Effect of soaking and spraying with potassium sulphate at different growth stages on some growth and quality traits of wheat crop

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Abstract :
During the winter season 2022-2023, a field experiment was conducted in the experimental field of the Department of Field Crops - College of Agriculture - Al-Qasim Green University located south of Hillah city - Babylon province, at latitude 032.40- north and longitude 044.39- east. The experiment aimed to know the effect of soaking seeds with potassium sulfate solution before planting and the effect of foliar spray treatment with potassium sulfate at different age stages in improving the growth and quality traits of bread wheat (Triticum aestivum L.) IPA 99 Cultivar order. The experimental land was prepared by, plowing, smoothing and leveling, then divided into plots and experimental units, each with an area of 4 m2 (2 m × 2 m) according to the randomized complete block design (RCBD) with a split-block arrangement with three replicates. The wheat seed soaking concentrations were (0, 1.5%, 3%) for eight hours with potassium sulphate solution for the main plots and stages of spraying potassium sulphate solution (tillering + elongation, tillering + booting, elongation + booting) at two spraying times for each stage for subplot and concentrations of spraying potassium sulphate solution (0, 1.5%, 3%) for the sub-sub plots. The three experimental factors and some of their interactions caused significant differences in the quality traits of wheat seed crop (number of tillers, number of spikes, seed ash content, seed nitrogen content, seed potassium content) with increasing concentrations of soaking and spraying with potassium sulphate solution and with timing of foliar spraying in advanced age stages. The results indicated that the 3% soaking concentration with potassium sulphate solution before planting was excelled in the above traits compared to not soaking and achieved the highest averages which reached (429.7 tiller. m-2, 419.0 spikes m-2, 2.39%, 1.95%, 1.50%) respectively, while the growth stage (elongation + booting) was significantly excelled in the above studied characteristics by giving the highest averages which reached (414.8 tiller. m-2, 378.0 spikes m-2, 2.22%, 1.92%, 1.55%) respectively, and the spraying factor also achieved significant differences, as the 3% spraying concentration gave the highest averages which reached (426.2 tiller. m-2, 414.9 spikes m-2, 2.24%). , 1.90%, 1.59%) respectively. As for bi and triple interactions, some of them were significant and others were not significant. From the above results, we can conclude that the experimental factors and some of their interactions have a positive role in improving some growth and quality traits of the wheat crop. The soaking and foliar spraying processes with potassium sulphate solution had a positive effect on the number of tillers and the number of spikes, and thus improved the quantitative and qualitative indicators of the crop. Spraying the solution at advanced stages of the plant's life was important in compensating for the deficiency of the depleted or fixed potassium element in the soil, and thus increasing the seed content of potassium, nitrogen and ash .

Keywords: wheat, potassium sulfate, seed soaking, growth stages, foliar spray, seed quality

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Introduction

The wheat crop Triticum aestivum L., which belongs to the Poaceae family, is one of the most important winter cereal crops in Iraq and the Middle East. It is grown in large areas globally and locally. In 2019, its global production reached 761.6 million tons[12]and in Iraq, its production for 2022 reached more than four million tons [11]. The availability of mineral nutrients at all stages of the plant's life, especially the filling stage, plays a major role in improving the quality of the crop in general and the seeds in particular [8]. Environmental and climatic factors such as (temperature, relative humidity, lighting, wind) control the growth and development processes that take place during the vegetative period of the crop's life, and often Environmental factors have a quantitative and qualitative impact on the wheat crop and its components [5] and therefore the properties of the resulting grains are also greatly affected [16] Many studies indicate that soaking wheat seeds or spraying them with some nutrients, including potassium sulfate, at developmental stages of the wheat crop's life on the vegetative part may play an important role in improving physiological activities that are reflected in increased growth and production of dry matter and its transfer to the seeds [17] and obtaining a quantity and quality of high-quality seeds for different grades and reducing the adverse effect of temperatures and various other surrounding conditions [18[

Materials and methods:

The experimental land was prepared by tilling, smoothing and leveling, then divided into plots and experimental units, each with an area of 4 m2 (2 m x 2 m) according to a randomized complete block design (RCBD) with split plots arranged in three replicates. The wheat seed soaking concentrations (0, 1.5%, 3%) for eight hours in potassium sulfate solution occupied the main plots and the stages of spraying potassium sulfate solution (tillering + elongation, tillering + booting, elongation + booting) at a rate of two spraying times for each stage in subplot and the concentrations of spraying potassium sulfate solution (0, 1.5%, 3%) in the sub-sub plots.

A field experiment was conducted during the winter season 2022-2023 in the experimental field of the Department of Field Crops - College of Agriculture - Al-Qasim Green University, in soil with some of its characteristics shown below in Table 1. After preparing the soil, it was divided into experimental plots and units, each with an area of (2 m x 2 m) according to the randomized complete block design (RCBD) with split plots arranged in three replicates. Seed soaking concentrations (for eight hours) with potassium sulfate solution (0, 1.5%, 3%) occupied the main plots and the stages of spraying potassium sulfate (tillering + elongation, tillering + booting, elongation + booting) occupied subplot and potassium sulfate solution spray concentrations (0, 1.5%, 3%) sub-secondary plots as shown in Tables (2, 3, 4). Nutrients were sprayed in the early morning until completely wet, taking into account the separation between the units Experimental. The growth stages that were sprayed with potassium sulfate solution were determined according to the Zadoks scale [20]. According to the method of [2]. The data were collected and statistically analyzed using the statistical program -12 GenStat (2009) and the statistical differences between the averages were tested using the L.S.D test and at the probability level (0.05) to compare the arithmetic averages [7.[

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Table 1: Soil and water analysis (Central Laboratory in the Directorate of Agriculture in Babylon / Al-Muradiyyah(

values	traits		Sample type
8.0	Soil reaction degree (pH)		field soil
3.0	Electrical conductivity (dSm-1 (EC)		
1.34	Organic matter %		
406	Clay percentage g kg^{-1}	Volume distribution of soil particles	
332	silt Percentage, g kg^{-1}		
262	Sand percentage, gm kg^{-1}		
Silty clay loam	soil texture		
39.0	Nitrogen mg kg^{-1} (ppm)		
9.6	Phosphorus mg kg^{-1} (ppm)		
146	Potassium mg kg^{-1} (ppm)		
5.64	Sulphate SO_4 Mq L^{-1}		
7.5	Reaction degree (pH)		irrigation water
2.5	Electrical conductivity (dSm^{-1} (EC		

The studied traits

-1The total number of tillers per square meter (tiller m-2.(

The number of tillers per square meter was calculated manually after harvesting the square meter and for each experimental unit [3,[

-2Number of spikes (spike m-2(

The number of spikes per square meter was calculated manually after harvesting the square meter and for each experimental unit [6[

:-3Ash content of seeds(%)

The percentage of ash was estimated in the Seed Technology Laboratory / Department of Field Crops / College of Agriculture / Al-Qasim Green University by burning a ground sample of wheat seeds placed in a special ceramic in the incinerator at a temperature of 550 °C for six hours, then the ash was weighed after subtracting the weight of the ceramic and extracting its weight percentage [4] and that seed ash generally consists of phosphorus, potassium, calcium, magnesium and other elements [19[

-4Nitrogen content of seeds.(%)

The nitrogen content of the seeds was estimated using the KJeldhal device [9] after digesting the milled grain sample according to the method of [10[

-5Potassium content of the seeds(%)

The potassium content in the digested grain sample was estimated using the Flame Photometer according to the method approved by [14[

Results

-1Number of tillers / tiller m-2

The results of Table 5 showed significant differences between the concentrations of soaking seeds before planting with potassium sulfate solution in the number of tillers trait, as soaking with the third concentration 3% potassium sulfate achieved the highest average of 429.7 tiller m-2, compared to control treatment without soaking which achieved the lowest average of 379.2 tiller m-2. It is also

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noted from Table 5 that there are significant differences between the growth stages sprayed with potassium sulfate solution in the number of tillers trait, as the growth stage (elongation + booting) achieved the highest average of 414.8 tiller m-2, while the growth stage (tillering + elongation) achieved the lowest average of 397.9 tiller m-2. In addition to the presence of significant differences between the foliar spray concentrations of potassium in the trait of the number of tillers, as the spray concentration of 3% achieved the highest average of 426.2 tillers m-2, while control treatment without spraying 0% achieved the lowest average of 380.5 tillers m-2. Table 5 showed the presence of significant differences in bi-interaction between the soaking factors and the growth stages in the trait of the number of tillers, as the interaction (soaking at a concentration of 3% × growth stage, elongation of the booting) was excelled by giving the highest average of 436.2 tillers m-2, while the interaction (without soaking × growth stage, tillering + elongation) achieved the lowest average of 369.4 tillers m-2. The interaction between the factors of soaking and foliar spraying of potassium sulfate solution achieved significant differences in the number of tillers, as the interaction (soaking at a concentration of 3% × spraying at a concentration of 3%) was excelled by giving the highest average of 453.3 tillers m-2, while the interaction (without soaking × without spraying) achieved the lowest average of 360.6 tillers m-2. The interaction between the factors of growth stages and foliar spraying of potassium sulfate solution also achieved significant differences in the number of tillers, where the interaction (elongation stage + booting × spraying at a concentration of 3%) was excelled by giving the highest average of 438.1 tillers m-2, while the interaction (tillering + elongation × without spraying) achieved the lowest average of 374.2 tillers m-2, while the triple interactions did not achieve any significant differences .

Table (1) Effect of soaking and spraying potassium sulphate at different growth stages on the number of tillers in wheat crop / tiller m-2

2023-2022season				treatments	
interaction of soaking and growth stages A × B	Foliar spray concentrations			Growth stages	Soaking seeds
	%3	%1.5	0		
369.4	382.3	374.7	351.3	tillering+ Elongation	0
374.9	391.7	371.7	361.3	tillering + booting	
393.1	414.7	395.7	369.0	Elongation + booting	
399.0	419.3	402.3	375.3	tillering+ Elongation	%1.5
408.9	429.7	404.3	392.7	tillering + booting	
415.1	437.7	418.7	389.0	Elongation + booting	
425.1	448.7	430.7	396.0	tillering+ Elongation	%3
427.7	449.3	439.0	394.7	tillering + booting	
436.2	462.0	451.3	395.3	Elongation + booting	
7.34	N.S			LSD 0.05	
Soaking seeds effect	426.2	409.8	380.5	Effect of foliar spray C	

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A	4.32			LSD 0.05	
379.2	396	381	361	0	Interaction of benefit and foliar spray A × C
407.7	429	408	386	% 1.5	
429.7	453	440	395	% 3	
6.16	7.73			LSD 0.05	
Growth stages effect B					
397.9	416.8	402.6	374.2	tillering+ Elongation	Growth stages and foliar spray overlap B × C
403.8	423.6	405.0	382.9	tillering + booting	
414.8	438.1	421.9	384.4	Elongation + booting	
4.00	7.09			LSD 0.05	

-2Number of spikes. m-2

The results of the statistical analysis shown in Table 2 showed significant effects of the experimental factors on the number of spikes per square meter, as soaking with the third concentration of 3% potassium sulfate was significantly excelled and gave the highest average of 419.0 spikes. m-2, compared to control treatment without soaking, which achieved the lowest average of 369.9 spikes. m-2. The growth stage (elongation + booting) also achieved the highest average of 378.0 spikes. m-2, while the growth stage (tillering + elongation) achieved the lowest average of 366.0 spikes. m-2. As for the spraying concentration of 3%, it achieved the highest average of 414.9 spikes. m-2, while control treatment without spraying achieved the lowest average of 372.8 spikes. m-2. As for bi and triple interactions, they did not achieve any significant differences.

Table (2) Effect of soaking and spraying potassium sulphate at different growth stages on the number of spikes per square meter of wheat crop/spike m-2

2023-2022season				treatments	
interaction of soaking and growth stages A * B	Foliar spray concentrations			Growth stages	Soaking seeds
	%3	%1.5	0		
360.0	372.0	366.0	342.0	tillering+ Elongation	0
365.3	381.0	361.0	354.0	tillering + booting	
384.3	404.0	387.0	362.0	Elongation + booting	
391.0	409.0	395.0	369.0	tillering+ Elongation	%1.5
397.3	419.0	392.0	381.0	tillering + booting	
407.0	428.0	411.0	382.0	Elongation + booting	
414.0	436.0	419.0	387.0	tillering+ Elongation	%3
417.3	437.0	427.0	388.0	tillering + booting	
425.7	448.0	439.0	390.0	Elongation + booting	
N.S	N.S			LSD 0.05	
Soaking seeds effect A	414.9	399.7	372.8	Effect of foliar spray C	
	9.12			LSD 0.05	
369.9	385.7	371.3	352.7	0	Interaction of benefit and foliar spray A * C
398.4	418.7	399.3	377.3	% 1.5	
419.0	440.3	428.3	388.3	% 3	
13.51	N.S			LSD 0.05	
Growth stages effect B					
366.0	405.7	393.3	366.0	tillering+ Elongation	Growth stages and foliar spray overlap B * C
374.3	412.3	393.3	374.3	tillering + booting	
378.0	426.7	412.3	378.0	Elongation + booting	
6.22	N.S			LSD 0.05	

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-3Seed ash content%

The results of Table 3 showed significant differences between the concentrations of soaking seeds before planting with potassium sulfate solution in the ash content of the seeds, as soaking with the third concentration of 3% potassium sulfate achieved the highest average of 2.39%, compared to control treatment without soaking, which achieved the lowest average of 1.89%. It is also noted that there are significant differences between the growth stages in which potassium sulfate solution was sprayed in the ash content of the seeds, as the growth stage (elongation + booting) achieved the highest average of 2.22%, while the growth stage (tillering + elongation) achieved the lowest average of 2.08%. The table below also indicated that there were significant differences between the potassium foliar spray concentrations in the seed ash content, as the 3% spray concentration achieved the highest average of 2.24%, while the 1.5% spray treatment achieved the lowest average of 2.03%. Table 2 showed that there were no significant differences in bi-interaction between the soaking and growth stages factors in the seed ash content. As for bi-interaction between the soaking and foliar spray factors, it achieved significant differences in the seed ash content trait, as bi-interaction treatment between (soaking concentration 3% × spraying concentration 3%) excelled by achieving the highest average of 2.46%, while the interaction treatment between the control treatments achieved the lowest average of 1.72%. Bi-interaction between the growth stages and foliar spraying of potassium sulphate solution also achieved significant differences in the seed ash content trait, as bi-interaction treatment between (elongation + booting × spraying at a concentration of 3%) excelled by achieving the highest average of 2.35%, while the lowest average was for bi-interaction treatment between (growth stage tillering + elongation × no spraying) which reached 1.99%. As for the triple interaction, it was significant in the seed ash content trait, as the triple interaction treatment (soaking at a concentration of 3% × growth stage elongation + booting × spraying at a concentration of 3%) excelled significantly by giving the highest average of 2.58%, while the triple interaction treatment (no soaking × growth stage tillering + elongation × no spraying) achieved the lowest average of 1.69%.

Table (3) Effect of soaking and spraying potassium sulphate at different growth stages on the ash content of wheat seeds(%)

2023-2022season				treatments	
interaction of soaking and growth stages A × B	Foliar spray concentrations			Growth stages	Soaking seeds
	%3	%1.5	0		
1.83	1.95	1.86	1.69	tillering+ Elongation	0
1.87	2.02	1.89	1.71	tillering + booting	
1.98	2.14	2.04	1.75	Elongation + booting	
2.09	2.17	2.09	2.02	tillering+	

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				Elongation	%1.5
2.16	2.21	2.16	2.10	tillering + booting	
2.23	2.34	2.18	2.17	Elongation + booting	
2.33	2.38	2.35	2.25	tillering+ Elongation	%3
2.38	2.42	2.39	2.31	tillering + booting	
2.45	2.58	2.48	2.31	Elongation + booting	
N.S	0.07			LSD 0.05	
Soaking seeds effect A	2.24	2.16	2.03	Effect of foliar spray C	
	0.02			LSD 0.05	
1.89	2.03	1.93	1.72	0	Interaction of benefit and foliar spray A *× C
2.16	2.24	2.14	2.10	% 1.5	
2.39	2.46	2.41	2.29	% 3	
0.02	0.04			LSD 0.05	
Growth stages effect B					
2.08	2.17	2.10	1.99	tillering+ Elongation	Growth stages and foliar spray overlap B × C
2.13	2.22	2.15	2.04	tillering + booting	
2.22	2.35	2.24	2.08	Elongation + booting	
0.04	0.05			LSD 0.05	

-4Seed nitrogen content %

The results of Table 4 showed significant differences between the concentrations of soaking seeds before planting with potassium sulfate solution in the trait of seed nitrogen content, as soaking with the third concentration of 3% potassium sulfate achieved the highest average of 1.95%, compared to control treatment without soaking, which achieved the lowest average of 1.70%. It is also noted that there are significant differences between the growth stages in which potassium sulfate solution was sprayed in the seed nitrogen content, as the growth stage (elongation + booting) achieved the highest average of 1.92%, while the growth stage (tillering + elongation) achieved the lowest average of 1.81%. The table below also indicated that there were significant differences between the potassium foliar spray concentrations in the nitrogen content of seeds, as the 3% spray concentration achieved the highest average of 1.90%, while the 1.5% spray treatment achieved the lowest average of 1.81%. Table 4 showed that there were significant differences in bi-interaction

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between the soaking and growth stages factors in the nitrogen content of seeds, as the interaction (soaking at a concentration of 3% × growth stage elongation + booting) was excelled by giving the highest average of 2.08%, while the interaction (without soaking × growth stage tillering + elongation) achieved the lowest average of 1.61%. The interaction between the factors of soaking and foliar spraying of potassium sulfate solution also achieved significant differences in the nitrogen content of seeds, as the interaction (soaking at a concentration of 3% × spraying at a concentration of 3%) was excelled by giving the highest average of 2.08%, while the interaction (without soaking × spraying at a concentration of 1.5%) achieved the lowest average of 1.66%. The interaction between the factors of growth stages and foliar spraying of potassium sulfate solution also achieved significant differences in the nitrogen content of seeds, as the interaction (growth stage elongation + booting × spraying at a concentration of 3%) was excelled by giving the highest average of 2.11%, while the interaction (growth stage tillering + booting × spraying at a concentration of 3%) achieved the lowest average of 1.62%. The triple interaction was significant, as the interaction (soaking at a concentration of 3% × growth stage elongation + booting × spraying at a concentration of 3%) was excelled, giving the highest average of 2.44%, while the interaction (without soaking × tillering + booting × spraying at a concentration of 3%) achieved the lowest average of 1.18% .

Table 4. Effect of soaking and spraying potassium sulphate at different growth stages on the nitrogen content of wheat seeds%

2023-2022season				treatments	
interaction of soaking and growth stages A × B	Foliar spray concentrations			Growth stages	Soaking seeds
	%3	%1.5	0		
1.61	1.98	1.19	1.65	tillering+ Elongation	0
1.69	1.18	1.99	1.90	tillering + booting	
1.82	1.99	1.79	1.67	Elongation + booting	
1.93	1.96	1.89	1.94	tillering+ Elongation	%1.5
1.88	1.89	1.79	1.97	tillering + booting	
1.85	1.89	1.78	1.89	Elongation + booting	
1.90	2.00	1.91	1.78	tillering+ Elongation	%3
1.87	1.79	1.96	1.86	tillering + booting	

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2.08	2.44	1.92	1.89	Elongation + booting	
0.1	0.2			LSD 0.05	
Soaking seeds effect A	1.90	1.80	1.84	Effect of foliar spray C	
	0.1			LSD 0.05	
1.70	1.72	1.66	1.74	0	Interaction of benefit and foliar spray A *× C
1.89	1.91	1.82	1.93	% 1.5	
1.95	2.08	1.93	1.84	% 3	
0.1	0.1			LSD 0.05	
Growth stages effect B					
1.81	1.98	1.66	1.79	tillering+ Elongation	Growth stages and foliar spray overlap B × C
1.82	1.62	1.91	1.91	tillering + booting	
1.92	2.11	1.83	1.82	Elongation + booting	
0.1	0.1			LSD 0.05	

-5Seed potassium content%

The results of the statistical analysis shown in Table 5 showed significant differences in the potassium content of seeds between the concentrations of soaking with potassium sulfate solution, growth stages, and spraying concentrations with potassium sulfate solution, and some binary and triple interactions. Soaking with the second concentration of 1.5% of potassium sulfate achieved the highest averages, which reached 1.63%, compared to control treatment without soaking, which achieved the lowest average of 1.49%. It is also noted that there are significant differences between the growth stages in which potassium sulfate solution was sprayed in the seed potassium content, as the growth stage (tillering + booting) achieved the highest averages, which reached 1.60%, while the growth stage (tillering + elongation) achieved the lowest average of 1.51%. The spraying concentration of 3% also achieved the highest average of 1.59%, while control treatment of 0% achieved the lowest average of 1.50%. Table 5 showed significant differences in bi-interaction between the soaking and growth stages in the seed potassium content, as the interaction (soaking at a concentration of 1.5% × growth stage tillering + booting) was excelled by giving the highest average of 1.79%, while the interaction (without soaking × growth stage tillering + elongation) achieved the lowest average of 1.33%. The interaction between the soaking and foliar spraying of potassium sulphate solution also achieved significant differences in the seed potassium content, as the interaction (soaking at a concentration of 3% × spraying at a concentration of 3%) was excelled by giving the highest average of 1.75%, while the

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interaction (soaking at a concentration of 3% × without spraying) achieved the lowest average of 1.29%. The interaction between the growth stages and foliar spraying of potassium sulfate solution also achieved significant differences in the seed potassium content, as the interaction (growth stage tillering + booting × spraying at a concentration of 3%) was excelled by giving the highest average of 1.73%, while the interaction (growth stage tillering + elongation × without spraying) achieved the lowest average of 1.45%.As for the triple interaction, it was significant in the seed potassium content, as the interaction (soaking at a concentration of 1.5% × growth stage tillering + booting × spraying at a concentration of 3%) was excelled by giving the highest average of 1.89%, while the interaction (without soaking × growth stage tillering + elongation × without spraying) achieved the lowest average of 1.32%.

Table (5) Effect of soaking and spraying potassium sulfate at different growth stages on the wheat seed potassium content%

2023-2022season				treatments	
interaction of soaking and growth stages A × B	Foliar spray concentrations			Growth stages	Soaking seeds
	%3	%1.5	0		
1.33	1.33	1.34	1.32	tillering+ Elongation	0
1.51	1.55	1.54	1.45	tillering + booting	
1.57	1.65	1.46	1.59	Elongation + booting	
1.69	1.71	1.69	1.67	tillering+ Elongation	%1.5
1.79	1.89	1.77	1.70	tillering + booting	
1.62	1.45	1.55	1.87	Elongation + booting	
1.45	1.45	1.56	1.35	tillering+ Elongation	%3
1.49	1.76	1.44	1.26	tillering + booting	
1.35	1.43	1.34	1.27	Elongation + booting	
0.08	0.15			LSD 0.05	
Soaking seeds effect A	1.59	1.52	1.50	Effect of foliar spray C	
	0.05			LSD 0.05	
1.49	1.55	1.46	1.46	0	Interaction of benefit and foliar spray
1.63	1.68	1.67	1.55	% 1.5	
1.50	1.75	1.45	1.29	% 3	

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					A *× C
0.06	0.09			LSD 0.05	
Growth stages effect B					
1.51	1.53	1.54	1.45	tillering+ Elongation	Growth stages and foliar spray overlap B × C
1.60	1.73	1.58	1.47	tillering + booting	
1.55	1.63	1.45	1.58	Elongation + booting	
0.04	0.08			LSD 0.05	

Discussion

The results indicate that there are significant effects of soaking with different concentrations of potassium sulphate solution on all the studied traits. The values of the traits increased with increasing concentrations of soaking with potassium sulphate solution, especially the 3% concentration. This may be due to the role of the soaking process in stimulating the seeds, which was positively reflected on all the vital processes of the seeds. The superiority in the number of tillers per square meter may be due to the role of potassium in the process of hormonal balance between auxins and cytokinins, reducing apical dominance and increasing the plant's ability to form tillers. The effectiveness of potassium in increasing the efficiency of photosynthesis and dry matter accumulation stimulates the plant to increase lateral growth rates, especially the number of tillers [1], and the increase in the number of spikes is a reflection of the increase in the number of tillers. Soaking with different potassium compounds regulates many physiological processes within the plant, including controlling growth, enhancing the role of the root in absorbing nutrients and moving solutes within the plant. This is consistent with what was indicated by [15]. In addition, foliar spraying at advanced stages of life is of great importance in improving the efficiency of sustainability and use of nutrients by compensating for their deficiency in sensitive stages of the crop's life while maintaining water balance within plants. This is consistent with what was indicated by [13], which was reflected in the increase in the percentage of ash, potassium and nitrogen in the wheat seed content. The fact that the foliar spray concentration exceeded 3% of potassium sulphate solution in advanced stages of life in increasing the seed content of ash, nitrogen and potassium may be due to the role of potassium in stimulating many enzymes necessary for vital activities in the plant, which leads to stimulating the absorption and transport of elements within the plant, in addition to increasing their absorption rates to a large extent. This result was consistent with what was found by [1 [

Conclusions From the above results, we can conclude that the experimental factors and some of their interactions have a positive role in improving some growth and quality characteristics of wheat crop. The soaking and foliar spraying processes with potassium sulphate solution had a positive effect on the number of tillers and the number of spikes, and thus improved the quantitative and qualitative indicators of the crop. Spraying the solution at advanced stages of the plant's life

was important in compensating for the deficiency of the depleted or fixed potassium element in the soil, and thus increasing the seed content of potassium, nitrogen and ash.

References

.1 Abu-Dahi, Y.M., Shati, R.k., & Al-Taher, F.M. (2009). Effect of foliar feeding of iron, zinc and potassium on grain yield, and protein percentage of bread wheat. Iraqi.J. of Agri. Sci.40 (4): 27-37.

.2 Al-Asadi, M, H., (2019). GenStat for analyzing agricultural experiments. Al-Qasim Green University - College of Agriculture. Dar Al-Warith Printing and Publishing Press. Iraq 304 p .

.3 Al-Barky, F, R., (2020). Plant breeding and improvement. Ministry of Higher Education - Al-Muthana University - College of Agriculture. Al-Najaf Al-Ashraf for Printing and Publishing. 401 p .

.4 Al-Fartousi, H, A, K, Al-Rubaie, S, M, & Ahmed, N A,. (2023). A guide to plant physiological analyses . 240 p.

.5 Al-Maeini, I, H,. (2016). Plant ecology. University House for Printing, Publishing and Translation. 712 P.

.6 Al-Muaini, I, H, & Al-Obaidi, M, A,. (2018). Scientific foundations for managing, producing and improving field crops. Dar Al-Warith for Printing and Publishing. 1067 p.

.7 Al-Rawi, K, M, & Khalaf Allah, A, M,. (2000). Design and analysis of agricultural experiments. Dar Al-Kutub Printing and Publishing Foundation. University of Mosul. Iraq . 488 p.

.8 Al-Sahuki, M,.(2009). Seed growth relationships. Ministry of Higher Education and Scientific Research - College of Agricultural Engineering Sciences. 1st edition, 150 p.

.9 Chapman, H .D., & Pratt, P.F., (1961): Method of analysis of soil , plant and water . University of California , Division Of Agriculture Sciences. p:309.

.10 Cresser, M.S., & Parsons, G.W., (1979): Sulphonic, Perchloric acid digestion of plant material for determination of nitrogen, phosphorus , potassium , calcium and Mg. Anal. Chem. Act. 109: 431-436.

.11 Directorate of Agricultural Statistics. (2023). Main indicators for wheat and barley crops. Iraqi Ministry of Planning.

.12 FAO . (2020) . The State of Food and Agriculture, Moving for Word on Food loss and waste reduction . http : www. Fao.org/3/ ca603en / ca603en. Pdf.

.13 Greenwood, D.J., and Karpinets, T.V., (1997): Dynamic model for the effects of K fertilizer on crop growth, K uptake and soil K in arable cropping. 1- Description of the model. Soil Use and Management, 13: 178-183.

.14 Horneck, D. A., & Hanson, D. (1998). Determination of Potassium and Sodium BY Flame Emission Spectrophotometry, pp: 157-164. In: Karla YP (Ed.). Handbook of reference methods for plant analysis, CRC Press, USA.

.15 Kajla . Mamta et al., (2015) , Management Practices to Mitigate The Impact of High Temperature on Wheat . Journal of Wheat Research . Indian Institute of Wheat and Botany Research . India.

.16 Sarlach, R. S., Sharma, A., & Bains, N. S. (2013). Seed Priming in Wheat: Effect on Seed Germination, Yield Parameters and Grain Yield. Progress. Res, 8, 109-112.

.17 Traad, N. A., & Al-Maeeni, A. H. (2020). Effect of spraying nutrients on the characteristics of the wheat seeds (Triticum aestivum L) of the basis of the local cv Babil 113. Plant Archives (09725210), 20(1.(

ISSN 2072-3857

.18 Turley. D. B. et al., (2001), Foliar – Applied Nitrogen for Grain Protein and canopy Management of Wheat , The Home – Grown Cereals Authority (HCGA) , Project no. 2456 .

.19 Wali, S, B,. (1990). Germination and dormancy of seeds. Dar Al-Hekma Printing and Publishing Press - Mosul. Ministry of Higher Education and Scientific Research.. 550p .

.20 Zadoks , J.C., Chang, T.T. & Konzak, C.F. (1974). A decimal code for the growth stages of cereals . Weed Res. 14:415 .

ISSN 2072-3857