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EFFECT OF CONCENTRATIONS AND TIMING OF SPRAYING ETHEPHON ON YIELD OF WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract:

A field experiment was conducted during the season of 2020-2021 in fields of the Agricultural Research Station of the College of Agriculture _ University of Basra (30 km north of Basra center). The aim was to study the effect of spraying different concentrations and timing of spraying ethephon on yield of wheat (*Triticum aestivum* L.). The experiment was conducted using four concentration of ethephon used 0, 0.300, 0.600 and 0.900 kg ha^{-1}, which took the following symbols E_0, E_1, E_2, and E_3 respectively and three dates for spraying ethephon at different stages of plant growth (ZGS_{18}, ZGS_{25} and ZGS_{30}) which took the symbols D_1, D_2 and D_3 respectively. A factorial experiment was used in randomized completely block design with three replicates. Wheat seeds cv. Bhooth 22 were planted at 15/11/2020 in a clay loam soil. The results showed that the concentrations of ethephon differed significantly in all most of the studied characteristics, and the E_3 level was superior to the crop growth rate, number of spikes and grain yield with an increase by 26.44, 35.36 and 32.21% respectively as compared to the control treatment (E_0). The spraying dates showed a significant effect. Moreover, the stage of ZGS_{25} gave the highest values for number of spikes and grain yield. The interaction between spraying dates and ethephon concentrations showed a significant effect on some of the studied characteristics, the combination of $ZGS_{25} \times E_3$ produced the highest values of number of spikes (390.00 spike m^{-2}) and grain yield (3.69 ton ha^{-1}).

Keywords: Wheat, Ethephon, Spraying stages.
Part of MSc thesis for the first author.

Introduction:

Wheat (*Triticum aestivum* L.) is considered one of the important and strategic cereal crops for most of the world's population, as it is planting on larger areas than any other commercial crop, and it is a staple food for about one third of the world's population and constitutes the most important source of carbohydrates in most countries. As well as containing fats, vitamins and some mineral salts, and the essential amino acids that human need in their food (Abd-Elhamied, 2016 and Elsahookie et al., 2021).

The lodging is the cause of large and unpredictable yield losses of cereal crops of 20-60% due to low light interception and difficulty in harvesting (Erndwein et al., 2020). Varieties with high yields tend to lodging due to weak stems (Bainsla et al., 2020). In order to promote the cultivation of this crop in order to achieve quantitative and qualitative improvement, several methods were used to face this problem, including the use of the growth regulator Ethephon, which is one of the growth retardants that has been commonly used recently with cereal crops, especially wheat, in order to prevent lodging 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 lodging. Ethephon also works to impede the transport of auxins in stem tissues and thus has an important role in managing the balance pattern of photosynthesis products distribution between the source and the sink and reducing the appearance of late tillers (Al-Zobiady et al., 2016 and Jaddoa et al., 2017). Ethephon increases the tolerance of plants to salinity and reduces the toxicity of heavy metals by increasing the efficiency of photosynthesis, increasing the activity of antioxidant enzymes, increasing the production of proline and regulating the water balance within the plant. as well as its role in improving the water use efficiency especially in the flowering stage, which makes it possible to use this compound in arid areas in order to increase yield (Khan et al., 2020 and Hussain et al., 2020). Tidemann et al. (2020) reported that spraying ethephon at a rate of 240 gm l^{-1} at ZGS $_{37}$ stage on barley gave significant differences in plant height, tillers number, number of days to maturity and lodging index. Guled et al. (2018) showed that spraying with four concentrations of ethephon on the growth and yield of wheat had a significant difference in the number of grains per spike, weight of 1000 grain, grain yield, biological yield and harvest index.

The effect of ethephon depends on date of spraying and stages of plant growth, the importance of these stages for the role of ethephon in reducing plant height and increasing stem diameter, as the stems treated with ethephon are shorter because they have shorter internodes. Mature cells in ethephon-treated stems are fewer in number and shorter in length (Zhang et al., 2019 and Peake et al., 2020). The results of Zeboon and Bager (2017) found that spraying ethephon at different stages, the elongation stage gave significant differences in crop growth rate. Shah et al. (2017) found that spraying of ethephon at a concentration of 480 g l^{-1} at ZGS $_{37}$ stage recorded the highest number of grains per spike, weight of 1000 grain and grain yield. Because of the scarcity of studies on the effect of ethephon on productivity of wheat in the soils of southern Iraq affected by salt, this study was conducted, which aimed to know the effect of ethephon concentrations and stage of spraying and the interaction between them on the growth characteristics and yield of wheat.

Materials and methods:

A field experiment was conducted during the season of 2020-2021 in fields of the Agricultural Research Station of the College of Agriculture _ University of Basra (30 km north of Basra center). Factorial experiment was used in randomized completely block design with three replicates. The first factor included spraying with four Concentration of ethephon were used 0, 0.300, 0.600 and 0.900 kg ha^{-1}, which took the following symbols E_0, E_1, E_2, and E_3 respectively. In addition, the second factor includes three dates for spraying ethephon at different stages of plant growth, before emergence of tillers (ZGS_{18}), tillering stage (ZGS_{25}) and beginning of stem elongation (ZGS_{30}) which took the symbols D_1, D_2 and D_3 respectively. Random samples were taken of soil before to planting, to assessed the physical and chemical properties (Table 1). Soil was prepared, softening and settling, and divided into three blocks; each block has 12 experimental units. The experimental unit area of 6 m^2 included 12 lines of planting length of 3 m and the distance between the line of

15 cm. Nitrogen fertilizer was given at the rate of 120 kg N h^{-1} and phosphate fertilizers at a rate of 120 kg P_2O_5 h^{-1} and the Potassium fertilizer at a rate of 60 kg K h^{-1}. Wheat seeds were plant at cv. Bhooth 22 on 15/11/2020. The irrigation method was Surface Irrigation. Service process were conducted out by continuously removing the weeds from the field. The ethephon were spray in the early morning using a hand spray and the control treatment was spray with distilled water only. The following characteristics have been studied: Crop growth rate (gm m^{-2} day^{-1}), lodging index, efficiency of spiking (%), number of spikes (spike m^{-2}), weight of 1000 grain (gm) and grain yield (ton ha^{-1}). Data collection was analyzed using SPSS and the least significant difference (L.S.D) was used to compare averages.

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

Properties		Value
pH	/	7.50
E.C	ds m^{-1}	4.12
Available N	mg kg^{-1} soil	52
Available P	mg kg^{-1} soil	19.05
Available K	mg kg^{-1} soil	165.3
Organic matter	g kg^{-1}	3.80
Sand	g kg^{-1}soil	260.45
Silt		318.85
Clay		420.70
Soil texture		clay loam

Results and discussion:

Crop growth rate (gm m^{-2} day^{-1})

The results of table (2) demonstrated there were significant differences between the concentrations of ethephon in this character. As the concentration E_3 recorded the highest rate of crop growth of 17.60 gm m^{-2} day^{-1} and an increase of 26.44% compared to treatment E_0, which recorded the lowest rate of crop growth of 13.92 gm m^{-2} day^{-1}, which it was not significantly different with E_1. This may be due to the role of ethephon in increasing the efficiency of photosynthesis, the activity of antioxidant enzymes, the production of proline, and regulating the water balance within the plant (Khan et al., 2020). These results were agreed with Zeboon and Bager (2017). Data in table (2) revealed that the effect of spraying stage and interaction did not affect significantly on this character.

Table (2) Effect of spraying stages, ethephon concentration, and their interaction in crop growth rate (gm m^{-2} day^{-1})

Spraying stages \ Ethephon	E_0	E_1	E_2	E_3	Average of Spraying stages
ZGS_{18}	14.10	14.38	15.44	19.42	15.83
ZGS_{25}	15.10	15.02	16.65	16.99	15.94
ZGS_{30}	12.57	13.77	15.13	16.39	14.47
Average of Ethephon	13.92	14.39	15.74	17.60	
L.S.D $\leq$ 0.05) (P	Spraying stages		Ethephon		Interaction
	N.S.		1.51		N.S.

Lodging index

The results in Table 3 indicate that there were significant differences between the spraying stages in this character, as the spraying treatment ZGS_{25} stage gave the lowest of the lodging index of 1.45, with a decrease of 52.46% compared to the spray treatment in the elongation stage (ZGS_{30}), which gave the highest of 3.05. The reason is that decrease can be attributed to the role of ethephon in increasing the strength and stiffness of the stems, as it increases percentage of dry matter in plant structure and regulates the deposition of cellulose, thus increasing the diameter of the stem (Zhang et al., 2019). These results are similar with that in Ramburan and Greenfield (2007). The results of Table 3 showed that there were significant differences between the concentrations of ethephon, the E_3 concentration gave the lowest mean of the lodging index of 1.46 with no differences with concentration E_2, which gave 1.53, while the treatment (E_0) recorded the highest mean of the lodging index of 3.73. These results were agree with Tidemann et al. (2020). The combination ($ZGS_{25} \times E_3$) recorded the lowest mean of the lodging index of 0.20 and it did not differ significantly from the combination ($ZGS_{25} \times E_2$), while the highest mean of the lodging index was 4.02 at the combination ($ZGS_{30} \times E_0$).

Table (3) Effect of spraying stages, ethephon concentration, and their interaction in lodging index

Spraying stages \ Ethephon	E_0	E_1	E_2	E_3	Average of Spraying stages
ZGS_{18}	3.20	3.20	2.40	1.80	2.65
ZGS_{25}	4.00	1.20	0.40	0.20	1.45
ZGS_{30}	4.02	4.00	1.80	2.40	3.05
Average of Ethephon	3.73	2.80	1.53	1.46	
L.S.D $\leq$ 0.05) (P	Spraying stages		Ethephon		Interaction
	0.60		0.56		0.97

Number of spikes (spike m^{-2})

The results in table (4) indicated that there are a significant difference between the spraying stages. The ZGS_{25} stage recorded the highest average number of spikes of 349.00 spike m^{-2}, with an increase of 11.27% compared to spraying in the elongation stage, which recorded the lowest average of 313.66 spike m^{-2}. These results are similar with Ramburan and Greenfield (2007) in barley. The results also showed that number of spikes increased significantly with the increase in ethephon concentrations. The highest value was recorded by E_3 level (371.33 spikes m^{-2} with an increase by 35.36% compared to the treatment (E_0) which gave 274.33 spike m^{-2}. These results are agreement with Jaddoa et al. (2017). As the combination ($ZGS_{25} \times E_3$) recorded, the highest average number of spikes of 390.00 spike m^{-2}, while the combination ($ZGS_{18} \times E_0$) recorded the lowest average of 272.00 spike m^{-2}.

Table (4) Effect of spraying stages, ethephon concentration, and their interaction in Number of spikes (spike m^{-2})

Ethephon / Spraying stages	E_0	E_1	E_2	E_3	Average of Spraying stages
ZGS_{18}	272.00	343.00	362.00	378.00	338.75
ZGS_{25}	277.02	351.00	378.04	390.00	349.00
ZGS_{30}	274.00	305.03	329.66	346.00	313.66
Average of Ethephon	274.33	333.00	356.55	371.33	
L.S.D ≤ 0.05) (P	Spraying stages		Ethephon		Interaction
	7.28		4.70		8.14

Number of grains in spike (grain $spike^{-1}$)

The results of table (5) presented that spraying stages has a not significant effect on the number of grains. These results are similar with that in Ramburan and Greenfield (2007) in the barley and Al-Naqeeb and Hashim (2017) in the wheat. The results also showed that the concentrations of ethephon had no significant effect on the number of grains (Table 5). The result is agreement with Jaddoa et al. (2017). There is no interaction between spraying stages and ethephon concentration.

Table (5) Effect of spraying stages, ethephon concentration, and their interaction in Number of grains in spike (grain $spike^{-1}$)

Ethephon / Spraying stages	E_0	E_1	E_2	E_3	Average of Spraying stages
ZGS_{18}	34.46	34.31	34.64	34.42	34.46
ZGS_{25}	35.00	34.54	34.66	34.38	34.64
ZGS_{30}	34.04	35.12	35.57	34.43	34.79
Average of Ethephon	34.50	34.66	34.95	34.41	

L.S.D ≤ 0.05) (P	Spraying stages	Ethephon	Interaction
	N.S.	N.S.	N.S.

Weight of 1000 grains (gm)

The results of table (6) showed a significant difference between the concentrations of ethephon. Treatment (E_0) recorded the highest average weight of 1000 grains amounting to 26.03 gm as compared with the treatment E_2, which gave the lowest value 25.81gm. This is due to the decrease in the number of spikes in treatment E_0, which reduced competition for energy and food sources, and thus increased the amount of dry matter that reached the grain during its fullness. These results were similar to Shah et al. (2017) and Tidemann et al. (2020) in barley. The results also showed that effect of spraying stages and interaction was not significant.

Table (6) Effect of spraying stages, ethephon concentration, and their interaction in Weight of 1000 grains (gm)

Ethephon / Spraying stages	E_0	E_1	E_2	E_3	Average of Spraying stages
ZGS_{18}	26.14	25.94	25.84	25.85	25.94
ZGS_{25}	26.00	25.92	25.80	25.90	25.91
ZGS_{30}	25.94	25.84	25.78	25.74	25.82
Average of Ethephon	26.03	25.90	25.81	25.84	
L.S.D ≤ 0.05) (P	Spraying stages		Ethephon		Interaction
	N.S.		0.11		N.S.

Grain yield (t ha^{-1})

The data of table (7) showed that the spraying stages differed significantly in their effect on the grain yield, as the spraying in ZGS_{25} stage recorded the highest average to grain yield 3.37 t ha^{-1} with an increase of 10.86% compared to ZGS_{30} stage, which gave the lowest average of 3.04 t ha^{-1}. These results are agreement with Ramburan and Greenfield (2007) and Shah et al. (2017) in barley. Ethephon concentrations differed significantly the E_3 gave the highest value for grain yield reached to 3.53 t ha^{-1}, while the treatment (E_0) recorded the lowest average of 2.67 t ha^{-1}. These results are consistent with his findings by some studies (Jaddoa et al., 2017; Ahmad et al, 2020). The highest value was obtained by using spraying in stage ZGS_{25} with E_3 (3.69 t ha^{-1}) and an increase of 38.72% compared to combination ($ZGS_{18} \times E_0$), which gave the lowest value (2.66 t ha^{-1}).

Table (7) Effect of spraying stages, ethephon concentration, and their interaction in Grain yield (t ha^{-1})

Ethephon / Spraying stages	E_0	E_1	E_2	E_3	Average of Spraying stages
ZGS_{18}	2.66	3.42	3.49	3.56	3.28

ZGS_{25}	2.67	3.52	3.61	3.69	3.37
ZGS_{30}	2.67	3.04	3.10	3.35	3.04
Average of Ethephon	2.67	3.32	3.40	3.53	
L.S.D ≤ 0.05) (P	Spraying stages		Ethephon		Interaction
	0.02		0.02		0.04

Conclusion:

Based on the obtained results, it could be concluded that ethephon plays an important role in plant growth, as ethephon spraying gave the best results of lodging index, number of spikes and grain yield**.** Ethephon sprayed at rate 0.900 kg ha-1 with ZGS_{25} stage were extremely effective in increasing grain yield.

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