was accepted. Mekhlif et al., (2020). The two Interaction treatment C1S1, C2S2 provided the greatest average 69.0 grain.spike^{-1}, whilst C1S1 was given the minimum mean 50.0 grain.spike^{-1}. This confirms the importance of spraying nano-organic fertilizers in the initial and middle stages of plant growth.

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Table 5. The effects of different spraying stages and concentrations of nano-organic fertilizer on the number of grains per spike (grain.spike^{-1})

Concentration	Spraying stage			Mean
	S1	S2	S3	
C1	69.0	62.7	50.0	**60.6**
C2	67.0	69.0	58.0	**64.7**
C3	65.3	66.3	66.0	**65.9**
Means	**67.1**	**66.0**	**58.0**	
L.S.D$_{0.05}$	**Concentration**	**Spraying stage**	**Interaction**	
	NS	**6.82**	**9.59**	

Weight of 1000 grains

Table (6) makes it evident that the study parameters and their interactions have a considerable impact, as the concentration (C1) provided the highest average, which came to 45.81 g, whilst the (C3) provided the least average 42.67 g. The explanation could be linked to the plant's physiological ability to transfer the photosynthetic products from the sources to the sinks, as the final weight of the grain depends on the ability of the source to supply the sink with the products of the photosynthesis process during the period of grain filling in the wheat crop, particularly considering that, at concentration (C1), the average number of grains per spike is lower than the average number of grains at all other concentrations, as shown in Table (5).

The spraying stage (S2) excelled by giving the greatest mean 44.71 g, This was not very different from the spraying stage (S3) that gave 44.70 g in contrast to the spraying stage (S1) that provided the poorest mean 42.80 g. The cause of the supremacy of the spraying stage (S2) possibly because of its superiority in vegetative growth characteristics, plant height, chlorophyll content, flag leaf area, and number of tillers, which were reflected in the increase in dry matter production transferred from the source to sink (Tables 1, 2, 3, 4). Treatment of interactions C1S3 provided the highest average, which came to 49.74 g, whilst C3S3 provided the least average 40.25 g. Perhaps the concentration C1 fertilizer was ideal for the efficiency of the construction process and the supply of food reserves, thus increasing its weight during the grain filling stage (Al-Gubori et al., 2020).

Table 6. The effects of different spraying stages and concentrations of nano-organic fertilizer on the weight of 1000 grains (g)

Concentration	Spraying stage			Mean
	S1	S2	S3	
C1	42.03	45.66	49.74	**45.81**
C2	43.21	43.80	44.11	**43.71**
C3	43.15	44.67	40.25	**42.67**
Means	**42.80**	**44.71**	**44.70**	
L.S.D$_{0.05}$	**Concentration**	**Spraying stage**	**Interaction**	
	1.072	**1.201**	**1.857**	

Grain yield

The results are shown in the table (7) the existence of significant impact of the study elements and interact with one another. The concentration (C3) provided the greatest average 8,171 ton.ha^{-1}, This was not very different from (C2), that given 7,904 ton.ha^{-1}. Whilst (C1) provided the least average 5.672 ton.ha^{-1}. The number of tillers and grains (tables 4,5) are two components of the yield that have favorably correlated with the effects of fertilizer on vegetative growth characteristics, which may

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account for the rise in grain production overall. It was decided upon this outcome with Hamedan and Jassim (2021).

The spraying stage (S2) provided the greatest average 7.911 ton.ha^{-1}, This was not very different from the spraying stage (S3), that gave 7.502 ton.ha^{-1} comparison with the spraying stage (S1), that provided the lowest average 6.334 ton.ha^{-1}. It could be related to the fact that spraying the fertilizer at this stage was more appropriate to benefit from, which provided the necessary nutrients and thus increased plant growth in (plant height, leaf area, and chlorophyll), This was represented in the components yields and the grain yield. There was agreement on this outcome with Al-Mashhadany et al. (2022). The interference treatment C3S2 exceeded the greatest mean 8,847 ton.ha^{-1}, whilst C1S1 has provided the lowest average 5.100 ton.ha^{-1}. Nano-organic fertilizer contributed to increasing the absorption of the nutrients that the plant uses, especially in the tillering and this was reflected in the increase in chlorophyll, the acceleration of the photosynthesis process, and the rise in the quantity of dry substance that is reflected in the component yield and increases the total grain yield. This result was agreed with Al-Mashhadany et al., (2022).

Table 7. The impact of concentrations and stages of spraying nano-organic fertilizer on total yield (ton.ha^{-1})

Concentration	**Spraying stage**			**Mean**
	S1	**S2**	**S3**	
C1	5.100	6.197	5.720	**5.672**
C2	6.700	8.690	8.323	**7.904**
C3	7.203	8.847	8.463	**8.171**
Means	**6.334**	**7.911**	**7.502**	
L.S.D$_{0.05}$	**Concentration**	**Spraying stage**	**Interaction**	
	0.514	**0.620**	**0.890**	

CONCLUSION

The three milliliters per liter concentration of the nano-organic fertilizer spraying (C3) in the tillering stage (S2) contributed to the improvement and efficiency of the characteristics of vegetative growth, This was evident in the components yield that was show in the grain yield, and therefore this fertilizer can be used to raise the productivity rate per unit area for the wheat crop.

ACKNOWLEDGEMENT

I would want to express my gratitude to all of you for your support and for providing me with direction and technical help while I conducted my research paper. I hope and pray for everyone's prosperity.

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