EFFECT OF SEED SOAKING WITH A GROWTH REGULATOR (ATONIK) AND SEEDING DATES ON THE VEGETATIVE GROWTH CHARACTERISTICS OF *SORGHUM BICOLOR* L.

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ABSTRACT

A field experiment was carried out during the spring and fall seasons of 2021 at Al-Hamidiya Research Station of the College of Agriculture, With the aim of studying the effect of soaking seeds with Atonik growth regulator and seeding dates on growth characteristics and plant nutrients content for three varieties of sorghum. A randomized complete block design with split-split plot arrangement was used with three replications. The main plot included seeding dates for both spring and fall seasons, while the sub-plot included the concentrations of the growth regulator (Atonk) which are 0-, 2.5- and 5-ml L^{-1}, while the three varieties (Inqath, Lelu and Giza 113) were allocated to the sub-sub plots. The results showed the superiority of the cultivar Inqath in most of the studied traits such as leaf area, plant content of chlorophyll and plant content of potassium, phosphorous and nitrogen (4406, 3888 cm^2 and 58.36 59.17 spad) for both seasons, respectively. Whereas, Giza 113 cultivar outperformed in terms of plant height for both seasons. The plants which seeds soaked at a concentration of 5 ml L^{-1} also outperformed in all studied traits seeding date had a significant effects for both seasons. The interaction between the studied factors had a significant effect for most of the traits.

Keywords: cultivars, Leaf area, growth regulator,

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تأثير نقع البذور بمنظم النمو (Atonik) ومواعيد الزراعة في صفات النمو الخضري للذرة البيضاء

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المستخلص

نفذت تجربة حقلية خلال العروتين الربيعية والخريفية لعام 2021 في محطة أبحاث الحامضية التابعة لكلية الزراعة, بهدف معرفة تأثير نقع البذور بمنظم النمو Atonik ومواعيد الزراعة في صفات النمو ومحتوى النبات من العناصر الغذائية لثلاثة اصناف من الذرة البيضاء. استعمل تصميم القطاعات العشوائية الكاملة بترتيب الالواح المنشقة المنشقة Split split plot وبثلاثة مكررات. تضمنت الالواح الرئيسة main plot مواعيد الزراعة لكلا العروتين الربيعية والخريفية, اما الالواح الثانوية sub plot فقد تضمنت تراكيز منظم النمو(Atonk) وهي 0 و2.5 و 5 مل لتر$^{-1}$. اما الالواح تحت الثانوية sub sub plot تضمنت ثلاثة اصناف من الذرة البيضاء (انقاذ وليلو وجيزة 113) وكانت أهم النتائج : تفوق الصنف انقاذ في اغلب الصفات المدروسة كالمساحة الورقية ومحتوى النبات من الكلوروفيل ومحتوى النبات من البوتاسيوم والفسفور والنتروجين (4406و3888 سم2 و 58.36 59.17 spad) لكلا العروتين بالتتابع فيما تفوق الصنف جيزة 113 في صفتي ارتفاع النبات ولكلا العروتين, كما تفوقت النباتات التي نقعت بذورها بالتركيز 5 مل لتر$^{-1}$ في كافة الصفات المدروسة اثرت مواعيد الزراعة معنويا ولكلا العروتين الربيعية والخريفية, وكان للتداخل بين عوامل الدراسة تأثير المعنوي لاغلب التداخلات الثنائية والتداخل الثلاثي.

الكلمات المفتاحية: اصناف, مساحة ورقية, منظم نمو.

جزء من اطروحة الدكتوراه للباحث الثاني.

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INTRODUCTION

Sorghum (*Sorghum bicolor* L.) is an important crop that is widely cultivated for the purpose of forage and grain production and ranks fifth in the world after wheat, rice, maize and barley in terms of economic importance (13). The global production of sorghum reached about 68.9 million tons for an area of 49.9 million hectares (14). In Iraq, the total production of sorghum during spring and fall seasons was 473.1 thousand tons, with an area of 128.8 thousand hectares (12). The application of the latest technology to predict future events of environmental changes, the world, at the beginning of the third millennium, is still unable to find solutions to meet the challenges of climate change, drought and the lack of water resources responsible for the deterioration of one-third of agricultural land and the problem of food deficit. It is expected in the coming decades to see more changes in temperature, and changes in the water levels of rivers and seas, The repercussions of the climate change problem in the arid and semi-arid areas in which Iraq is located on food security became clear. Therefore, interest in managing the crop by improving its germination or shortening its growth cycle is among the important objectives to bring about a tangible increase in the quantity of the crop and improve its quality. Currently, developing countries contribute two-thirds of the world's cereal production through the successful management of drought-tolerant crops, which are the first line of defense against agro-environmental changes. The Development of crop management systems, such as appropriate seeding dates and important nutrients, must be matched by the production of high-quality grains (7, 21). In terms of quantity and quality; the change of the growing season and the seeding dates limit the growth of certain varieties of sorghum in a very large way in their production areas, as most varieties of spring sorghum suffer from the deterioration of their germination and fall to the deterioration of their production as a result of the lack of water imports and the change in temperatures between the spring and fall seasons (8, 18). The productivity cultivars it does not achieve the highest production unless ideal environmental conditions with, as choosing best date for seeding the optimal crop is no less important with the variety or nutrition, as well as determining the optimal date for the crop growth is the basis for the success of sorghum cultivation because it provides the ideal conditions for growth and yield, (8, 11). To mitigate its effects, it requires the use of environmentally safe materials that contribute to improving the germination and growth of varieties, such as growth regulators (Atonik), leading to the completion of the seeds part of the metabolic processes during activation by soaking before sowing, which helps sorghum plants to withstand environmental stress conditions and enhance the plant's self-resistance. Experiments have proven that growth regulators play an important role in improving root growth characteristics (15, 19). As well as preserving leaves from aging, as well as chlorophyll and preserving protein from decomposition and getting rid of free radicals in plant tissues exposed to stress (22) This study was aimed to investigate of seeds soaking with a growth regulator and seeding dates on the vegetative traits of sorghum .

MATERIALS AND METHODS

A field experiment was carried out during the spring and fall seasons of 2021 at Al-Hamidiya Research Station of the College of Agriculture within 43˚ east longitude, 33˚ north latitude, and 34.1 m above sea level, to study the response of three cultivars of sorghum to soaking with Atonik growth regulator and seeding dates in growth characteristics and plant nutrients content. A randomized complete plot design within a split-split plot arrangement was used with three replications. The main plots included seeding dates during spring (15/3, 1/4 and 15/4), whereas for (fall) seeding dates 1/7, 10/7 and 20/7. The sub-plots included three concentrations of Atonik nutrient solution (0 control, 2.5-, and 5-ml l^{-1}), while the three varieties (Inqath, Lelu and Giza 113) were allocated to the sub-sub plot. The number of experimental units was 81, resulting from the all combination of the study factors. Field operations were carried out for the soil of the field, including plowing, smoothing and leveling, where the length of the row was 3 m, and the area of the experimental unit was (3 x

2.5 m) and included five rows, the distance between one line and another was 50 cm, and the distance between hills (plants) was 25 cm. The plant density is 80,000 plants ha^{-1}. The experiment land was fertilized with triple super phosphate fertilizer at a rate of 100 kg ha^{-1} P (46% P_2O_5) at once upon leveling before seeding, Whereas, nitrogen fertilizer was added at a rate of 200 kg ha^{-1} in the form of urea (46% N) in three batches, the first at seeding, the second after three weeks, and the third at the beginning of head formation (17). After completing the field operations and preparing the experimental units, the seeds were soaked with the nutrient solution Atonik according to the aforementioned concentrations for a period of eight hours and planted according to the seeding dates under study, by placing three seeds in the hill and giving them a calm irrigation to ensure that the seeds do not drift, then the seedlings thinned after two weeks of emergence to one plant per hill. Crop service operations were carried out by irrigation and weeding as needed(20).

Statistical analysis

The data were statistically analyzed using the statistical program Genstat, by the method of analysis of variance according to randomized complete block design within split-split plot. The least significant difference (L.S.D) test used to compare the means at the probability level of 0.05 (9).

RESULTS AND DISCUSSION

Plant height : The results showed that the cultivars differed significantly in this trait, as the plants of the cultivar Giza 113 recorded the highest average of 279.2 and 286 cm for both spring and fall seasons, respectively (Table 1), it differed significantly from the other two cultivars (Inqath and Lilo), The reason of the differences cultivars in this trait is due to genetis cultivars in their genetic structure or the extent of their response to environmental conditions, and its reflection on the characteristics of vegetative growth. These results are in agreement with those found by Abood and Abduihameed (3) and Abood *et al.* (2). The results also indicate that soaking sorghum seeds with nutrient solution (Atonik) had a significant effects by increasing the average of this trait, As the plants soaked their seeds in the nutrient solution at a concentration of 5 ml L^{-1} had the highest average plant height of 194.7 and 211.2 cm for both seasons, respectively, compared with the (the control treatment), which recorded the lowest mean for plant height of 181.7 and 195.8 cm for the two seasons respectively. The reason could be attributed to the role of Atonik in the synthesis of tryptophan, which is the raw material for the manufacture of IAA necessary for cell elongation. This result is consistent with the findings of Borowski and Blamowski (10).

The difference in seeding dates had a significant effect on plant height, as the plants grown in the late spring season (15/4) and early in the fall season (1/7) achieved the highest plant height average (196.8 and 216.4 cm) for both dates and seasons, respectively (Table 1). It is known that sorghum plants are plants of determinant growth type, so the reason for the difference in plant height under the influence of dates may be due to the difference in temperatures, photoperiod and relative humidity that led to the variation of plants of different dates and their response to environmental conditions and the reflection of this on this characteristic. This results agreed with the results of Kadhim (16) on maize and Ajaj *et al.* (5) on sorghum, who found a significant difference in plant height when seeding at different dates. The results also indicated that there was a significant interaction between seeding dates and Atonik concentrations in the spring season only, as plants of the late date and soaked in concentration 5 ml L^{-1} recorded the highest average plant height (206.1 cm). The results also showed a significant interaction between the cultivars and seeding dates for both seasons, as the Giza 113 plants planted on date 15/4 and 1/7 gave a higher mean plant height of 296.2 and 303.5 cm for both spring and fall seasons, respectively. The three-way interaction between the study factors was significant in plant height for the fall season only.

Table 1. Effect of cultivars, seed soaking concentrations with Atonik and seeding dates on plant height, cm for sorghum, for the spring and fall seasons of 2021

Seeding Dates	Atonik Conc ml L^{-1}	Spring season				Fall season			
		Cultivars			Seeding date x	Cultivars			Seeding date x
1st date	0	137.5	137.2	250.5	175.0	170.4	165.9	279.4	205.2
	2.5	139.6	137.5	264.8	180.6	177.1	175.1	315.2	222.4
	5	144.1	131.0	259.2	178.1	178.7	170.0	316.0	221.5
2nd date	0	148.2	139.0	276.1	187.7	158.9	159.1	274.6	197.5
	2.5	156.2	146.5	282.3	195.0	175.2	166.3	261.6	201.0
	5	158.4	150.1	291.9	200.1	173.3	171.1	311.5	218.6
3rd date	0	141.4	135.4	270.1	182.3	143.9	148.1	262.5	184.8
	2.5	154.1	143.2	309.4	202.2	155.8	159.2	282.3	199.1
	5	158.6	150.4	309.2	206.1	156.8	152.6	271.6	193.6
L.S.D %5			N. S		9.99		41.39		N. S
					Mean conc				Mean conc
Conc x cultivar	0	142.3	137.2	265.5	181.7	157.7	157.7	272.1	195.8
	2.5	150.0	142.4	285.5	192.6	169.3	166.8	286.3	207.5
	5	153.7	143.8	286.7	194.7	169.6	164.5	299.7	211.2
L.S.D %5			N. S		5.60		N. S		14.57
					Mean date				Mean date
Seeding Date x Cultivar	1st date	140.4	135.2	258.1	177.9	175.4	170.3	303.5	216.4
	2nd date	154.3	145.2	283.4	194.3	169.1	165.5	282.5	205.7
	3rd date	151.3	143.0	296.2	196.8	152.1	153.3	272.1	192.4
L.S.D%5			11.06		8.14		33.20		22.54
Mean cultivar		148.7	141.1	279.2		165.5	163.0	286.0	
L.S.D%5			6.50				10.64		

Leaf area (cm^2 plant^{-1})

The results indicate that the cultivars differed significantly in the average leaf area, as the plants of the cultivar Inqath recorded the highest mean of the leaf area amounted to 4406 and 3888 cm^2 for the spring and fall seasons, respectively). While plants of the two cultivars Lilo and Giza113 recorded the lowest average of 4248 and 3032 cm^2 for both cultivars and for the two seasons respectively (Table 2). The reason for the differences among in cultivars in this trait is due to the variation between cultivars in their genetic composition and length of vegetative growth. This result is in agreement with the results of Ahmad and Abood (4). Increasing the concentration of the nutrient solution (Atonik) for soaking the seeds led to a significant increase in the average leaf area compared to the control treatment for both seasons (Table 2). The highest mean of this trait was in plants whose seeds were soaked at a concentration of 5 ml L^{-1} with an average of 4442 and 3762 cm2 for the two seasons, respectively, which did not differ significantly with the treatment of 2.5 ml L^{-1} and it differed significantly with the control treatment. The results indicate that the seeding dates differed significantly in the average leaf area of the two seasons (Table 2), as the plants grown in the second date 1/4 of spring season and 10/7 of the fall season outperformed by giving their plants the highest leaf area of 4471 and 3794 cm^2 respectively. While the plants of the first date (15/3) for the spring season and the last date (20/7) for the fall season recorded the lowest average of 3245 and 3346 cm^2 respectively and that may be due to the appropriate environmental conditions for the stages of growth when seeding on dates that outperformed the characteristic of leaf area, which was positively reflected on the characteristics of vegetative growth of the plant, including leaf area. These results are in agreement with the results of Ajaj *et al*. (5), who indicated that the leaf area varies according to the seeding dates. The results also indicated that there were significant differences for this trait due to the effect of the interaction between seeding dates and Atonik concentrations in the fall season only. The plants seeded on 1/7 with seeds soaking at a concentration of 5 ml L^{-1} recorded the highest average of 3980 cm^2.

Table 2. Effect of cultivars, seed soaking concentrations with Atonik and seeding dates on leaf area (cm^2) for sorghum, for the spring and fall seasons of 2021

Seeding Dates	Atonik Conc ml L^{-1}	Spring season				Fall season			
		Cultivars			Seeding date x	Cultivars			Seeding date x
		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	
1st date	0	4002	3545	3669	3738	3380	3553	2725	3219
	2.5	4222	3954	4220	4132	3960	3957	3078	3665
	5	4359	4313	4326	4332	4280	4134	3526	3980
2nd date	0	4348	4162	4279	4263	3838	3712	2965	3505
	2.5	4594	4692	4488	4591	4421	4293	3007	3907
	5	4925	4337	4420	4560	4466	4279	3176	3973
3rd date	0	4207	4367	4215	4263	3446	3455	2758	3219
	2.5	4407	4566	4315	4429	3813	3565	3076	3484
	5	4599	4301	4401	4433	3399	3618	2987	3334
L.S.D %5			N. S		N. S		N. S		327.5
					Mean conc				Mean conc
Conc x cultivar	0	4185	4024	4054	4087	3555	3573	2816	3314
	2.5	4407	4404	4341	4384	4065	3938	3053	3685
	5	4627	4317	4382	4442	4048	4010	3229	3762
L.S.D %5			N. S		209.2		N. S		189.1
					Mean date				Mean date
Seeding Date x Cultivar	1st date	4194	3937	4071	4067	3873	3881	3109	3621
	2nd date	4622	4397	4395	4471	4241	4094	3049	3794
	3rd date	4404	4411	4310	4375	3552	3546	2940	3346
L.S.D%5			243.0		247.8		503.6		326.7
Mean cultivar		4406	4248	4258		3888	3840	3032	
L.S.D%5			140.3				238.9		

leaves chlorophyll content (Spad)

The results indicate that the sorghum cultivars under were significantly different in this trait, as the plants of the cultivar Inqath outperformed with the highest mean for the trait that reached 58.36 and 59.17 spad for both spring and fall seasons, respectively (Table 3). While the Giza 113 plants recorded the lowest average of 50.99 and 58.25 Spad for both seasons, respectively. This difference could be due to the cultivar differences in their genetic structure, this result is in agreement with the results of Abood et al and Abood and Salh (1). The results indicated that the chlorophyll content of the leaves increased significantly with the increasing of the concentration of the Atonik solution , as the concentration of 5 ml L^{-1} had the highest mean for the character 58.68 and 60.33 Spad for both seasons respectively and did not differed significantly from the treatment of 2.5 ml L^{-1} in the fall season. respectively. Perhaps the reason for the increase in the content of chlorophyll in the leaves by increasing the content of the nutrient solution is due to the role of this substance in increasing the activity of the photosynthesis process and the absorption of nutrients such as nitrogen, which is the basic building block of amino acids. seeding dates had a significant effect on the chlorophyll index for the spring and fall seasons, as the plants planted on 1/4 of the spring season and 1/7 of the fall season achieved the highest average chlorophyll content, while the first date of the spring season and the third date of Fall season has less chlorophyll index (52.07 and 56.26) Spad. The reason may be due to the different environmental conditions. The results indicate a significant interaction between seeding dates and growth regulator concentrations for both seasons, the plants soaked at a concentration of 5 ml L^{-1} and planted in the two dates 1/4 for the spring season and 1 / 7 for the fall season achieved the highest average for this trait (60.59 and 62.18) Spad for both seasons respectively. The results also indicate the significant interaction between seeding dates and cultivars in the spring season only, as the Inqath cultivar plants planted on the second date recorded the highest average of 60.75 spad.

Table 3. Effect of cultivars, seed soaking concentrations with Atonik and seeding dates on chlorophyll content for sorghum, for the spring and fall seasons of 2021

Seeding Dates	Atonik Conc ml L^{-1}	Spring season				Fall season			
		Cultivars			Seeding date x	Cultivars			Seeding date x
		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	
1st date	**0**	**51.43**	**48.77**	**40.39**	**46.86**	**61.13**	**61.00**	**61.02**	**61.05**
	2.5	**54.23**	**54.33**	**47.80**	**52.12**	**62.47**	**61.57**	**62.50**	**62.18**
	5	**60.00**	**59.23**	**52.40**	**57.21**	**63.77**	**60.17**	**60.17**	**61.37**
2nd date	**0**	**56.67**	**57.23**	**51.81**	**55.23**	**54.73**	**54.03**	**54.37**	**54.37**
	2.5	**61.33**	**60.67**	**55.40**	**59.13**	**59.83**	**59.40**	**59.63**	**59.62**
	5	**64.27**	**62.23**	**55.29**	**60.59**	**60.27**	**60.07**	**59.80**	**60.04**
3rd date	**0**	**56.13**	**60.03**	**47.57**	**54.57**	**50.61**	**51.37**	**51.53**	**51.17**
	2.5	**62.73**	**59.00**	**54.17**	**58.63**	**59.90**	**58.33**	**55.90**	**58.04**
	5	**58.53**	**61.97**	**54.17**	**58.22**	**59.90**	**59.50**	**59.37**	**59.59**
L.S.D %5			**3.67**		**2.63**		**2.86**		**2.27**
					Mean conc				**Mean conc**
Conc x	**0**	**54.74**	**55.34**	**46.59**	**52.22**	**55.49**	**55.46**	**55.64**	**55.53**
cultivar	**2.5**	**59.43**	**58.00**	**52.45**	**56.62**	**60.73**	**59.76**	**59.34**	**59.94**
	5	**60.93**	**61.14**	**53.95**	**58.68**	**61.31**	**59.91**	**59.78**	**60.33**
L.S.D %5			**2.17**		**1.61**		**N. S**		**1.26**
					Mean date				**Mean date**
Seeding	**1st date**	**55.22**	**54.11**	**46.86**	**52.06**	**62.45**	**60.91**	**61.23**	**61.53**
Date x	**2nd date**	**60.75**	**60.04**	**54.16**	**58.32**	**58.27**	**57.83**	**57.93**	**58.01**
Cultivar	**3rd date**	**59.13**	**60.33**	**51.97**	**57.14**	**56.80**	**56.40**	**55.60**	**56.26**
L.S.D%5			**2.14**		**1.84**		**N. S**		**1.86**
Mean cultivar		**58.36**	**58.16**	**50.99**		**59.17**	**58.38**	**58.25**	
L.S.D%5			**1.11**				**0.77**		

leaves Potassium content (%)

The results indicate that sorghum cultivars differed significantly in their potassium content in leaves for both spring and fall seasons (Table 4). The cultivar Inqath had the highest average of the potassium content of leaves for the spring and fall seasons, which was 1.68 and 1.70 %, respectively, it differed significantly from Giza 113, which recorded the lowest mean for this trait (1.67 and 1.65 %) respectively. The potassium percentage in the leaves increased significantly with an increase in the Atonik concentrations of a solution, the highest concentration of 5 ml L^{-1} outperformed for both seasons with 1.69 and 1.71% for the two seasons respectively. While the control treatment recorded the lowest average. The results also showed that seeding dates differed significantly in potassium content in sorghum leaves for the fall season, the third date (20/7) recorded the highest average of potassium in leaves (1.71%), while the first date (1/7) recorded the lowest average for the trait (1.64%). The results showed that the interaction between seeding dates and Atonik solution concentrations had a significant effect on this trait for both spring and fall seasons (Table 4). Where the treatment of seeds soaked with 5 ml L^{-1} and planted on the second date 1 / 4 for the spring seeding and the first date 1/7 for the fall seeding recorded the highest average of 1.71 and 1.74% respectively.. The results indicated the effect of the three-way interaction between the study factors in the spring season, where the plants of the cultivar Inqath of their seeds soaked with 5 ml L^{-1} and planted on the second date 1/4 recorded the highest percentage of potassium in the leaves of 1.79% for the spring season, while the plants of the cultivar Giza 113 soaked its seeds with distilled water only and planted on the first date 15/3 recorded the lowest average for the trait of 1.55%.

Table 4. Effect of cultivars, seed soaking concentrations with Atonik and seeding dates on Potassium content of leaves (%) for sorghum, for the spring and fall seasons of 2021

Seeding Dates	Atonik Conc ml L^{-1}	Spring season				Fall season			
		Cultivars			Seeding date x	Cultivars			Seeding date x
		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	
1st date	0	1.57	1.55	1.54	1.55	1.53	1.50	1.48	1.50
	2.5	1.70	1.67	1.67	1.68	1.71	1.68	1.70	1.69
	5	1.70	1.71	1.68	1.69	1.78	1.72	1.72	1.74
2nd date	0	1.61	1.59	1.60	1.60	1.60	1.65	1.68	1.64
	2.5	1.75	1.66	1.65	1.68	1.68	1.68	1.67	1.67
	5	1.79	1.68	1.68	1.71	1.73	1.68	1.68	1.69
3rd date	0	1.65	1.65	1.64	1.64	1.79	1.68	1.70	1.72
	2.5	1.68	1.69	1.68	1.68	1.79	1.70	1.67	1.72
	5	1.70	1.70	1.69	1.69	1.73	1.69	1.67	1.69
L.S.D %5			0.033		0.025		N. S		0.029
					Mean conc				Mean conc
Conc x cultivar	0	1.61	1.60	1.59	1.60	1.64	1.61	1.62	1.62
	2.5	1.71	1.67	1.66	1.68	1.72	1.68	1.68	1.69
	5	1.73	1.69	1.67	1.69	1.75	1.70	1.69	1.71
L.S.D %5			N. S		0.014		N. S		0.17
					Mean date				Mean date
Seeding Date x Cultivar	1st date	1.66	1.64	1.63	1.64	1.68	1.63	1.63	1.64
	2nd date	1.72	1.64	1.64	1.66	1.67	1.67	1.67	1.67
	3rd date	1.68	1.68	1.67	1.67	1.77	1.69	1.68	1.71
L.S.D%5			N. S		N. S		N. S		0.022
Mean cultivar		1.68	1.65	1.67		1.70	1.66	1.66	1.68
L.S.D%5			0.010				0.012		

leaves Phosphorous content (%)

The results indicate that sorghum cultivars differed significantly in their phosphorous content in leaves for both spring and fall seasons (Table 5). The cultivar Inqath gave the highest average of the phosphorous content of leaves for the spring and fall seasons, which was 0.50 and 0.47 %, respectively, it differed significantly from the other cultivars, as the cultivar Giza 113 for the two seasons recorded the lowest average for this trait (0.43 and 0.44) %, respectively. These results are in agreement with the results of Al-Fahdawi (6). The percentage of phosphorous in the leaves increased significantly with an increases in the Atonik concentrations of a solution, the highest concentration of 5 ml L^{-1} outperformed for both seasons with 0.47 and 0.48% respectively, which did not differed significantly with plants whose seeds were soaked with 2.5 ml L^{-1}. Whereas, The results also showed that the seeding dates had a significant effect on the phosphorous content of the sorghum leaves for the fall seeding, as the second and third dates (10/7 and 20/7) for the fall seeding scored the highest average for the trait (0.46%) for both treatments, while the first date (1/7) recorded the lowest average for the trait (0.43%). The results also indicate that the interaction between seeding dates and Atonik solution concentrations was not significant for the spring season, while it had a significant effect on the fall season, it reached 0.49%, while plants of the same date and treated with distilled water only recorded the lowest content of phosphorous in the leaves of 0.35% (Table 5). The interaction between seeding dates and cultivars was significant in the spring season, as plants for the second date in the spring season (1/4) for Inqath cultivar outperformed with the highest average phosphorous content in leaves (0.55 %), while the treatment of date 15/3 and cultivar Giza 113 recorded the lowest percentage of phosphorous in leaves was 0.42%. The interaction between the concentrations of Atonik and cultivars had a significant effects for the spring season, the Inqath cultivar plants whose seeds were soaked with 5 ml L^{-1} gave the highest percentage of phosphorous in the leaves (0.52%), while the Giza 113 cultivar plants soaked with distilled water only recorded the lowest phosphorous content of (0.42%). The effect of the three-way interaction between the study factors is significant on the averages of this trait for both spring and fall seasons. Where the plants of the cultivar Inqath of their seeds soaked with 5 ml L^{-1} and planted on 1/4 and 10/7 recorded the highest percentage of phosphorous in the leaves of 0.58% and 0.51% for the spring and fall seasons respectively, while the plants of the cultivar Giza 113 soaked its seeds with distilled water only and planted on the first date 15/3 and 1/7 recorded the lowest average for the trait of 0.40 and 0.33% respectively.

Table 5. Effect of cultivars, seed soaking concentrations with Atonik and seeding dates on phosphorous content of leaves (%) for sorghum, for the spring and fall seasons of 2021

Seeding Dates	Atonik Conc ml L^{-1}	Spring season				Fall season			
		Cultivars			Seeding date x	Cultivars			Seeding date x
1st date	0	0.42	0.42	0.40	0.41	0.36	0.37	0.33	0.35
	2.5	0.49	0.46	0.44	0.46	0.47	0.46	0.45	0.46
	5	0.51	0.43	0.42	0.45	0.50	0.49	0.49	0.49
2nd date	0	0.50	0.43	0.42	0.45	0.45	0.42	0.43	0.43
	2.5	0.56	0.45	0.45	0.48	0.51	0.47	0.46	0.48
	5	0.58	0.44	0.45	0.49	0.51	0.48	0.47	0.48
3rd date	0	0.43	0.45	0.44	0.44	0.46	0.46	0.45	0.45
	2.5	0.47	0.45	0.50	0.47	0.48	0.48	0.48	0.48
	5	0.48	0.48	0.43	0.46	0.49	0.48	0.47	0.48
L.S.D %5			0.049		N. S		0.025		0.021
					Mean conc				Mean conc
Conc x cultivar	0	0.45	0.43	0.42	0.43	0.42	0.42	0.40	0.41
	2.5	0.51	0.45	0.46	0.47	0.48	0.47	0.46	0.47
	5	0.52	0.45	0.43	0.47	0.50	0.48	0.47	0.48
L.S.D %5			0.025		0.020		N. S		0.013
					Mean date				Mean date
Seeding Date x Cultivar	1st date	0.47	0.44	0.42	0.44	0.44	0.44	0.42	0.43
	2nd date	0.55	0.44	0.44	0.48	0.49	0.46	0.45	0.46
	3rd date	0.46	0.46	0.45	0.45	0.48	0.47	0.46	0.46
L.S.D%5			0.038		N. S		N. S		0.015
Mean cultivar		0.49	0.44	0.43		0.47	0.46	0.44	0.49
L.S.D%5			0.49				0.009		

leaves Nitrogen content(%):

The averages of nitrogen content in leaves differed significantly by increasing the concentrations of soaking seeds with Atonik, as the concentration of 5 ml L^{-1} gave the highest mean (2.57 and 2.44%) for spring and fall seasons, respectively (Table 6). While the control treatment recorded the lowest mean of 2.25 and 2.16% for the spring and fall seasons, respectively. The results showed that seeding dates had a significant effect on nitrogen content in leaves for the fall season only, as the second date 10/7 was significantly superiored in the nitrogen content in plant leaves, and recorded the highest average of 2.33%, while the first date 1/7 recorded the lowest average of 2.28%. The results also showed that the interaction between seeding dates and Atonik solution concentrations was significant for both seasons. The plants planted on 15/3 and 1/7 for both seasons of spring and fall and their seeds soaked with 5 ml L^{-1} recorded the highest average of nitrogen in leaves 2.63 and 2.53% for the two seasons respectively, while the plants planted at the same time and soaked with distilled water only recorded the lowest average of 2.25 and 2.00% for the two seasons, respectively. The results also showed that the interaction between seeding dates and cultivars for the spring and fall seasons was significant, as the cultivar Inqath planted on 1/4 and 10/7 in the spring and fall seasons outperformed with the highest average of 2.92 and 2.49% for the two seasons, respectively. While the second date (15/4) for the spring season and the first date (1/7) for the fall season of Giza 113 plants recorded the lowest average (2.25 and 2.19%) for both seasons, respectively. The interaction between the concentrations of Atonik solution and the cultivars was significant for the spring season only. The cultivar Inqath and its seeds soaked with a concentration of 5 ml L^{-1} of Atonik solution recorded the highest average of 3.17%, while the plants of the Giza cultivar soaked with distilled water (the control treatment) recorded the lowest mean of 2.23%. The three-way interaction between the study factors was significant (Table 6), The plants grown on the first date 15/3 in the spring season and the first date 1/7 in the fall season for the cultivar Inqath and their seeds soaked with 5 ml $liter^{-1}$ recorded the highest average nitrogen content in leaves, which was 3.33 and 2.98% for the two seasons, respectively. While the Giza 113 plants, planted on dates 15/3 and 1/7 for both spring and fall seasons, and their seeds treated with distilled water only, recorded the lowest average of 2.22 and 2.00% respectively.

Table 6. Effect of cultivars, seed soaking concentrations with Atonik and seeding dates on nitrogen content of leaves (%) for sorghum, for the spring and fall seasons of 2021

Seeding Dates	Atonik Conc ml L^{-1}	Spring season				Fall season			
		Cultivars			Seeding date x Atonik	Cultivars			Seeding date x Atonik
		Inqath	Lilo	Giza		Inqath	Lilo	Giza	
1st date	0	2.30	2.23	2.22	2.25	2.00	2.00	2.00	2.00
	2.5	2.30	2.29	2.29	2.29	2.36	2.27	2.29	2.30
	5	3.33	2.30	2.27	2.63	2.98	2.31	2.30	2.53
2nd date	0	2.25	2.22	2.23	2.23	2.25	2.23	2.23	2.23
	2.5	3.25	2.27	2.26	2.59	2.48	2.25	2.25	2.32
	5	3.27	2.26	2.27	2.60	2.76	2.27	2.28	2.43
3rd date	0	2.30	2.29	2.24	2.27	2.25	2.26	2.26	2.25
	2.5	2.97	2.29	2.31	2.52	2.36	2.27	2.27	2.03
	5	2.92	2.32	2.27	2.50	2.50	2.31	2.27	2.36
L.S.D %5			0.049		0.039		0.044		0.041
					Mean conc				Mean conc
Conc x cultivar	0	2.28	2.24	2.23	2.25	2.16	2.16	2.16	2.16
	2.5	2.84	2.28	2.28	2.46	2.37	2.26	2.27	2.30
	5	3.17	2.29	2.27	2.57	2.75	2.29	2.28	2.44
L.S.D %5			0.025		0.017		N. S		0.018
					Mean date				Mean date
Seeding Date x Cultivar	1st date	2.64	2.27	2.26	2.39	2.45	2.19	2.19	2.28
	2nd date	2.92	2.25	2.25	2.47	2.49	2.25	2.25	2.33
	3rd date	2.73	2.30	2.27	2.43	2.37	2.28	2.26	2.30
L.S.D%5			0.038		N. S		N. S		0.015
Mean cultivar		2.76	2.27	2.26		2.43	2.24	2.23	
L.S.D%5			N.S				N.S		

REFERENCES

1. Abood. N.M., E. M. Shalal. and M. I. Hamdan. 2021. Impact of plant growth inhibitors on the growth and yield of sorghum. Iraqi Journal of Agricultural Sciences 52(6):1431 1440. https://doi.org/10.36103/ijas.v52i6.1484

2. Abood. N. M., and M.A.Salh. 2018. Response of several sorghum varieties to potassium foliar. Iraqi Journal of Agricultural Sciences. 49(6):973-981. https://doi.org/10.36103/ijas.v49i6.131

3. Abood, N.M. and Z. A. Abduihameed. 2017. Response of some sorghum (*Sorghum bicolor* L. Moench) cultivars to foliar spraying of riboflavin growth, grain yield and proline content. J. Plant Production, Mansoura Univ. 8(11):1093-1101. DOI:10.21608/jpp.2017.41117

4. Ahmad, Y.A., and N. M. Abood, 2016. Response of Two Varieties of Sorghum (*Sorghum bicolor* L. Moench) to Plant Density. Al-Anbar J. of Agric. Sci .14(2); 188-204. DOI:10.32649/ajas.2016.128000

5. Ajaj, H.A. Alrubaya, A. A, and A. M. Addaheri, 2021. Effect of Seeding Dates on the Growth, Yield and Quality of Three Cultivars of Sorghum (*Sorghum bicolor* L. Moench). IOP Conf. Ser. Earth Environ. Sci. 904 012019. DOI:10.1088/1755-1315/904/1/012019

6. Al-Fahdawi, Mustafa Abdel-Saleh. 2018. Effect of Potassium spraying on Growth and Yield of Grain and Its Components for Three Cultivars of Sorghum. Master Thesis. University of Anbar - College of Agriculture

7. Al-Hassan, M. F. H. and K. A. Jaddoa, Tillering pattern and capacity of wheat cultlivars influenced by sowing date, and its relationship with growing days degrees (Gddc°). Iraqi Journal of Agricultural

Sciences, 47(1): 223–237. https://doi.org/10.36103/ijas.v47i1.624

8. Al-Janabi, Yassin Abdel Ahmed. 2021. The Role of Amino Acids and Seeding Date in Influencing Physiological and Anatomical Characteristics and Limiting the Deterioration in the Yield of Maize in the Spring Season. PhD dissertation. University of Anbar - College of Agriculture. p. 172

9. Al-Rawi, K. and M. A. A. Khalaf. 1980. Design and Analysis of Agricultural Experiments. Ministry of Higher Education and Scientific Research, University of Mosul _College of Agriculture and Forestry. pp:488

10. Borowski, E, and Z. K. Blamowski, 2009. The effects of triacontanol 'TRIA' and Asahi SL on the development and metabolic activity of sweet basil (*Ocimum basilicum* L.) plant striated with chilling. FoliaHort 21, 39–48. DOI:10.2478/fhort-2013-0124.

11. Bughdady, A. M. M. 2016. Response of some sorghum (*Sorghum bicolor* L.) cultivars to sowing dates and phosphorus fertilization under New Valley conditions. Sci., 6(04):1150-1159

12. Central Agency for Statistics and Information Technology. 2018. Ministry of Planning - Iraq. doi: 10.2478/fhort-2013-0124.

13. Dembele, Boubacar Gano, Michel Vaksmann, Mamoutou Kouressy, Léonce Lamine Dembele, Mohamed Doumbia, Niaba Teme, Diaga Diof and Alain Audebert. 2020. Response of eight sorghum varieties to plant density and nitrogen fertilization in the Sudano-Sahelian zone in Mali. African Journal of Agricultural Research 16(10): 1401-1410. DOI:10.5897/AJAR2020.15025

14. FAOSTAT., 2015. Statistiques des données année 2015, Rome, Italy. United Nations Food and Agriculture Organization, Rome.

15. Kadhim, J. J. and J. H. Hamza. 2021. Effect of maize seeds soaked with acids of ascorbic, citric, and humic on field emergence. Iraqi Journal of Agricultural Sciences:52(4):971-976. https://doi.org/10.36103/ijas.v52i4.1407

16. Kazem, Kamal Ahmed. 2020. Evaluation of the Performance of Introduced Varieties of Maize Under Different Seeding Dates and Locations. Master's Thesis, University of Baghdad - College of Agriculture. p. 144

17. Kherbit, Hamid Khalaf and Ahmed Mohammed Jassim. 2015. Effect of seeding dates and cutting stages on yield and quality of green fodder for sorghum, cultivar Abu Sabeen. 1- Growth characteristics and yield of green fodder. Iraqi Journal of Agricultural Sciences. (4): 475-483.

18. Mahboob, W., H. Rehman, S.M.A. Basra, I. Afzal, M.A. Abbas, M. Naeem and M. Sarwar. 2015. Seed priming improves the performance of late sown spring maize (*Zea mays* L.) through better crop stand and physiological attributes. International Journal Agricultural Biology. 17(3): 491-498.

19. Mizban, Alaa Kazem. 2014. Response of the Growth and Yield of Two Maize (*Zea mays* L.) Hybrids to the Growth Regulator Atonik. M.Scᶜ. Thesis. College of Agriculture, University of Basra. DOI:10.17957/IJAB/17.3.14.283.

20. Mohammed Y.A.,B.H. Abdullah, A.M.A. Al-Kaisy, N.M.Abood and S.H.Cheyed. 2020. Impact of weeds to sunflower under zero tillage and phosphorus fertilization. Iraqi Journal of Agricultural Sciences. 50, (6) :1486 – 1494. https://doi.org/10.36103/IJAS.V50I6.836.

21. Mahmood, J. W. and M.F.H. AL-hassan.2023. Effect of hierarchy of the production of tillers in wheat (*Triticum aestivum* L.) cultivar (KM5180) under the influence of planting dates. Res. Crop. 24 (2): 236-240.

22. Shihab, M.O. and J. H. Hamza. 2020. Seed priming of sorghum cultivars by gibberellic and salicylic acids to improve seedling growth under irrigation with saline water. Journal of Plant Nutrition. 43(13): 1-17. DOI:10.1080/01904167.2020.1766066