Effect of NPK Nanocomposite Fertilizer on Growth and Yield of Two Varieties of Bread Wheat

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Abstract

This study was conducted during the 2024–2025 growing season at Malta location, Dohuk Governorate, northern Iraq, to determine the effect of two bread wheat varieties (Wafia and Tammuz 2) and eight levels of nano-NPK fertilizer (0, 1.0, 1.5, and 2.0 g L^{-1}) on some growth and yield traits. The experiment was arranged as a factorial experiment within a randomized complete block design (RCBD) with three replications. The results indicated that the Tammuz 2 variety was superior in all studied traits except no. grains spike-1, in which the Wafia variety was superior. As for the nano-NPK fertilizer, the 2 g L^{-1} treatment significant effect in all studied traits. The highest values were obtained from Tammuz 2 variety sprayed with 2.0 g L^{-1} nano-NPK fertilizer.

Keywords: Nano fertilizer, Bread wheat, , Yield components,

Introduction

Bread wheat (*Triticum aestivum* L.) is one of the most important cereal crops worldwide and plays a vital role in ensuring food security, particularly in developing countries. In Iraq, wheat cultivation is a strategic component of national agricultural policy, especially in the northern rainfed areas. However, wheat productivity in these regions is still constrained by low soil fertility, inefficient fertilizer management and adverse environmental conditions.

Conventional mineral fertilizers are widely used to supply essential nutrients, yet their efficiency is often limited due to nutrient losses through leaching, volatilization and fixation in the soil. These losses not only reduce fertilizer use efficiency but also increase production costs and environmental pollution. Consequently, modern agricultural research has focused on developing innovative fertilization approaches that enhance nutrient availability and uptake while minimizing losses.

Nanotechnology has recently emerged as a promising tool in sustainable agriculture. Nanocomposite fertilizers are characterized by their small particle size, high reactivity and controlled nutrient release, which allow better

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synchronization between nutrient supply and crop demand (8) and (13). Several studies have demonstrated that nano-NPK fertilizers improve plant growth, photosynthetic activity and yield components in cereal crops by enhancing nutrient absorption and translocation within plant tissues (1).

Varietal differences in response to nano-fertilizers have also been reported, indicating that genetic potential plays an important role in determining the efficiency of nutrient utilization. However, limited information is available regarding the response of bread wheat varieties to nano-NPK fertilizer under the agro-climatic conditions of northern Iraq. Therefore, the present study was conducted to evaluate the effect of different levels of NPK nanocomposite fertilizer on growth and yield of two bread wheat varieties cultivated in Dohuk Governorate.

Materials and Methods

The field experiment was conducted during the 2024–2025 growing season at Malta location, Dohuk Governorate, northern Iraq. Soil samples were collected from the 0–30 cm depth before sowing and analyzed for their chemical and physical properties (Table 1). The rates of rainfall , maximum and minimum temperatures and Relative Humidity were recorded from the Meteorological Department in Dohuk Governorate (Table 2).

The experiment was arranged as a factorial experiment in a randomized complete block design (RCBD) with three replications. The first factor consisted of two bread wheat varieties (Wafia and Tammuz 2), while the second factor included four levels of NPK nanocomposite fertilizer (0, 1.0, 1.5 and 2.0 g L^{-1}).

Nano-fertilizer NPK 20:20:20: a fertilizer with ultra-fine particles that dissolves completely in water and is used to legalize the use of fertilizers figure(1) ,Where was applied as a foliar spray using a hand sprayer at at the tillering stage depending on the instructional leaflets on the envelopes containing nano compound fertilizers issued by the manufacturer, while Control plots were sprayed with distilled water only. Area of plots was 2 m^2 and contained five lines, each line 2 m long, With 20 cm between each line. Added N fertilizer with rate 50 kg dunum-1 (urea 46%N) in two doses, the first at planting and the second after the emergence of shoots. Also, DAP fertilizer (N20 P20) was added at a rate of 50 kg dunum-1 at planting and for all experimental units.

The traits were studied {plant height (cm), spike length (cm) no. spikes (m^2), no. grains spike-1, wt. 1000 grains, biological yield (g m^{-2}) and grain yield (g m^{-2})}.

Statistical analysis: Use randomized complete block design (RCBD) with three replications. The comparison between the averages of the treatments employed the Duncan's multiple range test at the 0.05 probability level.

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Figure(1) : Nano-fertilizer NPK 20:20:20

Table (1) Chemical and physical traits of soil the experiment in Malta Location.

Chemical and physical traits	PH	Ec ($ds.m^{-1}$)	Organic matter ($g.kg^{-1}$)	Available P/mg.kg^{-1}	Available K ($mg.kg^{-1}$)	Available N ($mg.kg^{-1}$)	Clay ($g.kg^{-1}$)	Silt ($g.kg^{-1}$)	Sand ($g.kg^{-1}$)	Texture
	5.5	0.9	1.98	49.6	110.0	54.2	434.7	459.6	106.2	Silty clay

Table (2): Minimum and maximum monthly temperatures (C°), rainfall and relative humidity during season 2024/2025 for Malta site in Dohuk Governorate .

Months	Year	Min. Temperatures(c°)	Max. Temperatures(c°)	Rainfall (mm)	Relative Humidity %
December	**2024**	9	19.5	86	68
January	**2025**	7	17.5	93	70
February		9	19	84	70
March		11	23	86	65
April		14	27	60	60
May		18	31	25	45
Jun		21	34	1	27

*Weather station in Dohuk Governorate

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Results and Discussion

Plant height : Plant height was significantly affected by wheat varieties, nano-NPK fertilizer levels and their interaction (Table 3). Tammuz 2 recorded higher plant height (75.92cm) compared to Wafia (65.20cm), which may be attributed to its superior genetic potential and better nutrient utilization efficiency. This result is in line with (9) and (6). Increasing nano-NPK concentration led to a gradual increase in plant height with the highest value recorded at 2.0 g L^{-1} (73.73cm). This improvement can be attributed to the sustained release of N, P, and K nanoparticles, which enhances cell division, elongation, and photosynthetic activity. These results agree with (1) and (8). Interaction between the varieties and nano-NPK concentration, as Tammuz 2 variety with nano-NPK at a conc. 2.0 g L^{-1} recorded a significant superiority (80.20 cm) , while interaction between variety Wafia and control treatment recorded lowest rate (63.67 cm).

Spike length (cm): Spike length was significantly influenced by genotype, with Tammuz 2 variety producing longer spikes (9.74 cm) than Wafia (8.96 cm), which may be related to genetic differences in assimilate partitioning . This result is consistent with (3) and (4).Increasing nano-NPK levels led to a gradual increase in spike length, reaching the highest mean at 2 g L^{-1} (10.17 cm), while control treatment resulted in lowest mean (8.65 cm). Similar trends were reported by (14) and (12).The interaction revealed that Tammuz 2 supplied with 2 g L^{-1} nano-NPK recorded the maximum spike length (10.73 cm), compared to minimum value observed in Wafia under control treatment (8.23 cm). The enhancement in spike length is associated with improved phosphorus availability, which is critical for reproductive development.

Number of spikes (m^2): Number of spikes per unit area differed significantly between varieties, as Tammuz 2 achieved the highest mean (328.00 spikes m^2), while Wafia recorded a lower value (323.17 spikes m^2). The reason for this may be due to the genetic nature that excelled Tammuz 2 variety compared with wafia variety. This finding is in line with (11).Nano-NPK application increased spike density, with maximum mean observed at 2 g L^{-1} (330.67 spikes m^2) and minimum under control treatment (320.50 spikes m^2). This response is linked to improved tillering resulting from enhanced nitrogen availability in nano-form. These results agree with (13).The interaction showed that Tammuz 2 with 2 g L^{-1} nano-NPK produced highest spike number (333.33 spikes m^2), whereas Wafia under control treatment had lowest value (319.00 spikes m^2).

No. of grains spike^{-1}: Grain number per spike was significantly higher in Wafia (41.88 grain spike^{-1}) compared with Tammuz 2 (40.78 grain spike^{-1}), The superiority of Wafia variety in number of grains in the spike over Tammuz 2 variety is due to its genetic superiority in spike fertility and grain-setting efficiency. This is consistent with (15) and (5). Nano-NPK at 2 g L^{-1} resulted in the highest mean grain number (42.30 grain spike^{-1}), while the control treatment recorded the lowest (40.25 grain spike^{-1}).The superiority of

2 g/L⁻¹ NPK level in increasing number of grains in spike is attributed to enhanced spike fertility and grain-setting efficiency resulting from a balance of three nutrients compared to control treatment. This agreement with (17). The interaction indicated that Wafia treated with 2 g L^{-1} nano-NPK produced the maximum number of grains per spike (42.83 grain $spike^{-1}$), whereas Tammuz 2 under control conditions recorded minimum value (39.70 grain $spike^{-1}$).

1000-grain weight (g): Thousand grain weight significantly increased in Tammuz 2 (33.91 g) than in Wafia (33.59 g), reflecting genotypic differences in grain filling capacity. This is line with (10) and (4) .Nano-NPK significantly increased grain weight, with the highest mean recorded at 1.5–2 g L^{-1} (34.33–34.38 g), compared with control treatment (32.73 g). The improvement in grain weight can be attributed to enhanced potassium availability, which plays a crucial role in assimilate transport during grain filling. The interaction showed that Tammuz 2 combined with 1.5 g L^{-1} nano-NPK produced highest value(34.53g),while Wafia under control treatment had lowest (32.63g).

Biological yield (g m^{-2}) : Biological yield was significantly affected by variety, nano-NPK, and their interaction, where Tammuz 2 variety superiority and achieved highest mean of the trait (1111.67 g m^{-2}) compared with Wafia variety who achieved lowest mean of the trait (1081.25 g m^{-2}) , reflecting its superior vegetative growth and biomass accumulation. This is agreement with (2) and (4) . Increasing nano-NPK levels resulted in an increase significantly in biological yield, with the highest values recorded at 2 g L^{-1} (1150.00 g m^{-2}) and the lowest under control treatment (1059.17 g m^{-2}) This is in agreement with (7) and (8), This response is linked to improved nutrient use efficiency and photosynthetic capacity under nano-fertilization. interaction between Tammuz 2 variety and 2 g L^{-1} nano-NPK achieved the maximum value (1158.33 g m^{-2}), while the minimum value was associated with Wafia variety under control treatment (1050.00 g m^{-2}).

Grain yield (g m^{-2}) : Grain yield was significantly affected by wheat varieties, nano-NPK fertilizer levels, and their interaction. Tammuz 2 recorded a higher mean grain yield (461.83 g m^{-2}) than Wafia (455.03 g m^{-2}).The reason for this is that increase in grain yield in Tammuz 2 variety was due to its superiority in no. spikes (m2) and wt. 1000 grains (Table 5 and 7). The result is consistent with (11) and (4). Nano-NPK fertilizer application markedly improved grain yield, the 2 g L^{-1} level producing the highest mean yield (485.48 g m^{-2}) and control treatment producing the lowest (428.91 g m^{-2}). This increase is attributed to improved nutrient use efficiency, sustained nutrient release, and enhanced photosynthetic activity, which promote grain filling In addition to increase in no. spikes (m^2), no. of grains $spike^{-1}$and wt. 1000 grains (Table 5 ,6 and 7)which is reflected in grain yield .This is line with (16) and (2).Interaction between the varieties and nano-NPK concentration, as Tammuz 2 variety with nano-NPK at a conc. 2.0 g L^{-1} recorded a significant superiority (488.90 g m^{-2}) , while interaction between variety Wafia and control treatment recorded lowest rate (424.97 g m^{-2}).

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Conclusions and Recommendations: Foliar application of NPK nanocomposite fertilizer significantly enhanced growth, yield components and grain yield of bread wheat under the environmental conditions of Dohuk Governorate. The variety Tammuz 2 showed superior performance compared to Wafia. Application of nano-NPK at 2.0 g L^{-1} is recommended to achieve maximum productivity. It is recommended to repeat the study for several seasons and different locations, to study the interaction between variety, season and fertilization level, and to conduct an economic evaluation before recommending a high level of nano-fertilizer.

Table (3): Mean of plant height (cm)wheat affected by varieties and nano NPK fertilizer .

Varieties	Nano- NPK Fertilizer ($g.L^{-1}$)				Mean Varieties
	Control	1	1.5	2	
Wafia	63.67 g	64.27 fg	65.60 f	67.27 e	65.20 b
Tammuz 2	71.93d	74.23 c	77.30 b	80.20 a	75.92 a
Mean Nano- NPK Fertilizer	67.80 d	69.25 c	71.45 b	73.73 a	

Letters variation show significant differences in each column ($p<0.05$).

Table (4): Mean of spike length(cm) wheat affected by varieties and nano NPK fertilizer .

Varieties	Nano- NPK Fertilizer ($g.L^{-1}$)				Mean Varieties
	Control	1	1.5	2	
Wafia	8.23 e	8.90 d	9.10 d	9.60 bc	8.96 b
Tammuz 2	9.07 d	9.40 bc	9.77 b	10.73 a	9.74 a
Mean Nano- NPK Fertilizer	8.65 d	9.15 c	9.43 b	10.17 a	

Letters variation show significant differences in each column ($p<0.05$).

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Table (5): Mean of number of spikes (m^2). wheat affected by varieties and nano NPK fertilizer .

Varieties	Nano- NPK Fertilizer ($g.L^{-1}$)				Mean Varieties
	Control	1	1.5	2	
Wafia	319.00 d	322.33 c	323.33 c	328.00 b	323.17 b
Tammuz 2	323.00 c	328.00 b	328.67 b	333.33 a	328.00 a
Mean Nano- NPK Fertilizer	320.50 c	325.17 b	326.00 b	330.67 a	

Letters variation show significant differences in each column ($p<0.05$).

Table (6): Mean of no. grains $spike^{-1}$ wheat affected by varieties and nano NPK fertilizer .

Varieties	Nano- NPK Fertilizer ($g.L^{-1}$)				Mean Varieties
	Control	1	1.5	2	
Wafia	40.80 de	42.23 b	41.63 c	42.83 a	41.88 a
Tammuz 2	39.70 f	40.60 e	41.07 d	41.77 c	40.78 b
Mean Nano- NPK Fertilizer	40.25 c	41.42 b	41.35 b	42.30 a	

Letters variation show significant differences in each column ($p<0.05$).

Table (7): Mean of wt. 1000 grain (g) wheat affected by varieties and nano NPK fertilizer .

Varieties	Nano- NPK Fertilizer ($g.L^{-1}$)				Mean Varieties
	Control	1	1.5	2	
Wafia	32.63 e	33.30 d	34.13 bc	34.30 ab	33.59 b
Tammuz 2	32.83 e	33.80 c	34.53 a	34.47 ab	33.91 a
Mean Nano- NPK Fertilizer	32.73 c	33.55 b	34.33 a	34.38 a	

Letters variation show significant differences in each column ($p<0.05$).

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Table (8): Mean of biological yield (m^{-2}) wheat affected by varieties and nano NPK fertilizer .

Varieties	Nano- NPK Fertilizer ($g.L^{-1}$)				Mean Varieties
	Control	1	1.5	2	
Wafia	1050.00 c	1080.00 bc	1053.33 c	1141.67 a	1081.25 b
Tammuz 2	1068.33bc	1090.00 b	1130.00 a	1158.33 a	1111.67 a
Mean Nano- NPK Fertilizer	1059.17 c	1085.00 b	1091.67 b	1150.00 a	

Letters variation show significant differences in each column ($p<0.05$).

Table (9): Mean of grain yield ($g\ m^{-2}$) wheat affected by varieties and nano NPK fertilizer .

Varieties	Nano- NPK Fertilizer ($g.L^{-1}$)				Mean Varieties
	Control	1	1.5	2	
Wafia	424.97 e	453.47 d	459.63 c	482.05 a	455.03 b
Tammuz 2	432.85 e	458.22 d	467.33 b	488.90 a	461.83 a
Mean Nano- NPK Fertilizer	428.91 d	455.85 c	463.48 b	485.48 a	

Letters variation show significant differences in each column ($p<0.05$).

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