Response of some growth traits and yield of wheat (*Triticum aestivum* L.) to ethephon spraying dates and concentrations.

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Abstract:

A field experiment was conducted during the 2020-2021 season in the fields of the Agricultural Research Station of the College of Agriculture - University of Basra, which is 30 km north of the center of Basrah province.In order to study the effect of spraying with different times and concentrations of ethephon on the growth and yield of wheat (Triticum aestivum L.).Four concentrations of ethephon (zero, 0.300, 0.600 and 0.900 kg ha^{-1}) and three times of ethephon spraying at different stages of plant life (ZGS18, ZGS25 and ZGS30) were studied. A factorial experiment was applied using the R.C.B.D randomized complete block design with split plot arrangement and with three replications.The results showed that the concentrations of ethephon differed significantly among themselves in most of the studiestraits, and the level of 0.900 kg ha^{-1} exelled in the number of days from planting up to 50% of spike, number of stalks and grain yield, with an increase of 3.32, 23.15 and 32.21%, respectively, compared to the control treatment.As for the spraying dates, it showed a significantly excelled at the ZGS25 stage and gave the highest average number of days from 50% spike to full maturity, flag leaf area and grain yield.We conclude from this study that ethephon plays an important role in plant growth. Spraying ethephon at a rate of 0.900 kg ha^{-1} at the tillers formation stage gave a significant increase in the number of tillers and grain yield.

Keywords: wheat, ethephon, spraying stages

Introduction:

Iraq is one of the original country for the emergence of wheat and one of the countries where the success factors of its cultivation are available, but the average of wheat production in Iraq is still low compared to the global production . Statistics indicated that the cultivated area in the world for the year 2020 amounted to 221,860,000 hectares, producing 775,820,000 tons, with an average productivity of 3.50 tons, ha^{-1} (15)While the cultivated area in Iraq for the year 2020 amounted to 857,400 hectares, it produced 6,238,000 tons, with an average productivity of 2.91 tons ha^{-1} (7)There are many reasons behind the low productivity of wheat, and among these reasons is the lodging phenomenon, which is a cause of large and unexpected losses in the productivity of grain crops up to 20-60% due to low light interception and difficulty in harvesting (8).In order to promote the cultivation of this crop in order to achieve quantitative and qualitative improvement, several methods were used to address this problem, including the use of the growth regulator Ethephon, which is one of the growth impediments that has been commonly used recently with grain crops, especially wheat, in order to prevent sluggishness and reduce yield losses. Ethephon reduces the elongation of the main stem by reducing the elongation and division of cells in the subapical meristem, thus preventing recumbence, Ethephon also works to impede the transfer of auxins in the stem

tissues and thus has an important role in managing the balance pattern of the distribution of photosynthetic products between the source and sink and reducing the appearance of late tillers(10; 5).Al-Naqeeb and Hashim (4)showed in their study on the effect of spraying with four concentrations of ethephon on the growth and yield of wheat, there were significant differences in the average plant height, number of tillers and the percentage of tillers bearing cobs. Addaheri and Abood (2) mentioned that spraying ethephon at an average of 500 mg L^{-1} when sprayed in the five unwrapped leaf stages (ZGS 15) and the early branching stage (ZGS 20) recorded significant differences in the average number of days from planting to 100% flowering and the number of days From 100% flowering to physiological maturity, plant height and number of tillers.The effect of ethephon depends on the time of spraying and the stages of plant growth, which requires a great degree of understanding and awareness of the stages of growth and development of the crop. The importance of these stages lies in the role of ethephon in reducing the height of the plant and increasing the stem diameter .As the stems treated with ethephon are shorter because they have shorter internodes, and the mature cells in the stems treated with ethephon are fewer in number and shorter in length (18; 11).The results of Zeboon and Bager (17) during their study to know the effect of ethephon spraying at different stages on the growth trait of wheat showed that spraying ethephon during the elongation stage gave significant differences in plant height, flag leaf area and number of tillers. In another study, it was found that spraying ethephon at an average of 600 gm H-1 at the stage of emergence of the flag leaf recorded significant differences in plant height and lodging coefficient (12).Because of the lack of studies on the effect of ethephon on the productivity of wheat in the soils of southern Iraq affected by salt, this study was conducted, which aims to know the effect of the concentrations and stages of ethephon spray and the interaction between them on the growth characteristics of the wheat crop.

Materials and methods:

A field experiment was conducted during the 2020-2021 season in the fields of the Agricultural Research Station of the College of Agriculture - University of Basrah, which is located 30 km north of the center of Basrah province. A factorial experiment was applied using the randomized complete block design (R.C.B.D.) in the order of split plot and with three replications and included two factors, the first includes spraying with four concentrations of ethephon (0, 0.300, 0.600 and 0.900 kg ha^{-1}), which took the following symbols (E0, E1 and E2 and E3)The second factor includes three dates for spraying ethephon at different stages of plant age, which were determined according to the Zadoks scale (16), namely: before the stage of tillers formation (ZGS18), during the stage of tillers formation (ZGS25) and the beginning of the elongation stage (ZGS30).

Which took the symbols (D1, D2, and D3) respectively. Random samples were taken from the field soil before planting, dried and passed through a 2 mm sieve, and some physical and chemical properties of the soil were estimated (Table 1).

Table (1) Some chemical and physical properties of the study soil before cultivation

Traits		units	Values
pH		/	7.50
electrical conductivity (E.C)		ds m^{-1}	4.12
available nitrogen		mg kg^{-1} soil	52
available phosphorous		mg kg^{-1} soil	19.05
available potassium		mg kg^{-1} soil	165.3
Organic matter		g kg^{-1} soil	3.80
soil texture)silty loam(	sand	260.45	g kg^{-1}soil
	silt	420.70	
	clay	318.85	

Soil service operations were conducted from two orthogonal plowing, smoothing, then leveling, and then the field was divided into three replicates , each replicate containing 12 experimental units. The area of the experimental unit is 6 m2 (3 m x 2 m). The number of rows inside plot is 12 rows , the distance between the rows is 15 cm, the distance between each experimental unit and another is 1 m and between one replicates and another 1.5 m to ensure that the spray mist does not reach from one treatment to another.Nitrogen fertilizer was added at an average of 120 kg N ha^{-1}, phosphate fertilizer at an average of 120 kg P2O5 ha^{-1}, and potassium fertilizer at a rate of 60 kg K ha^{-1},Wheat seeds, type 22, were sown on 15/11/2020, and the method used in irrigation was tourist irrigation. Service operations were carried out by continuous removal of weeds from the field, The ethephon was sprayed in the early morning using a hand sprayer, and the control treatment was sprayed with distilled water only. The following traits have been studied: Number of days from planting to 50% spiking(day), number of days from 50% spiking to full maturity (day),Plant height (cm), flag leaf area (cm^2), number of tillers(tillers m^{-2}), lodging coefficient and grain yield (ton ha^{-1}).The lodging index after flowering was calculated based on the Wiersma scale according to the following equation: Lodging Index = S x I x 0.2.

The data were collected and analyzed using the SPSS statistical program and the least significant difference (L.S.D) test was used to compare the means.

Results and discussion:

1- Number of days from planting up to 50% spiking :

The results in Table 2 indicate that the stages of ethephon spray significantly affected this trait The spraying at the stage of formation of saplings ZGS25 recorded the longest period for the number of days from planting up to 50% spiking, which amounted to 99.33 days. Whereas, the spray treatment in the elongation stage ZGS30 recorded the lowest period of days, which was 97.66 days. The reason for this may be due to the fact that spraying ethephon at the stage of tiller formation leads to a decrease in the height of the plant, which results in an increase in competition between plants for light, as well as an increase in the number of tillers, and thus a delay in spiking. As the results of Table 2 show that spraying ethephon with concentration of E3 It significantly delayed flowering compared to the control treatment, with a difference of 3.22 days, with an average

number of days from planting up to 50%, spiking of 100.22 days.While the control treatment recorded the shortest period of 97.00 days. These results were similar to what was found (2). As for the effect of the interaction between the two workers, it was not significant in this trait.

Table (2) Effect of spraying stages and levels of ethephon and the interaction between them on the number of days from planting up to 50% spiking (day)

average	Ethephon levels				spraying stages
	E_3	E_2	E_1	E_0	
98.25	100.33	98.33	98.00	96.33	**D_1 (ZGS_{18})**
99.33	101.66	99.00	98.66	98.00	**D_2 (ZGS_{25})**
97.66	98.66	97.66	97.66	96.66	**D_3 (ZGS_{30})**
	100.22	**98.33**	**98.11**	**97.00**	**Average**

interaction	levels	stages	L.S.D
N.S.	0.52	0.24	**< 0.05) (P**

2- The number of days from 50% spiking until full maturity:

The results in Table 3 indicate that spraying the wheat plants with ethephon at the stage of formation of tillers ZGS25. It gave the longest period to reach full maturity, which amounted to 34.16 days, with an increase of 3.80%, compared to the spraying stage before the formation of tillers ZGS18 fragments, which recorded the shortest period of days from 50% spiking to full maturity, which amounted to 32.91 days. The reason for this can be due to the increase in the leaf area of the plant, and thus the increase in processed and stored foodstuffs, which results in a prolongation of the time required to fill grains As the ethephon has an important role in managing the balance pattern of the distribution of photosynthetic products between the source and the estuary (10), as well as the role of ethephon in prolonging the period from planting to flowering (Table 2). The levels of ethephon as well as the interaction between the two factors had no significant effect on this trait.

Table (3) Effect of spray stages and levels of ethephon and the interaction between them on the number of days from 50% spiking to full maturity (day)

average	Ethephon levels				spraying stages
	E_3	E_2	E_1	E_0	
32.91	33.66	32.33	32.66	33.00	**D_1 (ZGS_{18})**
34.16	34.33	34.33	34.33	33.66	**D_2 (ZGS_{25})**
33.66	32.66	34.00	34.66	33.33	**D_3 (ZGS_{30})**
	33.55	**33.55**	**33.88**	**33.33**	**D_1 (ZGS_{18})**

interaction	levels	stages	L.S.D
N.S.	N.S.	1.52	**< 0.05) (P**

3- Plant Height (cm):

It is noted from the results in Table (4) that there are no

significant differences between the stages of ethephon spray in the height of wheat plants. The results of Table 4 also indicate that the increase in the level of ethephon had a significant effect on the average height of wheat plants,The plants sprayed at the level of 0.900 kg.ha^{-1} (E3) gave the lowest average plant height of 75.00 cm and a decrease of 31% compared to the control treatment that gave the highest average plant height of 109.00 cm.The reason for the decrease in plant height may be due to the action of ethylene released from ethephon in the plant tissues, which inhibits the transfer of auxin in the stem tissues and thus reduces the ability to elongate the stem (13).These results were similar to what was obtained (1), (9). As for the effect of the interaction between the two workers, it was not significant.

Table (4) Effect of spray stages and levels of ethephon and the interaction between them on plant height (cm)

average	**Ethephon levels**				**spraying stages**
	E_3	**E_2**	**E_1**	**E_0**	
87.58	73.33	83.66	88.66	104.66	**D_1 (ZGS_{18})**
90.25	76.00	81.66	87.00	116.33	**D_2 (ZGS_{25})**
90.00	75.66	80.33	98.00	106.00	**D_3 (ZGS_{30})**
	75.00	**81.88**	**91.22**	**109.00**	**Average**

interaction	**levels**	**stages**	**L.S.D**
N.S.	6.91	N.S.	**< 0.05) (P**

4- The flag leaf area (cm^2):

The results in Table 5 show that there are significant effects of the spraying stage, where the spraying treatment at the stage of formation of tillers ZGS25 recorded the highest average area of the flag leaf amounted to 37.58 cm^2 and without a significant difference from the treatment of spraying before the formation of tillers ZGS18 While the spray treatment in the elongation stage ZGS30 recorded the lowest average area of the flag leaf amounted to 31.13 cm^2.The reason for this can be due to the fact that growth impediments increase the leaf area of the plant if they reduce it Depends on several factors, including the environment, plant type, cultivar, and spray stage. Also from the same table, it becomes clear to us that the levels of ethephon had a significant effect on the area of the flag leaf, where the E2 level recorded the highest average for this trait, which was 37.55 cm^2 and without a significant difference from the E3 level.Whereas, the control treatment (E0) recorded the lowest average of the flag leaf area which was 32.70 cm^2. The reason for the increase in the flag leaf area may be due to The reason for the increase in the area of the flag leaf may be due to the fact that plants treated with growth obstacles are more open and their leaves are more erect, which increases light reception to a greater degree, in

addition to the role of ethephon in increasing the period of vegetative growth (Table 2) This results in a longer growth period and therefore an increased area of the flag leaf (6). These results agree with (10) and (17). Whereas, the interaction effect between spraying stages and ethephon levels was not significant.

Table (5) Effect of spray stages and levels of ethephon and the interaction between them on the flag leaf area(cm^2)

average	**Ethephon levels**				**spraying stages**
	E_3	**E_2**	**E_1**	**E_0**	
36.67	37.90	39.55	34.62	34.64	**D_1 (ZGS_{18})**
37.58	39.61	40.62	35.11	34.99	**D_2 (ZGS_{25})**
31.13	32.34	32.48	31.26	28.46	**D_3 (ZGS_{30})**
	36.61	**37.55**	**33.66**	**32.70**	**average**

interaction	**levels**	**stages**	**L.S.D**
N.S.	2.35	1.72	**< 0.05) (P**

5- The number of tillers (tiller. m^{-2}):

Table 6 shows that the spraying treatment before the formation of tillers ZGS18 recorded the highest average number of tillers amounting to 433.08 tiller. m^{-2}without significant difference from the ZGS25 stage, with an increase of 8.39% compared to the spraying treatment in the ZGS30 elongation stage, which recorded the lowest average of 404.16 tiller. m^{-2}.This could be due to the fact that spraying ethephon before the formation of tillers has a role in stimulating the growth of tillers of the buds through the action of ethylene liberated from ethephon inside the plant tissues, which led to the liberation of the tillers from the inhibition associated with the phenomenon of apical dominance of the main stem, which is subject to internal hormonal control, which increased the tiller production. The levels of ethephon differed significantly among themselves in this trait (Table 6), as the level E3 gave the highest average number of bristles amounting to 452.77 tiller. m^{-2}shrapnel, with an increase of 23.15% compared to the control treatment that recorded the lowest average of 367.66 tiller. m^{-2}.The reason for this may be due to the role of ethephon in inhibiting the apical dominance, which results in the availability of photosynthetic products in a greater quantity and the accumulation of auxins at the base of the stem, which contributes to stimulating the growth and development of the buds of the tillers and thus increasing the number of tillers. These results were similar to results (5), (9).The results in Table 6 also show the significant effect of the interaction between spraying stages and ethephon levels on the number of tillers,The combination (ZGS25 × E3) recorded the highest average of 470.66 tiller. m^{-2}without a significant difference from (ZGS25 × E2), while the combination (ZGS18 × E0) recorded the lowest average of 362.66 tiller. m^{-2}.

Table (6) Effect of spraying stages and levels of ethephon and the interaction between them on the number of tillers (tiller. m^{-2})

average	Ethephon levels				spraying stages
	E_3	E_2	E_1	E_0	
433.08	459.33	455.00	455.33	362.66	**D_1 (ZGS_{18})**
431.75	470.66	462.33	425.00	369.00	**D_2 (ZGS_{25})**
404.16	428.33	419.33	397.66	371.33	**D_3 (ZGS_{30})**
	452.77	**445.55**	**426.00**	**367.66**	**average**

interaction	levels	stages	L.S.D
9.02	5.20	8.49	**< 0.05) (P**

6- The lodging index :

The results in Table 7 indicate that there are significant differences between the spraying stages in this trait, where the spraying treatment excelled in the ZGS25 tillers formation stage, and recorded the lowest mean of in lodging index of 1.45, with a decrease of 52.46% compared to the spraying treatment in the ZGS30 elongation stage, which gave the highest mean of 3.05.The reason for this decrease can be due to the fact that spraying ethephon at the stage of formation of the stems leads to an increase in the strength and stiffness of the stems, where it increases the percentage of dry matter in the plant structure and regulates the deposition of cellulose, thus increasing the diameter of the stem (18).The results of Table 7 showed that there was a significant difference between the levels of ethephon in this trait. The level E3 gave the lowest average regression coefficient of 1.46 without a significant difference from the level E2, which gave 1.53. While the control treatment (E0) recorded the highest average recumbency coefficient of 3.73. This may be due to the role of ethephon in stimulating the enzymes tyrosine ammonialyase (TAL), Cinnamyl alcohol dehydrogenase (CAD) and peroxidase (POD) responsible for the production of lignin, which results in an increase in leg strength. Thus lowering in lodging index. These results agree with (14).Table 7 also shows the significant effect of the interaction between the two factors in this trait, as the combination (ZGS25 × E3) recorded the lowest average lodging indexof 0.20 It did not differ significantly from the (ZGS25 × E2) combination, while the highest average in lodging index was 4.02 at the (ZGS30 × E0) combination.

Table (7): Effect of spray stages and levels of ethephon and the interaction between them on in lodging index

average	Ethephon levels				spraying stages
	E_3	E_2	E_1	E_0	
2.65	1.80	2.40	3.20	3.20	**D_1 (ZGS_{18})**
1.45	0.20	0.40	1.20	4.00	**D_2 (ZGS_{25})**
3.05	2.40	1.80	4.00	4.02	**D_3 (ZGS_{30})**
	1.46	**1.53**	**2.80**	**3.73**	**average**

interaction	levels	stages	L.S.D
0.97	0.56	0.60	**< 0.05) (P**

7. Grain yield (tons ha^{-1})

It is noted from the results in Table 8 that the spraying stages differed significantly in their effect on the grain yield, where the spraying treatment in the ZGS25 stage recorded the highest average grain yield of 3.37 tons ha^{-1}, with an increase of 10.86% compared to the ZGS30 treatment, which recorded the lowest average of 3.04 tons ha^{-1}.As many studies indicated that the reason for the increase in grain yield is due to the role of growth regulators in the processes related to the development and preparation of sink, such as reducing the top dominance that leads to an increase in the number of cob (6). This result agrees with (12).The results also show in Table (8) the significant effect of ethephon levels on the average grain yield, as the level recorded 0.900 kg tons ha^{-1} (E3), the highest average grain yield amounted to 3.53 tons ha^{-1} Whereas, the control treatment (E0) recorded the lowest average of 2.67 tons ha^{-1}. This result was similar to what was mentioned (3), (11).As for the effect of interaction, the results of Table (8) showed significant differences between the treatments, and the combination (ZGS25 × E3) recorded the highest average grain yield of 3.69 tons $ha^{-1}$with an increase of 38.72% compared to the combination (ZGS18 × E0), which recorded the lowest average It reached 2.66 tons ha^{-1}.

Table (8) Effect of spraying stages and levels of ethephon and the interaction between them on the grain yield (tons ha^{-1})

average	Ethephon levels				spraying stages
	E_3	E_2	E_1	E_0	
3.28	3.56	3.49	3.42	2.66	**D_1 (ZGS_{18})**
3.37	3.69	3.61	3.52	2.67	**D_2 (ZGS_{25})**
3.04	3.35	3.10	3.04	2.67	**D_3 (ZGS_{30})**
	3.53	**3.40**	**3.32**	**2.67**	**average**

interaction	levels	stages	L.S.D
0.04	0.02	0.02	**< 0.05) (P**

Conclusion:

Based on the results obtained, it can be concluded that ethephon plays an important role in plant growth, as the spraying with ethephon gave the best results in terms of flag leaf area, reclining coefficient and grain yield. Spraying of ethephon at a rate of 0.900 kg ha^{-1} at the stage of straw formation gave a significant increase in the number of rims and grain yield.

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