Response of Wheat Varieties (Triticum aestivum L.) to Nano and Chemical Kinetin Spraying under Saline Soil Conditions

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Abstract

A field experiment was conducted at the Agricultural Research Station of the College of Agriculture, University of Basrah, located in Karmah Ali (30 km north of Basrah), at a latitude of 30.57°N and a longitude of 47.80°E, during the winter season of 2023-2024. The objective was to investigate the response of three wheat varieties (Aksad 59, Buhoth 10, and Buhoth 22) to nano and chemical kinetin spraying at concentrations of 0, 40, and 60 mg L, and the interactions between them. The experiment followed a factorial design using a Randomized Complete Block Design (RCBD) with three replications. Several growth and physiological traits were studied .The results showed significant differences among the wheat varieties in most of the traits studied. The Buhoth 10 variety exhibited the highest average flag leaf area (52.18 cm²), chlorophyll content (106.46 mg 100g fresh weight), seed growth rate (0.4863 mg week), and crop growth rate (7.9540 g m day). Meanwhile, the Aksad 59 variety recorded the highest average number of tillers (492.53 tillers m).The application of kinetin (both nano and chemical forms) significantly affected most of the traits studied. The 60 mg L nano kinetin treatment resulted in the highest average flag leaf area (47.72 cm²), chlorophyll content (107.11 mg 100g fresh weight), and crop growth rate (8.0447 g m day), whereas the 60 mg L chemical kinetin treatment resulted in the highest average number of tillers (510.67 tillers m). Additionally, the 40 mg L chemical kinetin treatment was the most effective for seed growth rate (0.3997 mg week.(

The interaction between varieties and kinetin spray concentrations had a significant effect on some growth and physiological traits, yield and its components. The interaction treatment between the variety Buhuth 10 and the concentration 60 mg L-1 nano kinetin gave the highest average flag leaf area of 62.85 cm2, leaf chlorophyll content of 109.67 mg 100 g-1 and crop growth rate of 9.1425 g m-2 day-1.

Introduction

Wheat (Triticum aestivum L.) a member of the Poaceae family, is one of the most important cereal crops globally. More than 35% of the world’s population depends on wheat as a major food source. It is rich in carbohydrates, proteins, minerals, and certain amino acids, which has earned it the title of the "king of crops (22). The importance of wheat lies in its grain content, particularly gluten, which is the main protein responsible for producing high-quality flour essential for bread making. Gluten contributes to the elasticity of the dough, and it makes up 80% of the protein in the wheat grain .

Globally, wheat is grown on about 222.77 million hectares, with a yield of approximately 788.95 tons per hectare. In Iraq, however, the area planted with wheat is around 2.6 million hectares, with an average yield of 5.2 tons per

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hectare (25). This yield is below the global average, despite Iraq's favorable conditions for wheat cultivation.

Over the past decades, various agricultural technologies have been employed to increase the productivity of cereal crops. These include the development of new wheat cultivars through breeding programs and conducting extensive tests to assess the suitability of these varieties to local environments. Many studies have shown significant differences in growth and physiological traits among wheat varieties.

Another approach to increase productivity involves using plant growth regulators (PGRs), such as auxins, gibberellins, abscisic acid, ethylene gas, and cytokinins. Kinetin ($C10H9N5O$), a derivative of cytokinin, is one such growth regulator. It promotes growth by breaking apical dominance and encouraging the development of lateral branches, which is crucial for increasing the productivity of cereal crops. Kinetin also plays an important role in nutrient movement towards treated areas with high metabolic activity, as well as influencing flower and seed development, cell division, and seed germination (24).In addition, some researchers have been exploring the use of nanotechnology, combined with chemical fertilizers, to enhance their efficiency and reduce their environmental impact. This approach is aimed at improving crop yields and quality by increasing the effectiveness of fertilizers in a more sustainable manner. Based on the above, the importance of this study came, which aims to: Determine the best variety that can be grown in the region, which gives the highest yield in quantity and quality. The effect of nano- and mineral-based kinetin on growth and physiological traits and compare their effect. Study the effect of the interaction between nano- and mineral-based kinetin and varieties to determine the best combination that achieves the highest response in growth and physiological traits in order to improve and increase wheat productivity in quantity and quality.

Materials and Methods

A field experiment was conducted during the winter season of 2023024 at one of the fields of the Agricultural Research Station affiliated with the College of Agriculture, University of Basrah (Karmah Ali site). The site is located 30 km north of the center of Basra Province, at a longitude of 47.80° W and a latitude of 30.57° N, with the soil being a clay-loam texture. The aim of the study was to examine the response of wheat varieties (Triticum aestivum L.) to the application of both chemical and nano kinetin sprays under saline soil conditions .

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

الصفة		القيمة	الوحدة
pH		**7.9**	**/**
E.C		**10.6**	**Desi Siemens M**
Soil separators	**Sand**	**368**	**g kg soil**
	Mud	**536**	
	Alluvial	**96**	
Soil texture		**Alluvial clay blend**	

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After determining the required land area, the experimental field was prepared by plowing it with a moldboard plow in two perpendicular plowings to a depth of 30 cm. The soil was then leveled using disc harrows. The field was divided into three blocks according to the experimental design, with each block containing 15 experimental units, making a total of 45 experimental units. The area of each unit was 4 m². A space of 1.5 meters was left between blocks, and 1-meter wide paths separated the plots. The plants were sown on 15/11/2023 in the winter season of 2023024 at a seeding rate of 120 kg•ha^{-1} on rows with a spacing of 15 cm between each row (2). Urea fertilizer (46% N) was added at a rate of 120 kg•N•ha^{-1} in two doses: the first after planting and the second during the elongation stage (3). Phosphatic fertilizer was applied as 100 kg•ha^{-1} of triple superphosphate (20% P_2O_5) in a single dose before planting (12).Nanocytokinin and mineral cytokinin were sprayed on the plant foliage at the specified concentrations in two stages: the tillering stage and the booting stage. The spraying was done using a 16-liter capacity pump early in the morning to avoid high sunlight and ensure maximum absorption of the material by the plants. Harvesting began on 17/3/2024. Growth and physiological traits were studied, including plant height, flag leaf area, number of tillers, chlorophyll content of the leaf, spike length, seed growth rate, and crop growth rate.

Plant height (cm:(

Ten samples were taken from each experimental unit after the plants reached 100% flowering stage, and the main stem of the plants was measured using a measuring tape and then the average plant height was extracted for each experimental unit.

Number of tillers (m-2 tillers:(

It was calculated after harvest by calculating the number of tillers from an area of a quarter meter (50 cm2) for each experimental unit and then the area was converted to square meters.

Flag leaf area (cm2:(

It was calculated by measuring the length and width of the widest area of the flag leaf and at a rate of 10 plants for each experimental unit when the plants reached 100% flowering stage and according to the following equation:

Flag leaf area = length of the flag leaf × width at the widest area × correction factor (0.95) (26.(

Spike length (cm:(

It was calculated as the average length of ten spikes from the base of the spike to the end of the last terminal spikelet except for the spikes taken randomly from the central lines of each experimental unit.

Chlorophyll content (mg100 g-1 fresh weight:(

Chlorophyll pigment was estimated by extracting chlorophyll using acetone (80%) and crushing the plants using a ceramic mortar. After extracting chlorophyll, the absorbance of the samples was read using a spectrophotometer at a wavelength of 663 nm for chlorophyll a and 645 nm for chlorophyll b. Then, the amount of chlorophyll (mg-1 L-1) was estimated according to the following equation (27:(

Total Chlorophyll (mg L-1) = [20.2D (645) 8.02D (663)]×V/1000×W.

Whereas:

Total Chlorophyll: Total chlorophyll content

D: Optical density reading of the extracted chlorophyll based on wavelengths 663 nm 645 nm

V: Final volume of diluted acetone at a concentration of (80%(

W: Weight of the fresh sample (0.5 g(

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Then calculate the chlorophyll content based on (mg 100 g-1 fresh weight) from the following equation: (28.(

)mg 100 g-1) = (mg L-1)/1000 ml x 100/sample weight (g.(

Crop growth rate (g m-2 day-1(

It was calculated by harvesting a sample of plants from an area of 50 cm2 from each experimental unit during the growth period and air-dried, then placed in paper bags and placed in an electric oven at a temperature of 65 °C for 48 hours. After the weight stabilized, it was weighed with a sensitive balance, then the weight was converted to the area of the square meter, and then the following equation was applied: (29(

CGR =1/GA×(W2-W1)/(T2-T1(

Where

GA: Sample area (m2(

W2: Dry weight of the sample in the second period (21/2/2024(

W1: Dry weight of the sample in the first period (21/1/2024(

T2: The second time in which the sample was taken

T1: The first time in which the sample was taken

Grain growth rate (mg week-1(

The weight of 100 grains was calculated as a first reading, then the weight was repeated After a week, the average growth is calculated according to the following equation: Average growth of the grain (mg/week-1) = (weight of the second - weight of the first) / measurement period.

Results and Discussion

Plant Height (cm(

The results in Table 2 show no significant differences among the wheat varieties for the plant height trait. However, Table 2 indicates a significant effect of the applied concentrations of nano and mineral cytokinin sprays on plant height. The control treatment achieved the highest average plant height of 86.29 cm, showing an increase of 12.44% compared to the 40 mg L-1 nano cytokinin treatment, which recorded the lowest average height of 76.74 cm. This result is consistent with the findings of (5), who stated that increasing cytokinin levels at the expense of auxins in plants leads to the breaking of apical dominance and encourages the growth of lateral branches, due to the altered natural ratios of these hormones within plant tissues, which reduces the vertical growth of the plant. The results in Table 2 also show that the interaction between wheat varieties and cytokinin concentrations had a significant effect on this trait. The highest plant height, 89.43 cm, was recorded for the interaction treatment of the variety Buhoth 10 with the control treatment, while the lowest plant height of 72.17 cm was observed for the interaction treatment of the Buhoth 10 variety with the 40 ppm nano cytokinin concentration.

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Table (2) Effect of Varieties and Caintin and interaction between Them on the Average Plant Height Characteristic (cm(

kinetin levels	Varieties			Average kinetin
	Aksad 59	Buhoth 10	Buhoth 22	
0	86.67	89.43	82.77	86.29
40Nano	81.20	72.17	76.87	76.74
60Nano	81.07	79.80	75.80	78.89
Chemical40	78.20	83.07	80.80	80.69
60chemical	80.13	83.00	86.07	83.07
Average Varieties	81.45	81.49	80.46	
0.05	kinetin	Varieties		Interaction
	2.335	N.S		4.044

Flag Leaf Area (cm²(

Table 3 shows that the Buhoth 10 variety outperformed the other varieties studied in terms of flag leaf area, with the highest average of 52.18 cm², an increase of 44.98% compared to the Buhoth 22 variety, which recorded the lowest average of 35.99 cm². The superiority of the Buhoth 10 variety can be attributed to genetic differences among the varieties, which result in differences in photosynthetic efficiency and better utilization of growth requirements, as well as variations in growth characteristics and photosynthetic capacity. The flag leaf is a key indicator in photosynthesis, contributing to about 83% of the photosynthetic output and the transport of assimilates from the source to the sink, as it is the leaf closest to the spike (13). This result is consistent with the findings of (23) and (11), who observed significant differences between wheat varieties in terms of flag leaf area in their studies. Table 3 also indicates a significant effect of the applied concentrations of nano and mineral cytokinin sprays on flag leaf area. The 60 mg/L nano cytokinin concentration achieved the highest average of 47.72 cm², with an increase of 19.78% compared to the control treatment, which recorded the lowest average of 39.84 cm². This can be attributed to the effect of cytokinin on cell division, cell wall softening, and the ability of the cells to expand, leading to increased cell size and leaf area (21). This finding is in agreement with the results of (19), who also reported significant differences between cytokinin spray concentrations in flag leaf area during their study on cytokinin growth regulators. The results in Table 3 also show that the interaction between wheat varieties and cytokinin concentrations significantly affected this trait. The highest average flag leaf area of 62.85 cm² was recorded for the interaction treatment of the Buhoth 10 variety with the 60 mg L-1 nano cytokinin concentration, while the lowest leaf area of 30.07 cm² was observed for the interaction treatment with no spray on the Buhoth 22 variety.

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Table 3: Effect of varieties, cytokinin treatments, and their interaction on the average flag leaf area

kinetin levels	Varieties			Average kinetin
	Aksad 59	Buhoth 10	Buhoth 22	
0	41.30	48.15	30.07	39.84
40Nano	45.19	52.29	32.35	43.28
60Nano	41.72	62.85	38.60	47.72
Chemical40	40.47	52.54	37.14	43.38
60chemical	48.07	45.05	41.77	44.96
Average Varieties	43.35	52.18	35.99	39.84
0.05	kinetin	Varieties		Interaction
	0.884	0.685		1.532

Number of Tillers (tillers m²(

From Table 4, it is observed that the variety Aksad 59 showed the highest average number of tillers, recording an average of 492.53 tillers m², which was not significantly different from Buhoth 22 that recorded an average of 490.93 tillers m². On the other hand, the variety Buhoth 10 had the lowest average with 467.60 tillers m². The genetic factor is the primary determinant of a plant's ability to produce tillers, which leads to differences between varieties in this trait. This result aligns with those of (23) and (11), who found significant differences between varieties in the number of tillers during their studies on wheat.

Table 4 also indicates a significant effect of the concentrations of nano and mineral cytokinin sprays on the number of tillers. The 60 mg L-1 mineral** cytokinin treatment produced the highest average 510.67 tillers m², while the control treatment recorded the lowest average, 454.22 tillers m². The increased number of tillers can be attributed to the role of cytokinin in regulating the distribution of photosynthetic products between various plant parts, as well as its effect on cellular division and the breaking of apical dominance. Cytokinin's antagonistic action against auxins accumulated in apical buds results in the breaking of dormancy and the growth and development of lateral buds. This process, in turn, stimulates the differentiation and widening of vascular bundles (xylem and phloem), facilitating the flow of nutrients and water to the growing buds, which ultimately leads to an increase in the number of tillers (16). These results are consistent with those of (17) and (9), who found a significant increase in the number of tillers when wheat was treated with cytokinin. Furthermore, the interaction between varieties and cytokinin concentrations significantly affected the number of tillers. The interaction between Buhoth 22 and the 60 mg L mineral

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cytokinin treatment resulted in the highest average number of tillers, reaching 544.00 tillers m², while the lowest number of tillers (432.00 tillers m²) was observed in the Buhoth 10 variety under the control treatment.

Table 4: Effect of varieties, cytokinin treatments, and their interaction on the average number of tillers (tillers m²(

kinetin levels	Varieties			Average kinetin
	Aksad 59	Buhoth 10	Buhoth 22	
0	470.67	432.00	460.00	454.22
40Nano	492.00	445.33	521.33	486.22
60Nano	433.33	528.00	465.33	475.56
Chemical40	534.67	476.67	464.00	491.78
60chemical	532.00	456.00	544.00	510.67
Average Varieties	492.53	467.60	490.93	
0.05	kinetin	Varieties		Interaction
	4.267	3.305		7.390

Spike Length (cm(

The results in Table 5 indicate that the Buhuth 10 variety is superior in the average spike length, giving it the highest average of 12.36 cm, compared to the Axad 59 variety, which recorded the lowest average of 10.67 cm. The variation of varieties in this trait is due to the difference in genetic compositions between varieties, as it is considered one of the traits most closely related to genetic factors (4 .(

Table (5): Effect of Cultivars, Kinetin, and Their Interaction on the Average Spike Length (cm(

kinetin levels	Varieties			Average kinetin
	Aksad 59	Buhoth 10	Buhoth 22	
0	11.80	12.37	11.30	11.83
40Nano	10.47	11.90	11.53	11.30
60Nano	10.73	12.80	11.33	11.62
Chemical40	10.67	12.70	10.83	11.40
60chemical	9.63	12.03	11.93	11.20
Average Varieties	10.67	12.36	11.39	
0.05	kinetin	Varieties		Interaction
	N.S	0.895		N.S

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Chlorophyll Content in Leaf (mg 100 g^{-1} Fresh Weight(

The results presented in Table 6 indicate that the cultivar Buhoth 10 outperformed the other cultivars studied in terms of average chlorophyll content, with the highest average of 106.46 mg 100 g^{-1}, while the cultivar Buhoth 22 recorded the lowest average of 105.13 mg 100 g^{-1}. The superiority of Buhoth 10* is attributed to the genetic differences among cultivars and their ability to carry out photosynthesis (10). This result is in agreement with the findings of (8) and (7) in their studies on wheat.Table 6 also shows a significant effect of kinetin spray concentrations (nano and mineral) on chlorophyll content. The 60 mg L^{-1} nano kinetin treatment achieved the highest average of 107.11 mg 100 g^{-1}, whereas the 40 mg L^{-1} mineral kinetin treatment recorded the lowest average of 104.78 mg 100 g^{-1}. The reason can be attributed to the role of kinetin in stimulating the absorption of nutrients more effectively, which enhances the plant's ability to produce chlorophyll and perform physiological processes such as photosynthesis, increasing enzymatic activity, and stimulating plant hormones such as cytokinins that play a major role in leaf growth and increasing their chlorophyll content (20)

Table (6): Effect of Cultivars, Kinetin, and Their Interaction on the Average Chlorophyll Content in Leaf (mg 100 g^{-1} Fresh Weight(

kinetin levels	Varieties			Average kinetin
	Aksad 59	Buhoth 10	Buhoth 22	
0	105.32	103.10	106.41	104.94
40Nano	104.41	109.31	105.13	106.28
60Nano	105.65	109.67	106.02	107.11
Chemical40	104.27	106.87	103.19	104.78
60chemical	107.26	103.36	104.91	105.18
Average Varieties	105.38	106.46	105.13	
0.05	Kinetin	Varieties		interaction
	0.742	0.575		1.286

Seed Growth Rate (mg $week^{-1}$(

Table 7 shows that the cultivar Buhoth 10 outperformed the other cultivars in terms of average seed growth rate, with the highest average of 0.4863 mg $week^{-1}$, representing a 33.96% increase over Buhoth 22, which recorded the lowest average of 0.1925 mg $week^{-1}$. The superiority of Buhoth 10 can be attributed to the differences among cultivars in their growth characteristics and ability to produce dry matter. It is also related to the lower number of tillers for this cultivar (Table 6) and the number of spikes (Table 11), which allowed the fewer seeds to accumulate a larger amount of photosynthetic products. This is clearly reflected in the 1000-seed weight (Table 13), where Buhoth 10 was superior. This result is consistent with the findings of Abdul Jabbar and Nuri (2013).Table 7 also indicates a significant effect of kinetin spray concentrations (nano and mineral) on seed growth rate. The 40 mg L^{-1} mineral kinetin treatment achieved the highest average of

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0.3997 mg week^{-1}, a 19.99% increase over the 40 mg L^{-1} nano kinetin treatment, which recorded the lowest average of 0.3219 mg week^{-1}. This can be attributed to the lower number of seeds per spike (Table 12) at the same concentration, which reduces competition among seeds, thus positively impacting food production and dry matter accumulation. Additionally, kinetin helps delay plant senescence, which aids in activating absorption and transportation processes, increasing dry matter production, and prolonging the grain filling period, leading to increased dry matter accumulation in the seeds by facilitating the movement of metabolic products within the plant from source to sink (5). This result is in agreement with the findings of (17.(

The results of Table 7 also indicate that the interaction between cultivars and kinetin concentrations significantly affected this trait. The interaction between the Buhoth 10 cultivar and 40 mg L^{-1} mineral kinetin achieved the highest average seed growth rate of 0.6420 mg week^{-1}, while the interaction between Buhoth 22 and 40 mg L^{-1} mineral kinetin resulted in the lowest average of 0.1413 mg week^{-1}.

Table (7): Effect of Cultivars, Kinetin, and Their Interaction on the Average Seed Growth Rate (mg week^{-1}(

kinetin levels	Varieties			Average kinetin
	Aksad 59	Buhoth 10	Buhoth 22	
0	0.4077	0.4263	0.1757	0.3366
40Nano	0.3320	0.4073	0.2263	0.3219
60Nano	0.3143	0.4563	0.2287	0.3331
Chemical40	0.4157	0.6420	0.1413	0.3997
60chemical	0.3430	0.4993	0.1907	0.3443
Average Varieties	0.3625	0.4863	0.1925	
0.05	kinetin	Varieties		interaction
	0.02938	0.02275		0.05079

Crop Growth Rate (g m^{-2} day^{-1}(

As shown in Table 8, the cultivar Buhoth 10 outperformed the other studied cultivars in terms of average crop growth rate, achieving the highest average of 7.9540 g m^{-2} day^{-1}, while the cultivar Buhoth 22 recorded the lowest average of 6.9148 g m^{-2} day^{-1}. This superiority of Buhoth 10 can be attributed to its higher leaf area (Table 5) and chlorophyll content (Table 6), which resulted in an increased crop growth rate. These findings are consistent with those of (15) and (18).Table 8 also indicates a significant effect of kinetin spray concentrations (nano and regular) on the crop growth rate. The 60 mg L^{-1} nano kinetin treatment achieved the highest average of 8.0447 g m^{-2} day^{-1}, showing a 26.40% increase compared to the control treatment, which recorded the lowest average of 6.3640 g m^{-2} day^{-1}. The superiority of the 60 mg L^{-1} nano kinetin concentration can be attributed to the effective role of kinetin in enhancing chlorophyll content and leaf area, which led to increased dry matter accumulation in various plant parts, positively affecting the overall crop growth rate. This result is in agreement

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with (5).The results in Table 8 also show that the interaction between cultivars and kinetin concentrations significantly influenced this trait. The interaction between the Buhoth 10 cultivar and the 60 mg L^{-1} nano kinetin treatment achieved the highest average crop growth rate of 9.1425 g m^{-2} day^{-1}, while the interaction between Aksad 59 cultivar and the control treatment resulted in the lowest average of 6.2920 g m^{-2} day^{-1}.

Table (8): Effect of Cultivars, Kinetin, and Their Interaction on the Average Crop Growth Rate (g m^{-2} day^{-1}(

kinetin levels	Varieties			Average kinetin
	Aksad 59	Buhoth 10	Buhoth 22	
0	6.2920	6.3805	6.4195	6.3640
40Nano	6.6347	8.9066	7.1197	7.5537
60Nano	7.8887	9.1425	7.1029	8.0447
Chemical40	6.9753	7.1425	6.9935	7.0372
60chemical	7.8887	8.1977	6.9385	7.6749
Average Varieties	7.1359	7.9540	6.9148	
0.05	kinetin	Varieties		interaction
	0.05839	0.04523		0.10113

Conclusions

The Buhoth 10 cultivar outperformed the other cultivars in most of the studied traits, especially when treated with a 60 mg L^{-1} nano kinetin concentration, showing significant improvements in yield quantity and quality. The results showed that the interaction between cultivars and kinetin concentrations had a significant effect, with the combination of the Buhoth 10 cultivar and 60 mg L^{-1} nano kinetin concentration outperforming the other treatments in most of the traits measured.

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