

RESPONSE OF SOME QUALITY INDICATORS OF GRAIN YIELD OF BREAD WHEAT CULTIVARS TO SPRAYING WITH NANO-POTASSIUM FERTILIZER

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Abstract

A field experiment was conducted in plot numbered 95 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, where the cultivars (Abu Ghraib, Hawler, Aras) occupied the main plot, and the spraying stages (tilleting, elongation, booting) occupied the sub plot, while potassium nano-fertilizer concentrations occupied (2, 1, 0 g/L) for sub-sub-plot. The results showed that the Abu Ghraib cultivar had the highest values for traits of harvest index and for both seasons, with averages reaching (36.45 and 37.29), respectively, while the Aras cultivar excelled in trait of the percentage of carbohydrates in the grains and for the two seasons, with averages reaching (66.21% and 66.90%), and the Hewler cultivar excelled in trait of the percentage of nitrogen in the grains for both seasons, with an average of (1.97% and 2.02%), respectively, and the percentage of phosphorus in the grains, for the two seasons, with an average of (0.43% and 0.49%), respectively, and the percentage of potassium in the grains, for both seasons, with an average of (2.73%, 2.89%), respectively. The spraying treatment of nano potassium at a concentration of 2 gm L⁻¹ was excelled and recorded the highest averages of (31.18 and 32.34) for the harvest index, (62.05% and 62.85%) for the carbohydrate percentage, (1.74% and 1.79%) for the nitrogen percentage, and (0.40% and 0.47%) for the phosphorus percentage and (2.60% and 2.77%) for the potassium percentage, respectively, for both seasons.

Keywords: bread wheat, potassium, carbohydrates, NPK

Introduction

The genotypes have a different nature that makes them appear with a clear difference in traits of their growth and production, and that the genetic factor interferes 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 (Al-Rifai, 2006). (Al-Jabri, 2020) noticed that the cultivars differed significantly among themselves in terms of the number of spikes m², as the Iranian cultivar recorded the highest average of 495.7 spikes / m², with a significant difference from the two cultivars IPA 99 and bohuth 22, which achieved two averages of 436.6 and 412.8 spikes / m², respectively, without a significant difference between them. While the Iraq cultivar recorded the lowest average of 313.8 spikes/m², while the cultivars (Iraq, Bohuth 22, IPA 99 and Iranian) differed significantly among themselves in terms of the number of grains per spike, as the Bohuth 22 cultivar recorded the highest average of 57.34 grains. While the Iranian cultivar recorded the lowest average of 41.94 grains. spike⁻¹. The results

of (Farooq et al., 2018) on two wheat cultivars (Benazir and Tj-83) showed that they differed in the number of grains per spike, as Tj-83 excelled and gave an average of 57.30 grains. spike⁻¹, The results of (Radwan et al., 2018) when planting four cultivars of wheat (Sakha 93, Gemmeza 11, AL-Rasheed and Ghreib Abo) for both seasons (2017-2016 and 2017-2018) showed that Sakha93 was significantly excelled on other cultivars with an average of 57.10 and 58.60 grain. Al-Ramadi et al (2016) 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. Ali et al. (2014) 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. Noaeme et al. (2020) found the effect of spraying three levels of potassium (8.4.0 g L⁻¹) on wheat yield. The results showed a significant difference in the number of spikes per m², the number of grains per spike, grain yield, and biological yield. As the concentration of 8 gm L⁻¹ gave the highest mean for these traits, which amounted to 395.90 spikes . m⁻², 56.64 grains . spike⁻¹, 6761 Mg.ha⁻¹ and 14533 kg ha⁻¹, while the comparison treatment gave the lowest values (346.30 spikes.m⁻² and 31 .64 grains . spikes⁻¹, 6733 kg ha⁻¹ and 12452 kg ha⁻¹) respectively. Burhan (2018) when spraying three cultivars of bread wheat, IPA-99, Buhouth 158, and Orak, with NPK nanofertilizer, at levels (750 mg/l, 500 mg/l, and 250 mg/l) that exceeded the level of 750 mg/l in the grain yield class, giving 5.93 ton.ha⁻¹ and the number of spikes is 380.37 spikes m² and the number of grains per spike is 76.33 grains . spike⁻¹ or the biological yield is 10.67 tons ha⁻¹. Al-Juthery et al. (2018) explained in a study conducted on wheat crop, that spraying vegetative with a concentration of 150 nanopotassium NPK led to a significant increase in the biological yield (13.04 Mg.ha⁻¹) and grain yield (5.64 Mg.ha⁻¹ and the weight of 1000 grains (47.25 g) and harvest index (43.18%) compared to the control treatment, which decreased (11.49 Mg.ha⁻¹, 4.05 Mg.ha⁻¹, 39.69 g and 35.27%), respectively. Abdel-Aziz et al. (2016) in their study on wheat plants revealed the presence of NPK nanoparticles with a diameter ranging between 30 and 26 nm within the phloem tissue and their transmission through the phloem vessels at much higher rates than the addition of the fertilizer itself in its traditional form. They indicated that all the different growth variables of plants when fertilized with the NPK nano-fertilizer were higher in their estimates than when fertilized by the conventional fertilizers. The treatment of 10% of NPK nanofertilizer achieved the highest values for the traits of plant height, and the treatment of 25% nano-NPK achieved the highest values for dry matter weight at maturity, and also spraying bread wheat plants with the treatment NPK%10 nano gave the highest values for the spike length of 7.76 cm. The number of grains of spikelet is 8.66 grains of spikelet⁻¹ and its weight is 0.305 grains . spikelet⁻¹ and the weight of 1000 grains is 4.64gm and the yield of grain is 8.28gm. plant⁻¹ and increasing the level to 100, 25% led to a decrease in their averages to 6.23, 6.40 cm, 5.78, 6.40 grains of spikelet, and 0.178, 0.185gm spike or 3.98, 4.03 gm and 6.93, 7.23 g. plant⁻¹. As for the

harvest index, it reached its highest value of 27.15% when treating nanoparticles NPK 25% (Abdel-Aziz et al., 2016). Al-Hujairi (2013) found in his study on the wheat crop significant differences when using four levels of potassium fertilizer (150, 100, 50, 0 kg.ha⁻¹), as the level 150 kg.ha⁻¹ gave the highest average number of spikes 362.67 spikes m² and the number of grains per spike 58.70 grains, the weight of 1000 grains is 25.89 g, and the biological yield is 11.27 Mg.ha⁻¹

Materials and methods

A field experiment was conducted 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 silty 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 cultivars (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 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 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 plot 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.. Harvest index traits and the percentage of carbohydrates, nitrogen, phosphorus and potassium in wheat grains were measured.

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 traits of harvest index

The results in Table (2) indicate that there are significant differences between the levels of the studied factors in the average harvest index. The Abu Ghraib cultivar excelled and gave the highest average of 36.45 for the first season, and the highest average for the second season reached 37.29, followed by the Aras cultivar with an average of 27.01 for the first season and 28.41 for the first season. Second was the Hawler cultivar, with an average of 23.81 for the first season and 25.54 for the second season. Perhaps the superiority of the Abu Ghraib cultivar in this trait is due to its excelled in grain yield (Table 10), which indicates its high efficiency in converting the products of photosynthesis into its economic yield. This result is consistent with what he reached (Burhan, 2018). As for the application date, the spraying treatment in the booting stage excelled 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. As for the levels of nanopotassium, the treatment 2 g. L⁻¹ excelled gave the highest average of 31.18 for the first season and 32.34 for the second season, compared to the non-spraying treatment of nano potassium, which gave the lowest average of 27.29 for the first season and 28.73 for the second season. The difference between plants in their response to potassium concentrations in the harvest index trait may be due to the difference in their response to those concentrations in other traits such as grain yield and biological yield (Table (10, 11)). This result is consistent with Al-Jaafar (2014) and Al-Juthery et al. (2018). As for the bi- interaction treatments, the treatment (Abu Ghraib cultivar + spraying in the booting 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 + potassium spraying at a concentration of 2 g.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 lining stage + potassium spraying at a concentration of 2 g.L⁻¹) was significantly superior and gave the highest average 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 booting stage + potassium spraying at a concentration of 2 g.L⁻¹) was significantly excelled and gave the highest average of 42.32 for the first season and 43.07 for the second season.

Table (2) Effect of cultivar, spray stage, and nanopotassium on the average harvest index

second season 2021/2022				first season 2020/2021				Spraying date	cultivar
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	
cultivar * 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 * 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	

2-Effect of the cultivar, spraying stage, and nanopotassium on trait of the percentage of carbohydrates in grains

The results of Table (3) indicate that there are significant differences between the levels of the studied factors in trait of the average percentage of carbohydrates in grains (%). The Aras cultivar excelled and gave the highest average of 66.21% for the first season and the highest average for the second season reached 66.90%, followed by the Hewler cultivar with an average of 56.91. % for the first season and 58.18% for the second season, then the Abu Ghraib cultivar with an average of 55.70% for the first season and 56.24% for the second season. . This result agreed with what was found by (Al-Ajili, 2018) and (Muhammad, 2020). As for the application date, the spraying treatment in the elongation stage excelled and gave the highest average of 62.57% for the first season and 63.57% for the second season, followed by the spraying treatment in the elongation

stage and gave an average It reached 58.75% for the first season and 59.64% for the second season. As for the nanopotassium levels, the 2 g.L-1 treatment excelled it and gave the highest average of 62.05% for the first season and 62.85% for the second season compared to the treatment without spraying nanopotassium, which gave the lowest average of 57.07. % for the first season and 58.02% for the second season. As for the bi- interaction treatments, the treatment (Aras cultivar + spraying in the booting stage) excelled and gave the highest average of 67.60% for the first season and 68.54% for the second season, while the treatment (Aras cultivar + potassium spraying at a concentration of 2 g.L-1) excelled and gave the highest average. It reached 68.73% for the first season and 69.35% for the second season, while the interaction treatment (spraying in booting stage + potassium spraying at a concentration of 2 g.L-1) was significantly excelled and gave the highest average of 65.68% for the first season and 66.88% 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 average of 69.50% for the first season and 69.33% for the second season.

Table (3) Effect of cultivar, spraying stage, and nanopotassium on the average percentage of carbohydrates in grains

second season 2021/2022				first season 2020/2021			Spraying date	cultivar	
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1	0		
53.14	54.33	53.00	52.10	52.53	53.93	52.57	51.10	tillering	Abu Ghraib
54.63	56.17	54.80	52.93	54.30	55.77	54.57	52.57	elongation	
60.93	65.80	60.90	56.10	60.28	64.47	60.90	55.47	booting	
56.36	58.40	56.40	54.27	55.87	57.80	55.90	53.90	tillering	Howler
56.97	58.57	56.53	55.80	55.02	57.23	54.73	53.10	elongation	
61.22	64.33	62.23	57.10	59.83	63.07	60.47	55.97	booting	
64.86	68.20	64.77	61.60	64.10	67.63	64.03	60.63	tillering	Aras
67.31	69.33	67.30	65.30	66.92	69.07	66.83	64.87	elongation	
68.54	70.50	68.17	66.97	67.60	69.50	67.30	66.00	booting	
0.881	1.087			1.226	1.486			LSD0.05	
cultivar * nano Potassium									
56.24	58.77	56.23	53.71	55.70	58.06	56.01	53.04	Abu Ghraib	
58.18	60.43	58.39	55.72	56.91	59.37	57.03	54.32	Howler	
66.90	69.34	66.74	64.62	66.21	68.73	66.06	63.83	Aras	
0.722	0.627			1.064	0.858			LSD0.05	
Spraying stage * nano Potassium									
58.12	60.31	58.06	55.99	57.50	59.79	57.50	55.21	tillering	
9.64	61.36	59.54	58.01	58.75	60.69	58.71	56.84	elongation	
63.57	66.88	63.77	60.06	62.57	65.68	62.89	59.14	booting	

0.509	0.627			0.708	0.858			LSD0.05
	16.44	15.92	15.73		16.30	15.81	15.60	average
	0.362				0.495			LSD0.05

3-Effect of the cultivar, spraying stage, and nanopotassium on trait of the nitrogen percentage in grains

The results of Table (4) indicate that there are significant differences between the levels of the studied factors regarding the average percentage of N in grains. The Holler cultivar excelled and gave the highest average of 1.97% for the first season and the highest average for the second season amounted to 2.02%, followed by the Abu Ghraib cultivar with an average of 1.69% for the first season. And 1.73% for the second season, then the Aras cultivar with an average of 1.35% for the first season and 1.39% for the second season. As for the spraying date, the spraying treatment in the booting stage excelled and gave the highest average of 1.81% for the first season and 1.86% for the second season, followed by the spraying treatment in the booting stage. Elongation gave an average of 1.65% for the first season and 1.69% for the second season. As for the nanopotassium levels, the 2 g.L-1 treatment excelled it and gave the highest average of 1.74% for the first season and 1.79% for the second season compared to the no-spray nanopotassium treatment, which gave less. An average of 1.61% for the first season and 1.65% for the second season. As for the bi-interaction treatments, the treatment (Hawler cultivar + spraying in the booting stage) excelled and gave the highest average of 2.12% for the first season and 2.17% for the second season, while the treatment (Hawler cultivar + potassium spraying at a concentration of 2 g.L-1) excelled and gave the highest average. It reached 2.04% for the first season and 2.12% for the second season, while the interaction treatment (spraying in the lining stage + potassium spraying at a concentration of 2 g.L-1) significantly and gave the highest average of 1.94% for the first season and 2.00% 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 average of 2.22% for the first season and 2.32% for the second season.

Table (4) Effect of cultivar, spraying stage, and nanopotassium on trait of N% in seeds

second season 2021/2022				first season 2020/2021			Spraying date	cultivar	
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1			0
1.62	1.65	1.61	1.60	1.58	1.62	1.58	1.56	tillering	Abu Ghraib
1.69	1.73	1.69	1.64	1.65	1.69	1.65	1.60	elongation	
1.88	2.00	1.85	1.79	1.84	1.96	1.81	1.75	booting	
1.87	1.92	1.86	1.82	1.83	1.89	1.82	1.78	tillering	Howler
2.02	2.10	2.00	1.96	1.97	2.02	1.96	1.92	elongation	
2.17	2.32	2.10	2.09	2.12	2.22	2.09	2.05	booting	
1.30	1.33	1.30	1.27	1.26	1.29	1.26	1.23	tillering	Aras
1.36	1.41	1.34	1.35	1.33	1.37	1.30	1.31	elongation	

1.51	1.69	1.48	1.38	1.48	1.65	1.44	1.34	booting	
0.032	0.044			0.025	0.040			LSD0.05	
cultivar * nano Potassium									
1.73	1.79	1.72	1.68	1.69	1.76	1.68	1.64	Abu Ghraib	
2.02	2.12	1.98	1.96	1.97	2.04	1.96	1.92	Howler	
1.39	1.47	1.37	1.33	1.35	1.44	1.33	1.29	Aras	
0.015	0.025			0.025	0.023			LSD0.05	
Spraying stage * nano Potassium									
1.60	1.64	1.59	1.56	1.56	1.60	1.55	1.52	tillering	
1.69	1.75	1.68	1.65	1.65	1.69	1.64	1.61	elongation	
1.86	2.00	1.81	1.75	1.81	1.94	1.78	1.71	booting	
0.019	0.025			0.014	0.023			LSD0.05	
	1.79	1.69	1.65		1.74	1.66	1.61	average	
	0.015				0.013			LSD0.05	

4-Effect of the cultivar, spraying stage, and nanopotassium on trait of the phosphorus percentage in grains

The results of Table (5) indicate that there are significant differences between the levels of the studied factors in the average plant height. The Hawler cultivar excelled, giving the highest average of 0.43% for the first season and the highest average for the second season of 0.49%, followed by the Abu Ghraib cultivar with an average of 0.36% for the first season and 0.42. % for the second season, then the Aras cultivar, with an average of 0.34% for the first season and 0.41% for the second season. As for the spraying date, the spraying treatment in the elongation stage excelled and gave the highest average of 0.40% for the first season and 0.47% for the second season, followed by the spraying treatment in the elongation stage and gave An average of 0.38% for the first season and 0.44% for the second season. As for the levels of nanopotassium, the treatment 2 g.L-1 excelled and gave the highest average of 0.40% for the first season and 0.47% for the second season compared to the treatment without spraying nanopotassium, which gave the lowest average of 0.34% for the first season. 0.40% for the second season. As for the bi- interaction treatments, the treatment (Hawler cultivar + spraying in the booting stage) excelled and gave the highest average of 0.46% for the first season and 0.52% for the second season, while the treatment (Hawler cultivar + potassium spraying at a concentration of 2 g.L-1) excelled and gave the highest average of 0.47. % for the first season and 0.54% for the second season, while the interaction treatment (spraying in the lining stage + potassium spraying at a concentration of 2 g.L-1) was significantly excelled and gave the highest average of 0.44% for the first season and 0.50% 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 superior and gave the highest average of 0.46% for the first season and 0.52% for the second season.

Table (5) Effect of cultivar, spraying stage, and nanopotassium on the P% character in seeds

second season 2021/2022				first season 2020/2021				Spraying date	cultivar
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1	0		
0.40	0.42	0.40	0.38	0.34	0.35	0.34	0.32	tillering	Abu Ghraib
0.42	0.45	0.43	0.39	0.36	0.38	0.36	0.33	elongation	
0.44	0.48	0.45	0.40	0.38	0.41	0.38	0.34	booting	
0.46	0.49	0.48	0.40	0.39	0.42	0.41	0.35	tillering	Howler
0.50	0.55	0.52	0.42	0.43	0.48	0.45	0.36	elongation	
0.52	0.58	0.52	0.47	0.46	0.52	0.45	0.40	booting	
0.39	0.40	0.39	0.38	0.32	0.33	0.32	0.31	tillering	Aras
0.41	0.43	0.41	0.39	0.34	0.36	0.34	0.32	elongation	
0.43	0.45	0.43	0.41	0.36	0.38	0.36	0.34	booting	
0.007	0.0143			0.005	0.0073			LSD0.05	
cultivar * nano Potassium									
0.42	0.45	0.43	0.39	0.36	0.38	0.36	0.33	Abu Ghraib	
0.49	0.54	0.51	0.43	0.43	0.47	0.44	0.37	Howler	
0.41	0.43	0.41	0.39	0.34	0.36	0.34	0.32	Aras	
0.008	0.008			0.003	0.004			LSD0.05	
Spraying stage * nano Potassium									
0.42	0.44	0.42	0.39	0.35	0.37	0.36	0.33	tillering	
0.44	0.48	0.45	0.40	0.38	0.41	0.38	0.34	elongation	
0.47	0.50	0.47	0.43	0.40	0.44	0.40	0.36	booting	
0.004	0.008			0.003	0.004			LSD0.05	
	0.47	0.45	0.40		0.40	0.38	0.34	average	
	0.005				0.002			LSD0.05	

5--Effect of the cultivar, spraying stage, and nanopotassium on trait of the percentage of potassium in grains

The results of Table (6) indicate that there are significant differences between the levels of the factors studied in the average plant height. The Holler cultivar excelled, giving the highest average of 2.73% for the first season and the highest average for the second season of 2.89%, followed by the Abu Ghraib cultivar with an average of 2.33% for the first season and 2.49. % for the second season, then the Aras cultivar, with an average of 2.48% for the first season and 2.65% for the second season. As for the spraying date, the spraying treatment in the elongation stage excelled and gave the highest average of 2.69% for the first season and 2.87% for the second season, followed by the spraying treatment in the elongation stage and gave An average of 2.47% for the first season and 2.64% for the second season. As for the levels of nanopotassium, the treatment 2 g L-1 excelled and gave the highest average of 2.60% for the first season and 2.77% for the second

season compared to the treatment without spraying nanopotassium, which gave the lowest average of 2.43% for the first season and 2.59% for the second season. As for the dual interaction treatments, the treatment (Hawler cultivar + spraying in the booting stage) excelled and gave the highest average of 2.88% for the first season and 3.06% for the second season, while the treatment (Hawler cultivar + potassium spraying at a concentration of 2 g.L-1) excelled and gave the highest average. It reached 2.73% for the first season and 2.89% for the second season, while the interaction treatment (spraying in the lining stage + potassium spraying at a concentration of 2 g.L-1) was significantly superior and gave the highest average of 2.69% for the first season and 2.87% 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 superior and gave the highest average of 3.03% for the first season and 3.22% for the second season.

Table (6) Effect of cultivar, spraying stage, and nanopotassium on the K% in seeds

second season 2021/2022				first season 2020/2021				Spraying date	cultivar
average	Nano potassium g.L-1			average	Nano potassium g.L-1				
	2	1	0		2	1	0		
2.40	2.44	2.41	2.34	2.23	2.28	2.23	2.17	tillering	Abu Ghraib
2.47	2.51	2.47	2.43	2.30	2.35	2.29	2.25	elongation	
2.62	2.80	2.54	2.51	2.45	2.63	2.37	2.35	booting	
2.76	2.88	3.78	2.64	2.63	2.71	2.63	2.57	tillering	Howler
2.84	2.92	2.81	2.79	2.68	2.74	2.70	2.61	elongation	
3.06	3.22	3.06	2.91	2.88	3.03	2.89	2.72	booting	
2.43	2.47	2.43	2.39	2.26	2.29	2.28	2.20	tillering	Aras
2.61	2.72	2.57	2.53	0.43	2.54	2.40	2.34	elongation	
2.92	3.01	2.93	2.82	2.75	2.85	2.79	2.63	booting	
0.044	0.055			0.039	0.061			LSD0.05	
cultivar * nano Potassium									
2.49	2.58	2.47	2.42	2.33	2.42	2.30	2.26	Abu Ghraib	
2.89	3.01	2.88	2.78	2.73	2.83	2.74	2.63	Howler	
2.65	2.73	2.64	2.58	2.48	2.56	2.49	2.39	Aras	
0.056	0.032			0.040	0.035			LSD0.05	
Spraying stage * nano Potassium									
2.53	2.60	2.54	2.46	2.37	2.43	2.38	2.31	tillering	
2.64	2.72	2.61	2.58	2.47	2.54	2.47	2.40	elongation	
2.87	3.01	2.84	2.74	2.69	2.84	2.68	2.57	booting	
0.025	0.032			0.023	0.035			LSD0.05	
	2.77	2.67	2.59		2.60	2.51	2.43	average	
	0.018				0.020			LSD0.05	

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