

Response of some growth indicators of different bread wheat cultivars to spraying with nano-potassium fertilizer

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Astract

A field experiment was conducted in plot numbered 95, plot 2, affiliated to Al-Mahaweel district, north of Babylon, during the seasons 2020-2021 and 2021-2022. In order to know the response of three bread wheat cultivars to the stages and concentrations of nano-spraying potassium. A randomized complete block design (RCBD) was used in a split-split plot with three replicates. As the cultivars (Abu Ghraib, Hawler, Aras) occupied the main plot, and the spraying stages (branching, elongation, inlay) occupied sub plot , while potassium nano fertilizer concentrations (0,1,2 g/L) occupied the sub-sub plot. The results showed the Hawler cultivar excelled in plant height and the content of leaves of chlorophyll for both season of the study, with averages of (80.59 and 81.45) cm and (39.43spad and 41.17spad) respectively, while the Abu Ghraib cultivar recorded the highest values for the harvest index and for both seasons, with averages of (36.45%). and 37.29%, respectively. The treatment of potassium spraying with a concentration of 2 g L⁻¹ was excelled in booting stage and recorded the highest values in the potassium content of the leaves (2.26% and 2.29%) for both seasons, the chlorophyll content of the leaves, plant height and biological yield, and for both season it reached (38.87 spad and 40.40 spad). And (74.54 cm and 76.30 cm) and (40% and 47%) respectively.

Keywords bread wheat, nano potassium , growth indicators, harvest index

introduction

The genotypes have a different nature that makes them appear with a clear difference in traits of their growth and production, and the genetic factor interaction with the environment of the experiment area and thus has a clear influence in drawing the phenotypic and productive traits as well as the influence of the experiment factors that share with them and affect and are affected by them, and therefore they all participate in determining the amount of Traits under study[1]. [2]indicated that there were significant differences in the results of his study, where the cultivar Rashid achieved the highest average plant height of 104.02 cm, without a significant difference from the Babylon 113 cultivar, which averaged 97.7 cm, which in turn did not differ significantly from the Bohuth 22 cultivar, which recorded the lowest average of 91.2, while The cultivar Bohuth 22 recorded the highest values in terms of the number of

tillings for both seasons, as it reached (523.6 and 591.9) tillers.m² [3] concluded in their experiment, which included twelve cultivars of bread wheat, that the Ala cultivar recorded the highest mean leaf area of 50.5 cm² with a significant difference from the other cultivars, while the cultivar Tammuz 22 and the Soleimani 2 cultivar recorded the lowest average of 37.2 cm², and for both cultivars.[4] showed that nanotechnology is one of the modern means to develop crops and increase their growth and production on a large scale, as it is one of the promising applications to improve plant growth and increase production because it works to increase the absorption of water and nutrients and thus improve the quantity and quality of production, and technological applications in the field It contributes to reducing economic costs by increasing the efficiency of fertilizers while reducing the cost of materials.[5] indicated

that spraying nutrients on the leaves is a positive method with micro and macro nutrients, in addition to being economical, easy and fast, and there are no problems in the soil, and a rapid response is achieved in obtaining plants to their nutritional needs during growth. The results of the field study obtained by [6] in Al-Muthanna province on wheat crop showed that spraying nano potassium with a concentration of 8 g.L^{-1} on the vegetative of the plant gave the highest average chlorophyll content in the leaves 194.56 Mg g^{-1} and the highest average plant height 98.24 cm , compared to control treatment, which gave the lowest average of the traits 165.67 Mg g^{-1} and 91.77 cm , respectively. [7] indicated in his study to find out the effect of fragmentation of mineral fertilizers and nano-fertilizers (N,P) on bread wheat plants, and the levels were 120 kg N ha^{-1} and 100 kg P ha^{-1} , and the recommendation for nanofertilizers was $1 \text{ liter N ha}^{-1}$ and 1 kg P ha^{-1} , that the level (0.5 nano + 0.5 mineral) of recommended fertilizer N, P has been excelled in most of traits of vegetative growth and yield. A study was conducted to find out the effect of nano-fertilizers on the vegetative growth and yield traits of wheat crop. Fertilization levels were (N+P+K), (N+K), (P+N), (P+K) and Super Milro nano fertilizer and its control treatment without nano-fertilization. The results showed the excelled of the Nano SMP treatment in most growth and yield traits, followed by the Nano (N+P+K) treatment[9].The results of the field study conducted by Ali and Ahmed (2017) on wheat plants showed that there were significant differences between traits of vegetative growth, as the concentration of 3000 mg kL^{-1} sprayed in two stages (booting and flowering) gave the highest average plant height (71.90 and 79.35 cm).The flag leaf area was (25.60 and 30.30 cm^2), while control treatment gave the lowest mean for the traits (61.14 and 62.02 cm^2 , 21.44 and 24.82 cm^2) for both season, respectively.[10] showed the addition of levels of potassium $0, 120, 180 \text{ kg K ha}^{-1}$ to wheat cultivar Abu Ghraib 3 - the

level of 180 kg K ha^{-1} gave high values for the flag leaf area of 35.90 cm^2 , as well as its chlorophyll content of $51.58 \mu\text{g cm}^2$.The results of the field study conducted by[11] on five wheat cultivars indicated that the cultivars differed significantly in traits of their response to potassium fertilization, as the level 180 kg ha^{-1} gave the highest average plant height of 79.85 cm , the flag leaf area of 40.55 cm^2 , and the chlorophyll content in the leaves. 28.27 spad , and the percentage of potassium in the leaves is 3.58% . While the level of 120 kg K ha^{-1} gave the lowest mean for the mentioned traits.

Materials and methods

A field experiment was carried out to grow wheat (*Triticum aestivum* L.) during the winter season (2020-2021) and repeated in the winter season (2021-2022) in one of the farmers' fields in Al-Imam sub-district in Al-Mahaweel district, north of Babylon, District 95, plot 2, to find out the response of three cultivars of Bread wheat for stages and concentrations of nano potassium in silt loam soil (Table 1).The experiment was conducted according to the split-split plots arrangement, with three replicates. The different treatments were randomly distributed according to the R.C.B.D., the main plots represented the three items (Abu Ghraib, Hawler, Aras) that were obtained. From Al-Muradia Agricultural Research Station dedicated to researching the wheat crop and affiliated to the Directorate of Agriculture of Babylon, located 20 km southwest of the center of Babylon province.The sub-plot represented the stages of nano potassium - fertilizer (Tillering stage, elongation stage, and booting stage) and the sub-sub-plot represented potassium nano-fertilizer concentrations ($0, 1, 2 \text{ g/L}$). The field was plowed with two perpendicular plows, and it was smoothed and leveled, then the field was divided into (81) boards with dimensions ($3 * 2 \text{ m}$), one board contains (13) lines, and the distance between one line and another is (15 cm) and the plot separate shoulders with a

width of (1 m) to prevent leakage of the sprayed fertilizer between the panels and between the repeaters. Drivers with a width of (2 m), the seeds were sown on 11/15/2020 for the first season, and they were repeated on 11/15/2021 in the second season, in an amount of 72 g per board, i.e. an average of 30 kg /dunum. Phosphorous fertilizer was added in the amount of 100 kg p per hectare of triple superphosphate fertilizer 45 P₂O₅, added in one batch when preparing the soil after plowing and before smoothing. As for nitrogen, it was added in an amount of 200 kg N per hectare in the form of urea fertilizer (46% N) (Jadoua, 1995) and in three equal batches after germination, then the tillering stage and in the flowering stage using a sprinkler with a capacity of (20) liters to spray the crop manually by mixing potassium nanofertilizer with a concentration of (2).

1g/L) with water, and sprayed at the beginning of the branching stage. Then the crop was sprayed at the beginning of the elongation, then at the beginning of the booting stage, and after adding 1 ml / L of Al-Zahi dispersant to break the surface tension of the water, and the spray was done until the plants were completely wetted, and all soil and crop service operations were conducted and according to the needs of the plants, the plants were harvested on 3/5/2021 for the first season and on 3/5/2022 for the second season, after taking the necessary measurements before harvesting. The traits of plant height, flag leaf area, chlorophyll content, potassium content, harvest index and biological yield were measured. The means were compared using the value of the least significant difference at the 5% probability level.

Table (1) shows some chemical and physical properties of the experimental soil.

unites	values	traits
DS.m ⁻³	1.89	Electrical conductivity (E.c)
	8.1	pH
g.kg ⁻¹	1.21	organic matter
mg.kg ⁻¹	0.33	total nitrogen
mg.kg ⁻¹	18.2	nitrates
		Soil separator
g.kg ⁻¹	170	sand
	471	silt
	359	clay
Silty loam		soil texture

Results and discussion

1- Effect of cultivar, spraying stage and nanopotassium on plant height

The results of Table (2) indicate that there are significant differences between the levels of the studied factors in traits of average plant height. The Hawler cultivar excelled and gave the highest average of 80.59 cm for the first season and the highest average for the second season of 81.45 cm, followed by the Abu Ghraib cultivar with an average of 73.50 cm for the first season and 75.39 cm for the second season, then the Aras cultivar with an average of 65.72 cm for the first season and 68.21 cm for the second season. The reason may be due to the difference in genetic factors between the taxa included in the study and the difference between them in the number of nodes and the length of the internodes, especially the superior phalanges, which are among the important traits in distinguishing the cultivars. As well as the environmental conditions, especially the somewhat moderate temperatures during the second season compared to the first season. Table (3) Genetic factors and environmental factors. As for the timing of spraying, the spraying treatment excelled in the booting stage and gave the highest mean of 75.71 cm for the first season and 77.66 cm for the second season. Followed by spraying treatment with the elongation stage, which gave an average of 72.91 cm for the first season and 74.93 cm for the second season. The reason for the excelled of this stage may be due to being one of the important physiological stages in the wheat crop, which

many researchers agreed on as the appropriate stage for adding nutrients. , As for nanopotassium levels, the 2g L⁻¹ treatment was superior and gave the highest average of 74.54 cm for the first season and 76.30 cm for the second season, compared to the treatment of no nano-potassium spraying, which gave the lowest average of 72.06 cm for the first season and 73.73 cm for the second season. The reason may be due to the role of potassium and its contribution to improving vegetative growth. As it increases the absorption of nitrogen, magnesium and calcium and thus will increase the vital activities in the plant and then cell division and its reflection on the height of the plant. This result is in line with what [11] found. As for the bi-interaction treatments, the treatment (Hawler cultivar + spraying in the booting stage) excelled and gave the highest average of 84.12 cm for the first season and 85.48 cm for the second season, while the treatment (Hawler cultivar + spraying potassium) excelled. At a concentration of 2 g L⁻¹ It gave the highest average of 81.97 cm for the first season and 83.49 cm for the second season, while the interaction treatment (spraying in the booting stage + spraying potassium at a concentration of 2 g L⁻¹) was significantly superior and gave the highest average of 77.51 cm for the first season and 80.06 cm for the second season. As for the triple interaction, the treatment (Hawler cultivar + spraying in the booting stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly excelled and gave the highest mean of 85.43 cm for the first season and 87.93 cm for the second season.

Table (2) Effect of cultivar, spraying stage and nanopotassium on plant height

The second season 2021/2022				The first season 2020/2021				Spraying date	cultivars
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1	0		
73.97	75.13	73.60	73.17	72.03	72.80	72.27	71.03	tillering	Abu Ghraib
74.96	75.67	75.00	74.20	73.37	73.83	73.73	72.53	elongation	
77.24	79.20	76.87	75.67	75.10	77.20	74.70	73.40	booting	
77.82	79.73	78.70	75.03	77.86	78.93	77.87	76.77	tillering	Howler
81.04	82.80	81.03	79.30	79.78	81.53	79.73	78.07	elongation	
85.48	87.93	84.93	83.57	84.12	85.43	83.93	83.00	booting	
65.58	65.97	65.97	64.80	63.66	64.80	63.57	62.60	tillering	Aras
68.80	70.63	68.53	67.23	65.58	66.47	65.60	64.67	elongation	
69.82	71.70	69.90	67.87	67.92	69.90	67.43	66.43	booting	
4.711	4.798			0.483	0.852			LSD0.05	
cultivars * Spray nano potassium									
75.39	76.67	75.16	74.34	73.50	74.61	73.57	72.32	Abu Ghraib	
81.45	83.49	81.56	79.30	80.59	81.97	80.51	79.28	Howler	
68.21	69.88	68.13	66.63	65.72	67.06	65.53	64.57	Aras	
1.411	2.770			0.870	0.492			LSD0.05	
spraying stage * Spray nano potassium									
72.46	73.61	72.76	71.00	71.18	72.18	71.23	70.13	tillering	
74.93	76.37	74.86	73.58	72.91	73.94	73.02	71.76	elongation	
77.66	80.06	77.23	75.70	75.71	77.51	75.36	74.28	booting	
2.720	2.770			0.279	0.492			LSD0.05	
	76.30	75.13	73.73		74.54	73.20	72.06	average	
	1.599				0.248			LSD0.05	

As the spraying treatment gave 500 mg L⁻¹ nanopotassium + three-quarters of the amount of ground potassium (K5), the highest rate of height was (187.2) cm, and the lowest rate of plant height when control treatment was (164.7) cm [12]. The study aims to find out the response of wheat cultivars to spraying with nano potassium and its effect on some indicators of vegetative growth.

2- The effect of cultivar, spraying stage and nanoparticle potassium on flag leaf area cm²

The results in Table (3) indicate that there are significant differences between the levels of

the studied factors in traits of the average flag leaf area. The cultivar Aras excelled and gave the highest average of 34.40 cm² for the first season, and the highest average for the second season of 35.37 cm². It was followed by the Abu Ghraib cultivar with an average of 30.51 cm² for the first season and 31.18 cm² for the second season, then the cultivar Hawler with an average of 26.59 cm² for the first season and 27.43 cm² for the second season. The reason for this difference between the cultivars for the second season may be attributed to the nature of their genetic structure and their interaction with the surrounding environmental conditions, and then their

differences in growth traits, including the size of the flag leaf, as well as the appropriateness of average temperatures may have had an impact on the growth of these cultivars in a better way. This result agreed with what was obtained by [13,8] who indicated that there were significant differences between the cultivars due to the size of the flag area. As for the date of addition, the spray treatment excelled in the booting stage and gave the highest average of 33.02 cm² for the first season and 33.93 cm² for the second season, followed by the spray treatment in the elongation stage and gave an average of 30.36 cm² for the first season and 31.16 cm² for the second season. As for nanopotassium levels, the 2g L⁻¹ treatment was superior and gave the highest average of 31.69 cm² for the first season and 32.64 cm² for the second season, compared to the treatment of not spraying nanopotassium, which gave the lowest average of 29.35 cm² for the first season and 30.3 cm² for the second season. . Perhaps the reason for this is due to the role of nanomaterials in maintaining the vitality of chloroplasts for a longer period, as well as delaying aging in plant tissues. This results from the contribution of nanomaterials to increasing the activity of enzymes that stimulate stopping the production of ethylene and activating its

work, which has a role in the activity of the enzyme oxidized by chlorophyllase, which works to destroy chloroplasts, as well as the role of nanomaterials in stimulating photosynthetic enzymes, and the outcome of these two activities stimulates cell division, growth and development. This is reflected in an increase in the flag leaf area. The results are consistent with the findings of [14]. As for the bi-interaction treatments, the treatment (cultivar Aras + spraying in the booting stage) excelled and gave the highest average of 36.81 cm² for the first season and 37.53 cm² for the second season, while the treatment (cultivar Aras + spraying potassium with a concentration of 2 g L⁻¹) excelled and gave the highest average of 35.47 cm² for the first season and 36.69 cm² for the second season. While the interaction treatment (spraying in the booting stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly excelled and gave the highest mean of 34.59 cm² for the first season and 35.56 cm² for the second season. As for the triple interaction, the treatment (Aras cultivar + spraying in the booting stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly superior and gave the highest mean of 37.90 cm² for the first season and 38.70 cm² for the second season.

Table (3) The effect of cultivar, spraying stage and nanopotassium on flag leaf area traits

The second season 2021/2022				The first season 2020/2021				Spraying date	cultivars
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1	0		
29.19	30.60	29.13	27.83	28.67	29.97	28.60	27.43	tillering	Abu Ghraib
30.39	31.37	30.57	29.23	29.78	30.70	29.83	28.80	elongation	
33.97	35.53	34.23	32.13	33.09	34.87	32.90	31.50	booting	
24.38	25.37	24.37	23.40	23.82	24.70	24.03	22.73	tillering	Howler
27.63	28.43	28.00	26.47	26.79	27.57	27.10	25.70	elongation	
30.29	32.43	29.67	28.77	29.17	31.00	28.83	27.67	booting	
33.13	34.67	33.07	31.67	31.89	33.20	31.73	30.73	tillering	Aras
35.46	36.70	35.53	34.13	34.51	35.30	34.70	33.53	elongation	
37.53	38.70	37.30	36.60	36.81	37.90	36.47	36.07	booting	
1.378	1.839			0.549	0.904			LSD0.05	
cultivars * Spray nano potassium									
31.18	32.50	31.31	29.73	30.51	31.84	30.44	29.24	Abu Ghraib	
27.43	28.74	27.34	26.21	26.59	27.76	26.66	25.37	Howler	
35.37	36.69	35.30	34.13	34.40	35.47	34.30	33.44	Aras	
1.089	1.062			0.500	0.522			LSD0.05	
spraying stage * Spray nano potassium									
28.90	30.21	28.86	27.63	28.13	29.29	28.12	26.97	tillering	
31.16	32.17	31.37	29.94	30.36	31.19	30.54	29.34	elongation	
33.93	35.56	33.73	32.50	33.02	34.59	32.73	31.74	booting	
0.796	1.062			0.317	0.522			LSD0.05	
	32.64	31.32	30.3		31.69	30.47	29.35	average	
	0.613				0.301			LSD0.05	

Effect of cultivar, spraying stage and nano potassium on the chlorophyll content of spad leaves

The results in Table (4) indicate that there are significant differences between the levels of the factors studied in traits of the average content of chlorophyll spad in the leaves. Followed by Aras cultivar with an average of 37.30 spad for the first season and 38.15 spad for the second season, then Abu Ghraib with an average of 37.00 spad for the first season and 37.80 spad for the second season. The existence of a significant difference between the cultivars in the content of the flag leaf of chlorophyll may be due to the difference in its genetic susceptibility in the main degree, and

this is consistent with the findings of [15] . ,As for the date of addition, the spray treatment excelled in the lining stage and gave the highest average of 40.36 spad for the first season and 41.46 spad for the second season, followed by the spray treatment in the elongation stage and gave an average of 37.56 spad for the first season and 39.02 spad for the second season. 2 g L⁻¹ and gave the highest average of 38.87 spad for the first season and 40.40 spad for the second season, compared to the treatment of nano potassium spray, which gave the lowest average of 37.01 spad for the first season and 37.93 spad for the second season. The reason for this increase is due to the role of potassium in activating enzymatic and metabolic activities within the plant, such

as the process of respiration and photosynthesis, as well as its direct entry into the hormones stimulating the formation of the chlorophyll molecule in the leaf and increasing its content of elements and preserving it from demolition. The leaf and its development. Potassium also has a role in reducing the formation of abscisic acid (ABA), which results in delayed aging and a lack of chlorophyll degradation. These results were similar to what was reached by [8,6] on the wheat crop. As for the bi- interaction treatments, the treatment (Hawler cultivar + spraying in the booting stage) excelled and gave the highest mean of 42.37 spad for the first season and 44 spads. 46 spad for the second season, while the treatment (Hawler

cultivar + potassium spray with a concentration of 2 g L⁻¹) excelled and gave the highest mean of 40.42 spad for the first season and 42.57 spad for the second season. While the interaction treatment (spraying in the booting stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly excelled and gave the highest mean of 42.06 spad for the first season and 43.69 spad for the second season. As for the triple interaction, the treatment (Hawler cultivar + spraying in the booting stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly excelled and gave the highest mean of 44.03 spad for the first season and 44.46 spad for the second season.

Table (4) Effect of cultivar, spraying stage, and nanopotassium on leaves' chlorophyll content

The second season 2021/2022				The first season 2020/2021				Spraying date	cultivars
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1	0		
36.16	36.63	36.50	35.33	35.49	35.97	35.83	34.67	tillering	Abu Ghraib
37.51	38.53	37.87	36.13	36.49	37.07	36.93	35.47	elongation	
39.72	41.53	38.93	38.70	39.02	40.57	38.37	38.13	booting	
38.18	38.90	37.80	37.83	36.84	37.23	36.93	36.37	tillering	Howler
40.88	42.17	40.60	39.87	39.08	40.00	39.20	38.03	elongation	
44.46	46.63	44.13	42.60	42.37	44.03	41.87	41.20	booting	
35.57	37.13	35.33	34.23	35.12	35.80	35.33	34.23	tillering	Aras
38.67	39.17	38.40	38.43	37.10	37.57	37.00	36.73	elongation	
40.21	42.90	39.47	38.27	39.68	41.57	39.20	38.27	booting	
1.211	1.658			0.594	1.104			LSD0.05	
cultivars * Spray nano potassium									
37.80	38.90	37.77	36.72	37.00	37.87	37.04	36.09	Abu Ghraib	
41.17	42.57	40.84	40.10	39.43	40.42	39.33	38.53	Howler	
38.15	39.73	37.73	36.98	37.30	38.31	37.18	36.41	Aras	
1.199	0.957			0.452	0.637			LSD0.05	
spraying stage * Spray nano potassium									
36.63	37.56	36.54	35.80	35.82	36.33	36.03	35.09	tillering	
39.02	39.96	38.96	38.14	37.56	38.21	37.71	36.74	elongation	
41.46	43.69	40.84	39.86	40.36	42.06	39.81	39.20	booting	
0.699	0.957			0.343	0.637			LSD0.05	
	40.40	38.78	37.93		38.87	37.85	37.01	average	
	0.553				0.368			LSD0.05	

4- Effect of cultivar, spraying stage and nano potassium on leaves potassium content (%)

The results in Table (5) indicate that there are significant differences between the levels of the factors studied in the average potassium content of the leaves. Followed by the Aras cultivar with an average of 2.05% for the first season and 2.10% for the second season, then the Abu Ghraib cultivar with an average of 1.89% for the first season and 1.92% for the second season. % for the first season and 2.29% for the second season Followed by the spraying treatment with the elongation stage, and it gave an average of 2.03% for the first season and 2.07% for the second season. As for the nanopotassium levels, the treatment was excelled on 2 g L⁻¹ and gave the highest average of 2.17% for the first season and 2.21% for the second season compared to the no-spray treatment. Nano potassium, which gave the lowest average, was 2.00% for the season and 2.69% for the second season.

first season and 2.04% for the second season, and this is consistent with [10]. As for the bi-interaction treatments, the treatment (variety Hawler + spraying in the booting stage) excelled and gave the highest average of 2.45% for the first season and 2.50% for the second season, while the treatment (variety Hawler + spraying potassium with a concentration of 2 g L⁻¹) excelled and gave the highest An average of 2.40% for the first season and 2.45% for the second season. While the interaction treatment (spraying in the booting stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly excelled and gave the highest mean of 2.40% for the first season and 2.44% for the second season. As for the triple interaction, the treatment (Hewler cultivar + spraying in the booting stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly excelled and gave the highest mean of 2.61% for the first

Table (5) the effect of cultivar, spraying stage and nanopotassium on the average potassium concentration in the leaves

The second season 2021/2022				The first season 2020/2021				Spraying date	cultivars
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1	0		
1.84	1.89	1.84	1.80	1.79	1.84	1.80	1.73	tillering	Abu Ghraib
1.89	1.92	1.87	1.87	1.86	1.90	1.86	1.82	elongation	
2.03	2.21	1.96	1.91	2.01	2.19	1.94	1.90	booting	
2.23	2.31	2.21	2.18	2.19	2.27	2.17	2.13	tillering	Howler
2.27	2.35	2.24	2.22	2.23	2.32	2.20	2.19	elongation	
2.50	2.69	2.48	2.34	2.45	2.61	2.45	2.30	booting	
1.90	1.99	1.87	1.84	1.82	1.86	1.82	1.78	tillering	Aras
2.04	2.13	2.01	1.97	2.00	2.11	1.96	1.92	elongation	
2.35	2.43	2.37	2.24	2.31	2.41	2.33	2.21	booting	
0.059	0.062			0.044	0.055			LSD0.05	
cultivars * Spray nano potassium									
1.92	2.01	1.89	1.86	1.89	1.98	1.87	1.82	Abu Ghraib	
2.34	2.45	2.31	2.25	2.29	2.40	2.27	2.21	Howler	
2.10	2.18	2.08	2.02	2.05	2.13	2.04	1.97	Aras	
0.093	0.036			0.056	0.032			LSD0.05	
spraying stage * Spray nano potassium									
1.99	2.06	1.98	1.94	1.93	1.99	1.93	1.88	tillering	
2.07	2.13	2.04	2.02	2.03	2.11	2.01	1.98	elongation	
2.29	2.44	2.27	2.16	2.26	2.40	2.24	2.14	booting	
0.034	0.036			0.025	0.032			LSD0.05	
	2.21	2.10	2.04		2.17	2.06	2.00	average	
	0.021				0.018			LSD0.05	

Effect of cultivar, spraying stage and potassium nanoparticles on biological yield

The results of Table (6) indicate that there are significant differences between the levels of the studied factors in the average biological yield, ton ha⁻¹. It was followed by the Abu Ghraib cultivar with an average of 12.53 ton ha⁻¹ for the first season and 12.65 ton ha⁻¹ for the second season, then the Aras cultivar with an average of 11.34 ton ha⁻¹ for the first season and 11.50 ton ha⁻¹ for the second season. The reason may be due to its traits in some of affecting the increase in biological yield, such as the content of leaves of chlorophyll Table (4) As the presence of chlorophyll in high

concentration leads to an increase in the outputs of photosynthesis, which is reflected in the increase in the biological yield, as well as its superiority in the trait of the number of vegetative. m² and the number of spikes. m², number of grains per spike, and grain yield tables (6, 7, 8, 10), which also greatly reflected in the increase in biological yield. This result is consistent with what was reached by [16] who indicated that the wheat varieties differed significantly among them in the traits of the biological yield. As for the date of addition, the spraying treatment excelled in the booting stage and gave the highest average of 14.53 ton ha⁻¹ for the first season and 14.70 ton ha⁻¹ for the second

season, followed by spraying treatment in the elongation stage, and it gave an average of 13.05 ton ha⁻¹ for the first season and 13.15 ton ha⁻¹ for the second season. As for the nanopotassium levels, the 2 gm L⁻¹ treatment excelled and gave the highest average of 13.73 ton ha⁻¹ for the first season and 13.91 ton ha⁻¹ for the second season, compared to the non-spraying nanopotassium treatment, which gave the lowest average of 12.75 ton ha⁻¹ for the first season. And 12.87 ton ha⁻¹ for the second season. Perhaps the reason for the superiority of the above treatment is due to its excelled in plant height, number of cuttings, flag leaf area, and grain yield (10, 3, 6, 2). This result is in line with [6,8] . As for the bi-interaction treatments, the treatment (variety Hewler + spraying in the blanket stage) excelled and gave the highest average of 17.11 tons H-1 for

the first season and 17.23 ton ha⁻¹ for the second season, while the treatment excelled (variety Hewler + spraying potassium with a concentration of 2 gm L⁻¹) and gave the highest average of 16.28 ton ha⁻¹ for the first season and 16.40 ton ha⁻¹ for the second season, While the interaction treatment (spraying in the booting stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly excelled and gave the highest mean of 15.47 ton ha⁻¹ for the first season and 15.75 ton ha⁻¹ for the second season. As for the triple interaction, the treatment (Hewler cultivar + spraying in the booting stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly excelled and gave the highest mean of 18.02 ton ha⁻¹ for the first season and 18.23 ton ha⁻¹ for the second season.

Table (6) Effect of cultivar, spraying stage, and nanopotassium on the average biological yield

The second season 2021/2022				The first season 2020/2021				Spraying date	cultivars
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1	0		
11.43	11.58	11.39	11.33	11.32	11.56	11.27	11.12	tillering	Abu Ghraib
12.36	12.71	12.42	11.96	12.28	12.52	12.38	11.96	elongation	
14.15	15.50	13.63	13.33	13.98	15.16	13.59	13.21	booting	
14.61	14.83	14.65	14.35	14.52	14.81	14.51	14.23	tillering	Howler
15.72	16.13	15.76	15.28	15.61	15.99	15.68	15.16	elongation	
17.23	18.23	16.90	16.56	17.11	18.02	16.90	16.41	booting	
10.44	10.74	10.45	10.13	10.28	10.64	10.25	9.94	tillering	Aras
11.37	11.91	11.31	10.88	11.25	11.64	11.23	10.88	elongation	
12.70	13.52	12.56	12.03	12.50	13.24	12.38	11.88	booting	
0.260	0.281			0.227	0.200			LSD0.05	
cultivars * Spray nano potassium									
12.65	13.26	12.48	12.20	12.53	13.08	12.41	12.09	Abu Ghraib	
15.85	16.40	15.77	15.40	15.75	16.28	15.70	15.27	Howler	
11.50	12.06	11.44	11.01	11.34	11.84	11.29	10.90	Aras	
0.172	0.162			0.120	0.115			LSD0.05	
spraying stage * Spray nano potassium									
12.16	12.38	12.16	11.94	12.04	12.34	12.01	11.76	tillering	
13.15	13.58	13.16	12.71	13.05	13.38	13.10	12.66	elongation	
14.70	15.75	14.36	13.97	14.53	15.47	14.29	13.83	booting	
0.150	0.162			0.131	0.115			LSD0.05	
	13.91	13.23	12.87		13.73	13.13	12.75	average	
	0.094				0.067			LSD0.05	

(ton ha⁻¹)

6- Effect of cultivar, spraying stage and nanopotassium on the quality of harvest index

The results of Table (7) indicate that there are significant differences between the levels of the factors studied in the characteristic of the average harvest index. Followed by Aras cultivar with an average of 27.01 for the first season and 28.41 for the second season, then Hewler cultivar with an average of 23.81 for the first season and 25.54 for the second season. The excelled of the Abu Ghraib cultivar in this trait may be attributed to its excelled in grain yield, Table (10), which

indicates its high efficiency in converting photosynthetic products into economic yield. This result agreed with its findings[15], As for the date of addition, the spraying treatment excelled in the booting stage and gave the highest average of 33.87 for the first season and 35.20 for the second season, followed by the spraying treatment in the elongation stage and gave an average of 28.74 for the first season and 29.91 for the second season. It gave the highest mean of 31.18 for the first season and 32.34 for the second season, compared to the treatment of no potassium nanospray, which gave the lowest mean of

27.29 for the first season and 28.73 for the second season. As the difference of plants in their response to potassium concentrations in the trait of harvest index may be due to the difference in their response to those concentrations in other characteristics such as grain yield and biological yield (Table (10, 11). This result is consistent with [10,8] As for the bi-interaction treatments, the treatment (Abu Ghraib cultivar + spraying in the blanket stage) excelled and gave the highest average of 42.32 for the first season and 43.07 for the second season, while the treatment (Abu Ghraib cultivar + spraying potassium with a concentration of 2g L⁻¹) excelled and gave the

highest average It reached 39.32 for the first season and 39.74 for the second season. While the interaction treatment (spraying in the blanket stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly superior and gave the highest mean of 36.38 for the first season and 37.43 for the second season. As for the triple interaction, the treatment (Abu Ghraib cultivar + spraying in the blanket stage + potassium spraying at a concentration of 2 g L⁻¹) was significantly superior and gave the highest mean of 42.32 for the first season and 43.07 for the second season.

Table (7) Effect of cultivar, spraying stage, and nanopotassium on the average yield index

The second season 2021/2022				The first season 2020/2021				Spraying date	cultivars
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1	0		
31.36	33.69	31.52	28.85	30.64	32.52	30.78	28.61	tillering	Abu Ghraib
37.45	40.35	37.08	34.92	36.40	39.62	36.16	33.42	elongation	
43.07	45.20	43.14	40.88	42.32	45.82	41.86	39.29	booting	
22.28	23.65	21.87	21.31	20.11	21.77	19.81	18.74	tillering	Howler
24.12	25.47	24.30	22.58	22.82	24.10	22.94	21.40	elongation	
30.24	32.55	29.99	28.18	28.52	31.10	27.33	27.11	booting	
24.79	26.68	24.41	23.28	23.27	25.23	23.29	21.28	tillering	Aras
28.15	28.95	27.74	27.76	27.01	28.22	26.70	26.11	elongation	
32.30	34.53	31.55	30.81	30.77	32.21	30.46	29.63	booting	
1.663	1.488			0.986	1.607			LSD0.05	
cultivars * Spray nano potassium									
37.29	39.74	37.25	34.89	36.45	39.32	36.27	33.77	Abu Ghraib	
25.54	27.22	25.38	24.02	23.81	25.66	23.36	22.42	Howler	
28.41	30.05	27.90	27.28	27.01	28.55	26.82	25.67	Aras	
1.867	0.859			2.042	0.928			LSD0.05	
spraying stage * Spray nano potassium									
26.14	28.01	25.93	24.48	24.67	26.51	24.63	22.88	tillering	
29.91	31.59	29.71	28.42	28.74	30.65	28.60	26.98	elongation	
35.20	37.43	34.89	33.29	33.87	36.38	33.22	32.01	booting	
0.960	0.859			0.569	0.928			LSD0.05	
	32.34	30.18	28.73		31.18	28.81	27.29	average	
	0.496				0.536			LSD0.05	

References

1. Al-Rifai, Shaima Ibrahim Mahmoud. (2006). Response of wheat cultivars (*Triticum aestivum*) to foliar feeding with iron and manganese, PhD thesis. College of Agriculture - Basra University.
2. Al-Masoudi, Amer Nema Karim. 2023. Response of three cultivars of bread wheat, *T.aestivum* L., to seed quantities and late sowing dates. PhD thesis. Al-Musayyib Technical College, Al-Furat Al-Awsat University.
3. Al-Jubouri, Jassim Muhammad Aziz, and Pashtwan Hama Ali Abdul-Karim. 2021. Genetic-environmental interaction of approved varieties of bread wheat, *Triticum aestivum* L. across different Iraqi environments. *Syrian Journal of Agricultural Research*. 8(1):58-73.
4. Al-Ramadi, Hassan Rajab and Nehmeh Abdulmonem Abdullah, Tareq Ali Shall, Abdullah Hassan Al-Saeedi, Mohammed Salem Al-Sikhan and Tareq Abdulaziz Shalabi.(2016). *Botany and Environmental Nanotechnology* . Faculty of Agriculture –Kafr El-Saeikh University .first Edition .P.189.
5. Ali, N. S., Rahi, H.S., and Shaker, A. A.,(2014). *Soil Fertility*. Scientific Book House College of Agriculture-University of Baghdad.
6. Noamea, A. H; H.R. Leiby and A. R. Alhassany.2020. Effect of spraying Nano fertilization of Potassium and Boron on Growth and of wheat ((*Triticum aestivum* L.). *IOP Conf. Series Materials science and Engineering*. 871: 012012.
7. Al-Saedan, Khudair Judah Yasser. 2019 Effect of fractionation of mineral and nanofertilizers (N,K) and stages of their application on growth metric, yield and its components for two cultivars of wheat (*Triticum aestivum*L.), field crop section. faculty of Agriculture. Muthanna University.
8. **Al-Juthery**, H.A., Habeeb, K.H., Altaee, F.J., Al-Taey, D.A. and Al- Tawaha, A.R. 2018. Effect of foliar application of different sources of nano-fertilizers on growth and yield of wheat. *Journal by Innovative Scientific Information & Services Network*.15(4): 3988-3997.
9. Abdel-Hassan, Shatha, Najat Hussein Zboun, and Haider Abdel-Razzaq Baqer. 2015 Effect of potassium supplementation dates and levels on the growth of bread wheat. *Iraqi Journal of Agricultural Sciences*, 46 (4): 528-522.
10. Al-Jaafar, Shorouq Kani Yassin. 2014. Response of cultivars of wheat, *Triticum aestivum* L., to irrigation water quality, potassium fertilization, and estimation of the genetic correlation coefficient. Master Thesis. College of Education for Pure Sciences, Karbala University.
11. Al-Mousawi, Bassem Abbas Kassar.2020.The effect of bio-organic and nano-fertilizers and levels of NPK on some soil fertility properties and the growth and yield of wheat *aestivum* l. *Triticum*. PhD thesis - College of Agriculture - Al-Muthanna University.
12. Hussein, Sari Riad (2020). Response of maize growth and yield to potassium nanoparticles under water stress. Master Thesis, College of Agriculture, Al-Qasim Green University, Iraq.
13. Zidan, Basem Ahmed and Ahmed Farhan Musleh and Ali Fadam Abdullah Al-Mohammadi. 2018. Effect of tillage systems on growth and yield of five cultivars of bread wheat. *Iraqi Journal of Desert Studies*. 10-15: (1) 8.
14. Abdel-Aziz ,H. M. M. ,M. N. A. Hasaneen and A. M. Omer. 2016. Nano chitosan-NPK fertilizer enhances the growth and productivity of wheat plants grown in sandy soil. *Spanish Journal of Agricultural Research* ,14(1): 1-9.
15. Burhan, Majid Jabari and Shatha Abdel-Hassan Ahmed. 2019 Effect of NPK nanofertilizer on the association between yield, quality, and flag leaf area of some bread wheat cultivars. *Iraqi Journal of Agricultural Sciences* 50 (special issue) 7-1.
16. Al-Jabri, Hazem Hussein Farhoud. 2020. The contribution of the main stem and the cuttings to the yield and its components of soft wheat varieties under the influence of nitrogen fertilization. Master Thesis . College of Agriculture - Al-Muthanna University.

