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Evaluation of wheat verities (*Triticum aestivum* L.) grown under different seeding rates and ethephon in desert conditions, south of Basrah, Iraq

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Due to climate change in recent years, there has been an increasing water deficit during the winter wheat growing period due to reduce rivers water and low precipitation. Consequently, there is increasing thoughts to grow crops depending on well water under desert conditions were crops management completely different. Field experiment was conducted in winter session of 2021-2022. The aim was to evaluate the production of wheat cultivars grown under desert condition at Alahais south of Basrah, Iraq (30°46'89.07"N 46°99'36.77"E). Moreover, two seeding rate and two levels of ethephon have been applied. The experiment include three factors, eleven wheat cultivars, two rate of seeding (140 and 200 kg ha^{-1}) and two concentration of ethephon (0 and 2.25 ml l^{-1}). Factorial experiment was applied (11x2x2) according to randomized complete block design with three replicates. The area of experimental unit was 4x3 m^2. The results revealed that, wheat varieties differed significantly in all most traits measured. Alrasheed variety produced higher grain yield, higher grains spike^{-1} and 1000 grain weight by 4.077 t ha^{-1}, 56.18 grains spikes^{-1}, and 43.17 g respectively. Moreover, increased seeding rate from 100 to 200 kg ha^{-1} lead to increase spike m^{-2} and grain yield by 12.53% and 11.59% respectively. In addition foliar application of ethephon lead to enhance spike m^{-2}, grains spike^{-1} and grain yield by 5.31%, 6.81% and 11.15% respectively. For the interaction effect, the results revealed that, the increased of seeding rate improved grain yield for all wheat varieties. Moreover, the application of ethephon improved grain yield for all wheat varieties. Alrasheed variety under 140 and 200 kg ha^{-1} seeding rate with foliar application of 2.25 ml l^{-1} ethephon gave highest grain yield by 4.321 and 4.235 t ha^{-1} respectively. In addition Alrasheed under seeding rate of 200 kg ha^{-1} and ethephon foliar application produced highest biological yield by 14.261 t ha^{-1}. The results showed that foliar application of ethephon compensate the increase of seeding rate from 140 to 200 kg ha^{-1} for grain yield of some wheat varieties.
Keyword: Wheat verities, desert agriculture, ethephon, grain yield, seeding rate.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the major cereal crops, which provides energy requirement of the human diet across the world. Wheat grain's protein contains essential gluten, which is important for bread production (Sharma *et al*., 2015; Noaema *et al*., 2020; Alrishdi and Alhabbar, 2023). The total wheat production in the world estimated by 779.03 million tons, at a rate of 3.510 t ha^{-1} (USDA, 2022). While, in Basrah Governorate which located south of Iraq, Wheat production reached to 2.624 t ha^{-1} (ARMA, 2021). In addition to the decline in grain yield production per unit area in Iraq as compared to global production, climatic changes have played a major role in reduced agricultural production due to the increase water scarcity and the decrease water level of Tigris and Euphrates rivers, which consequently led to decrease cultivated area with field crops, including wheat (Lobell *et al*., 2011; Osborne and Wheeler, 2013; Kissoudis *et al*., 2016; Urban *et al*., 2017). This required searching for alternative sources of water (underground water) and moving the cultivation of this strategic crop to other new regions. This new region characterized by abundance of underground water but in other hand by extremes climate, insufficient nutrient and light soils that differ in their characteristics and so their management as compared to suitable soils for Wheat cultivation. This requires reconsideration by selecting a new varieties that are suitable for these new agricultural conditions. Varieties generally differ in grain yield production according to genetic traits and its interaction with Ecology (growth conditions). The highest yield can be obtained when

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there is a compatibility between the genotypes and available growth conditions (when these conditions are invested in a manner optimize) (Inamullah *et al*., 2011; Altaweel and Alhamdani, 2022). Determine appropriate seed rate that achieve the suitable plant density to invest in growth and production factors with high efficiency by reducing competition among plants on soil resources and increase light distribution and heat available and thus regulate physiological processes in plants which reflect positively on growth, yield and its components (Turner *et al*., 1994). The use of growth regulators is considered one of the new technologies that represent in agricultural production. Growth inhibition group is among the growth regulators that have described as slowing down elongation and cell division in the sub-apical meristem, which reduces stem elongation. Studies have indicated that the effect of these compounds in increasing grain yield is not by inhibiting stem elongation but by its positive effect on the yield components (Al-Zubaidi and Mohsen, 2022). Ethephon is among the growth regulators commonly used with grain crops, especially wheat. Some research has indicated its ability and effectiveness in preventing apical stigmas, increasing number of tillers, and then increasing the number of spikes per plant, which is one of the important components of grain yield (Kolbert *et al*., 2019; Hussain *et al*., 2020). Therefore, this study aimed to evaluate performance of introduced genotypes for light soils, seeding rate and ethephon application and their interaction which will give the highest grain yield and quality under desert conditions south of Iraq.

MATERIALS AND METHODS

A Field experiment was conducted in winter session of 2021-2022 at Al-Luhais south of Basrah, Iraq (30°46'89.07"N 46°99'36.77"E). The objectives were to evaluate the some growth properties, grain yield and component of eleven wheat genotype *Triticum aestivum* L. (Abugraib3, Alrasheed, Barcelona, Mawada, Jehan, Wafyah, IPA99, Babyl, Bhooth22, Jihad and Adina) to grow in desert condition under the effect of tow seeding rate (140 and 200 kg ha^{-1}) which they are symbolized by S_1 and S_2 and two ethephon concentration (0 and 2.25 ml l^{-1}) which they are symbolized by A_0 and A_1. Factorial experiment was applied (11x2x2) according to randomized complete block design with three replicates. The total number of experimental units was 132 with a distance aria of 4x3 m^2. Experimental soil was prepared by two orthogonal tillage and then, soil leveled by disc harrows. Random samples were taken from a well of water and soil before planting (depth of 0-30cm), dried and passed in a 2 mm sieve to determine some physical and chemical properties of water and soil (Table 1 and 2). In addition, weather information obtained from Iraq ministry of agriculture (Table 3). Seeds were sowing at 21/11/2022 and NPK fertilizer (20:20:20) was added to the soil at seed sowing at 200 kg h^{-1}. Watering system used was sprinkler irrigation method. Nitrogen fertilizer was added in form of urea, (46% N) at 200 kg h^{-1} at two equal time, the first one at tillering stage and the second one at booting stage. Moreover, microelements Mg, Mn, Fe, Zn and Cu foliar applied at 400 g per 400 l^{-1} ha^{-1} at two equal time, elongation and booting stage. Ethephon treatments were sprayed at the beginning of tillering stage. Tween 20 was used to decrease the surface tension of solution. Samples harvested when plants reached to maturity stage (25/04/2022) and, yield, components and biological yield, harvest index and protein content measured from harvested plants of 1 m^2 from each experimental unit. Data were collected and analyzed statistically by GenStat statistical software 12 (Table 3). Averages of data were compared by using least significant difference (LSD $_{P\leq0.05}$).

Table 1. Some physical and chemical properties of well water.

Properties	Value	unit
pH	7.58	-
EC	4.20	ds m^{-1}
Ca	7.65	mM l^{-1}
Mg	4.12	
Na	2.99	
HCO3	1.90	
CL	29.24	
K	1.87	
SAR	0.61	-

Table 2. Some physical and chemical properties of experimental soil before seeds sowing.

Properties	Value at 20 cm	Value at 40 cm	unit
pH	7.19	7.04	-
EC	5.20	6.00	ds m^{-1}
N	33.00	30.00	mg kg^{-1}
P	3.24	2.48	
K	234.50	368.20	
$CaCo_3$	254.30	265.70	g kg^{-1}
O.M.	6.50	6.70	g kg^{-1}
sand	792.00	812.00	g kg^{-1}
silt	80.00	80.00	g kg^{-1}
clay	128.00	108.00	g kg^{-1}
Soil type	Loamy sand		-
Water content at Field capacity	0.114	0.162	cm^3 cm^{-3}
Water content at wilting point	0.074	0.104	cm^3 cm^{-3}

RESULTS

***Spike m*$^{-2}$:** The results of Table 5 showed significant differences between wheat cultivars, seeding rate and foliar

Table 3. Weather information of study locations. Information obtained from ministry of Agriculture.

Month-Year	Week	Temp. Min. C°	Temp. Max C°	Average Temp. C°	Humidity Min.%	Humidity Max.%	Evaporation mm	Rainfall mm
Nov-21	1	17.52	32.78	25.15	17.00	51.87	3.69	0.00
	2	12.20	27.15	19.67	17.27	55.02	3.43	0.00
	3	12.28	25.95	19.11	16.37	63.84	3.10	0.00
	4	11.71	26.12	18.92	19.84	68.81	2.77	0.00
Dec-21	1	8.96	23.39	16.18	18.21	77.27	2.83	0.00
	2	7.61	22.59	15.10	21.55	77.34	2.90	0.01
	3	13.19	21.76	17.48	43.20	95.56	2.26	2.41
	4	6.76	16.42	11.59	37.58	84.78	2.19	0.51
Jan-22	1	6.45	16.10	11.27	32.04	83.19	1.35	3.00
	2	10.08	20.41	15.24	24.84	77.12	1.54	0.15
	3	2.55	14.20	8.38	26.59	80.14	1.76	0.00
	4	6.13	18.96	12.55	23.89	80.02	2.23	2.54
Fib-22	1	8.26	19.46	13.86	26.64	80.07	2.64	0.43
	2	8.47	21.93	15.20	20.35	77.74	3.04	0.01
	3	9.59	23.69	16.64	22.66	78.68	3.86	0.00
	4	11.38	25.27	18.32	27.65	83.68	3.84	1.03
Mar-22	1	9.04	24.87	16.96	18.86	75.40	4.01	0.01
	2	14.89	26.07	20.48	13.67	61.92	3.97	0.00
	3	8.13	22.67	15.40	19.97	74.85	3.97	0.00
	4	10.56	27.63	19.09	17.04	63.43	4.49	0.00
Apr-22	1	15.39	29.62	22.50	10.85	53.87	6.01	0.00
	2	17.53	32.19	24.86	12.41	53.11	6.61	0.00
	3	17.84	30.62	24.23	10.47	44.46	7.06	0.00
	4	14.17	29.96	22.06	12.41	51.31	6.84	0.00

Table 4. Analysis of variance represented by Mean of Square of yield and components of wheat varieties growing under different seeding rates and Ethephon at desert conditions.

S.O.V	d.f.	Spike m^{-2}	Grains $Spike^{-1}$	1000 grain weight	Grain yield t ha^{-1}	Biological yield t ha^{-1}	HI %	Protein %
Replicate	2	110.8	4.025	10.535	0.03220	0.0967	2.757	1.414
V	10	10983.4**	577.230**	294.941**	3.59924**	22.8432**	21.349**	5.498**
S	1	295169.6**	832.366**	110.826**	3.42936**	43.0675**	3.539	24.658**
E	1	46536.0**	149.739**	0.099	10.69431**	71.2164**	26.718**	9.531**
V.S	10	3159.8**	36.582**	10.016	0.31158**	1.7434**	14.505**	1.485
V.E	10	1665.4**	60.859**	34.082**	0.20881**	2.1585**	4.272**	0.617
S.E	1	23025.2**	16.742*	26.943	2.12535**	11.0597**	3.354	0.108
V.S.E	10	1735.4**	8.843*	3.107	0.26325**	1.5557**	1.639	0.576
Error	86	153.9	4.019	5.468	0.06505	0.3651	1.902	1.685

* Significant at $P \leq 0.05$; ** Significant at $P \leq 0.01$

application of ethephon in spike m^{-2}, Barcelona gave highest average by 491.36 spike m^{-2}, whereas, Wafyah gave the lowest average by 389.66 spike m^{-2}. The increase of seeding rate from 140 to 200 kg ha^{-1} increased spike m^{-2} by 12.53%. Foliar application of ethephon increased number of tillers by plants which reflect positively on spike m^{-2}. The results of table 6 indicated that there is significant interaction between wheat varieties and seeding rates. The increase of seeding rate significantly increased spike m^{-2} for all wheat varieties. Barcelona variety under S_2 gave the highest average by 507.48 spike m^{-2}. While, Wafyah variety under S_1 gave the lowest average by 358.16 spike m^{-2}. The results of Table 7 showed that, the interaction of wheat varieties and ethephon have significant effect on spike m^{-2}. Foliar application of ethephon significantly increased spike m^{-2} for all wheat varieties. Barcelona variety under E_1 foliar application gave highest average by 486.42 spike m^{-2}. While, Wafyah variety under E_0 foliar application of ethephon gave the lowest average by 367.77 spike m^{-2}. The results of table 8 indicated that, there is significant interaction between seeding rate and foliar application of ethephon. Increased both seeding rate and foliar application of ethephon significantly increased spike m^{-2}. The interaction of S_2 x E_1 gave highest average by 490.5 spike m^{-2}, while the interaction of S_1 x E_0 gave lowest average by 358.4 spike m^{-2}. The results of Table 9 showed that, the interaction of wheat varieties, seeding rate and ethephon have significant effect on spike m^{-2}. Barcelona variety under S2 and foliar application of ethephon (E1) gave highest average by

519.52 spike m^{-2}. While, Wafya under S_1 seeding rate with no foliar application of ethephon (E_0) gave lowest average by 347.66 spike m^{-2}.

***Grains Spike^{-1}*:** The results of Table 5 showed significant effect for wheat cultivars, seeding rate and foliar application of ethephon in grains spike^{-1}. Alrasheed variety gave highest average by 56.18 grains spike^{-1}. Whereas, Wafyah gave the lowest average by 29.63 grains spike^{-1}. The increase of seeding rate from 140 to 200 kg ha^{-1} reduced kernels spikes^{-1} by 12.68%. Foliar application of ethephon increased significantly grains spike^{-1} by 7.27% as compared to control. The results of Table 6 indicated that there is significant interaction between wheatvarieties and seeding rates. The increase of seeding from 140 to 200 kg ha^{-1} significantly reduced grains spike^{-1} for all wheat varieties. Alrasheed variety under S_1 seeding rate gave the highest average by 61.12 grains spike^{-1}. While, Wafyah variety under S_2 seeding rate gave the lowest average by 25.14 grains spike^{-1}. The results of Table 7 showed that, the interaction of wheat varieties and ethephon have significant effect on grains spike^{-1}. Foliar application of ethephon increased kernels spikes^{-1} for all wheat varieties except for Mawada and Wafyah. Alrasheed variety under E_0 and E_1 concentration of ethephon gave highest average by 56.88 and 55.48 grains spike^{-1}. While, Wafyah and Jehan variety under E_0 foliar application of ethephon gave the lowest average by 30.64 and 32.92 grains spike^{-1} respectively. The results of table 8 indicated that, there is significant effect for the interaction between seeding rate and foliar application of ethephon on grains spike^{-1}. The interaction of S_1 x E_1 gave highest average by 41.16 grains

Table 5. Effect of Wheat varieties, seeding rate and ethephon on grain yield, components, harvest index, biological yield and protein content.

Treatment		Spikes m^{-2}	Grains Spikes^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index	Protein%
Varieties	Abugraib3	474.42	40.17	29.95	3.300	10.462	31.55	13.29
	Alrasheed	430.02	56.18	43.17	4.077	12.435	32.80	11.52
	Barcelona	491.36	36.18	30.14	3.388	11.500	29.48	12.34
	Mawada	474.57	32.27	41.12	3.663	12.192	30.02	11.89
	Jehan	445.58	39.23	36.61	3.675	11.430	32.20	10.89
	Wafyah	389.66	29.63	29.15	3.019	10.741	28.12	13.08
	IPA-99	456.44	39.54	39.47	3.612	11.386	31.69	12.63
	Babyl	432.21	35.24	39.63	3.685	11.698	31.45	11.99
	Bhooth22	457.26	34.17	38.97	3.193	10.233	31.18	12.05
	Jihad	456.32	34.34	39.14	3.457	10.884	31.80	12.08
	Adina	466.09	37.12	36.12	3.685	11.630	31.55	11.90
	LSD $_{(P\leq0.05)}$	10.07	1.63	1.90	0.207	0.490	1.12	1.05
Seeding rate Kg ha^{-1}	140	407.07	40.31	37.97	3.330	10.749	30.98	12.58
	200	458.09	35.20	36.14	3.716	11.904	31.26	11.72
	LSD $_{(P\leq0.05)}$	4.29	0.69	0.81	0.088	0.209	N.S	0.45
Ethephon ml l^{-1}	0	421.38	36.43	37.08	3.337	10.585	31.53	12.42
	2.25	443.78	38.91	37.03	3.709	12.068	30.74	11.88
	LSD $_{(P\leq0.05)}$	4.29	0.69	N.S	0.088	0.209	0.48	0.45

Table 6. Effect of the interaction of wheat varieties and seeding rate on grain yield, components, harvest index, biological yield and protein content.

Varieties	Spikes m^{-2}		Grains Spikes^{-1}		1000 grain weight (g)		Grain yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index		Protein%	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Abugraib3	420.79	473.47	41.48	38.86	29.38	30.52	3.194	3.406	10.008	10.916	31.87	31.23	13.46	13.12
Alrasheed	382.25	442.73	61.12	51.24	39.82	39.45	3.990	4.164	11.202	13.669	35.63	30.43	12.64	10.40
Barcelona	445.82	507.48	39.68	33.82	30.80	29.47	3.409	3.368	11.042	11.958	30.89	28.18	12.89	11.79
Mawada	433.55	471.42	33.80	30.74	43.01	39.32	3.496	3.830	11.437	12.948	30.59	29.58	12.34	11.43
Jehan	388.92	460.06	40.84	37.62	38.29	34.92	3.537	3.814	11.040	11.820	32.07	32.23	10.89	10.90
Wafyah	358.16	395.82	34.12	25.14	28.93	29.36	2.495	3.543	10.398	11.085	24.04	31.95	13.14	13.02
IPA-99	407.87	457.21	43.34	35.74	41.31	37.62	3.366	3.859	11.150	11.623	30.22	33.22	13.13	12.13
Babyl	387.36	429.46	38.90	31.58	44.07	42.26	3.593	3.777	11.297	12.098	31.77	31.24	12.34	11.64
Bhooth22	406.90	456.17	36.70	31.64	39.17	38.77	2.917	3.470	09.565	10.901	30.54	31.83	12.35	11.76
Jihad	416.74	466.19	33.10	35.58	40.90	37.37	3.091	3.824	09.606	12.163	32.15	31.41	13.06	11.11
Adina	429.38	479.04	40.31	35.20	41.98	38.46	3.544	3.826	11.490	11.770	31.44	33.07	12.17	11.64
LSD $_{(P\leq0.05)}$	14.24		2.301		NS		0.293		0.694		1.583		NS	

spike^{-1}, while the interaction of S_2 x E_0 gave lowest average by 34.01 grains spike^{-1}. The results of Table 9 showed that, the interaction of wheat varieties, seeding rate and ethephon have significant effect on grains spike^{-1}. Babyl variety under S_1 and foliar application of ethephon (E_1) gave highest average by 44.91 grains spike^{-1} with no significant differences from the interaction of (Mawada x S_1 x E_1), (Babylon x S_1 x E_0), (Jehan x S_1 x E_0) and (Mawada x S_1 x E_0) by 44.91, 43.54, 43.24, 43.13 and 42.29 grains spike^{-1} respectively. While, Wafyah under S_1 seeding rate with no foliar application of ethephon (E_0) gave lowest average by 28.13 grains spikes^{-1} with no significant differences from the interaction of (Abugraib3 x S_1 x E_0), (Barcelona x S_1 x E_0), (Barcelona x S_2 x E_0) and (Abugraib3 x S_2 x E_0) by 28.13, 28.29, 28.34, 29.16 and 29.62 grains spike^{-1} respectively.

***1000 grains weight (g)*:** The results of Table 5 showed significant differences between wheat varieties and seeding rate in 1000 grains weight. Alrasheed variety gave highest average by 43.17 g. Whereas, Wafyah gave the lowest average by 29.15 g. The increase of seeding rate from 140 to 200 kg ha^{-1} reduced 1000 grains weight by 4.82%. The results of Table 7 showed that, the interaction of wheat varieties and ethephon have significant effect on 1000 grains weight. Foliar application of ethephon increased 1000grains weight for all most wheat varieties except for Jehan, IPA-99 and Bhooth22. Babyl under E_1 and E_0 foliar application of ethephon gave highest average by 44.06 and 42.27 g. While, Barcelona, Abugraib3 and Wafya under E0 ethephon and Wafya and Abugraib3 under E1 ethephon gave the lowest 1000 grains weight by 28.75, 28.95, 29.13, 29.16 and 30.95 g respectively.

Grain yield (t ha^{-1}): The results of Table 5 showed significant differences between wheat varieties, seeding rate and foliar application of ethephon on grain yield. Alrasheed variety gave highest average by 4.077 t ha^{-1}, whereas, Wafyah gave the lowest average by 3.019 t ha^{-1}. The increase of seeding rate from 140 to 200 kg ha^{-1} increased grain yield by 11.59%. Foliar application of ethephon increased significantly grain yield by 11.15%. The results of table 6 indicated that there is significant interaction between wheat varieties and seeding rates. The increase of seeding rate lead to significantly increased grain yield for all wheat varieties except Barcelona and Babyl. Alrasheed variety under S_2 and S_1 seeding rate gave the highest average by 4.164 and 3.990 t ha^{-1} respectively. While, Wafyah variety under S_1 seeding rate gave the lowest average by 2.495 t ha^{-1}. The results of Table 7 showed that, the interaction of varieties and ethephon have significant effect on grain yield. Foliar application of ethephon significantly increased grain yield for all wheat varieties. Alrasheed and Mawada variety under E_1 foliar application of ethephon gave highest average by 4.278 t ha^{-1}. While, Wafyah and Bhooth22 under E_0 gave the lowest average by 2.899 and 2.975 t ha^{-1} respectively. The results of Table 8 showed significant effect for interaction of seeding rate and foliar application of ethephon on grain yield. Foliar application of ethephon lead to increase grain yield under both seeding rate S_1 and S_2. The interaction of S_2 x E_1 and S_1 x E_1

Table 7. Effect of the interaction of wheat varieties and ethephon on grain yield, components, harvest index, biological yield and protein content.

Varieties	Spikes m^{-2}		Grains Spikes^{-1}		1000 grain weight (g)		Grain yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index		Protein%	
	E0	E1	E0	E1	E0	E1	E0	E1	E0	E1	E0	E1	E0	E1
Abugraib3	440.64	453.62	40.06	40.28	28.95	30.95	3.067	3.534	9.923	11.001	30.91	32.12	13.49	13.09
Alrasheed	407.42	417.56	55.48	56.88	38.57	40.70	3.876	4.278	11.754	13.116	32.98	32.62	11.28	11.75
Barcelona	466.88	486.42	35.90	37.60	28.75	31.52	3.184	3.593	10.599	12.401	30.04	28.97	12.74	11.94
Mawada	438.95	466.02	33.04	31.50	40.99	41.34	3.406	3.920	11.322	13.063	30.08	30.01	11.99	11.79
Jehan	414.04	434.94	35.38	43.08	40.95	32.26	3.429	3.922	10.885	11.976	31.50	32.75	11.35	10.44
Wafya	367.77	386.21	30.64	28.62	29.13	29.16	2.899	3.139	10.041	11.442	28.87	27.43	13.46	12.71
IPA-99	413.93	451.15	37.80	41.28	39.88	39.06	3.550	3.675	10.626	12.146	33.41	30.26	12.91	12.36
Babyl	398.04	418.78	35.10	35.38	42.27	44.06	3.465	3.905	11.221	12.174	30.88	32.08	12.62	11.36
Bhooth22	420.96	442.10	30.15	40.38	40.68	37.26	2.975	3.412	8.404	12.062	35.40	28.29	12.17	11.94
Jihad	426.73	456.20	32.92	35.76	38.01	40.26	3.272	3.643	10.176	11.593	32.15	31.42	12.34	11.83
Adina	439.81	468.61	35.38	36.12	39.71	40.72	3.593	3.776	11.485	11.776	31.28	32.07	12.28	11.52
LSD $_{(P\leq0.05)}$	14.25		2.301		2.684		0.288		0.7		NS		NS	

Table 8. Effect of the interaction of seeding rate and ethephon on grain yield, components, harvest index, biological yield and protein content.

Seeding rate	Spikes m^{-2}		Grains Spikes^{-1}		1000 grain weight (g)		Grain yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest index		Protein%	
	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
S1	394.04	448.71	39.41	33.79	37.55	38.40	3.101	3.924	9.948	11.996	31.08	32.64	12.82	12.34
S2	420.08	467.47	41.21	36.60	36.62	35.66	3.677	3.993	11.669	12.559	31.41	31.65	12.02	11.42
LSD $_{(P\leq0.05)}$	6.07		1.14		NS		0.1248		0.296		0.675		NS	

gave highest average by 3.993 and 3.924 t ha^{-1} respectively. While the interaction of S_1 x E_0 gave lowest average by 3.101 t ha^{-1}. The results of Table 9 showed significant effect for the interaction of wheat varieties, seeding rate and ethephon on grain yield. Alrasheed variety under the interaction of (S_2 x E_1), (S_1 x E_1) and (S_2 x E_0) gave highest average by 4.321, 4.235 and 4.006 t ha^{-1}. While, Wafya under S_1 seeding rate with no foliar application of ethephon (E_0) gave lowest average by 2.727 t ha^{-1}.

***Biological yield (t ha^{-1})*:** The results of Table 5 showed significant differences among wheat varieties, seeding rate and foliar application of ethephon in biological yield. Alrasheed and Mawada varieties gave highest average by 12.435 and 12.192 t ha^{-1} respectively. Whereas, Bhooth22 gave the lowest average by 10.233 t ha^{-1}. The increase of seeding rate from 140 to 200 kg ha^{-1} increased biological yield by 10.75%. Foliar application of ethephon significantly increased biological yield by 14.01%. The results of Table 6 indicated that there is significant interaction between wheat varieties and seeding rates. The increase of seeding rate significantly increased biological yield for all wheat varieties. Alrasheed variety under S_2 seeding rate gave the highest average by 13.669 t ha^{-1}. While, Bhooth22 and Jihad varieties under S_1 seeding rate gave the lowest average by 9.565 and 9.606 t ha^{-1}. The results of table 7 showed that, the interaction of wheat varieties and ethephon have significant effect on biological yield. Foliar application of ethephon significantly increased biological yield for all wheat varieties. Alrasheed and Mawada variety under E_1 foliar application gave highest average13.116 and 13.063 t ha^{-1} respectively. While, Bhooth22 variety under E_0 gave the lowest average by 8.404 t ha^{-1}. The results of Table 8 showed significant effect for interaction of seeding rate and foliar application of ethephon on biological yield. Increasing both seeding rate and foliar application of ethephon significantly increased biological yield. The interaction of S_2 x E_1 gave highest average by 12.559 t ha^{-1}, while the interaction of S_1 x E_0 gave lowest average by 9.948 t ha^{-1}. The results of Table 10 showed significant effect for the interaction of wheat varieties, seeding rate and ethephon on grain yield. Alrasheed variety

Table 9. Effect of the interaction of wheat varieties, seeding rate and ethephon on grain yield and components.

Varieties	Spikes m^{-2}				Grains Spikes^{-1}				1000 grain weight (g)				Grain yield (t ha^{-1})			
	S1		S2		S1		S2		S1		S2		S1		S2	
	A0	A1	A0	A1	A0	A1	A0	A1	A0	A1	A0	A1	A0	A1	A0	A1
Abugraib3	413.80	427.78	467.47	479.46	41.52	41.44	38.60	39.12	28.29	30.48	29.62	31.42	2.796	3.592	3.337	3.475
Alrasheed	373.13	391.38	441.71	443.75	60.20	62.04	50.76	51.72	38.02	41.61	39.12	39.78	3.745	4.235	4.006	4.321
Barcelona	438.32	453.32	495.43	519.52	39.12	40.24	32.68	34.96	28.34	33.26	29.16	29.78	3.155	3.662	3.212	3.524
Mawada	417.16	449.94	460.74	482.10	33.52	34.08	32.56	28.92	42.49	43.54	39.50	39.14	2.983	3.575	3.828	3.831
Jehan	378.82	399.02	449.26	470.86	38.04	43.64	32.72	42.52	43.13	33.46	38.78	31.06	3.255	3.818	3.602	4.025
Wafyah	347.66	368.66	387.89	403.76	36.04	32.20	25.24	25.04	28.13	29.73	30.13	28.60	2.263	2.727	3.535	3.551
IPA-99	380.49	435.25	447.38	467.05	40.48	46.20	35.12	36.36	40.87	41.76	38.89	36.35	3.305	3.426	3.795	3.923
Babyl	370.81	403.90	425.26	433.66	39.52	38.28	30.68	32.48	43.24	44.91	41.31	43.22	3.361	3.825	3.568	3.985
Bhooth22	394.90	418.90	447.03	465.31	31.40	42.00	24.52	38.76	40.15	38.20	41.21	36.32	2.662	3.171	3.287	3.653
Jihad	402.94	430.54	450.52	481.86	33.20	33.00	32.64	38.52	39.82	41.98	36.20	38.55	2.872	3.309	3.671	3.977
Adina	416.46	442.30	463.16	494.92	40.42	40.20	36.21	34.19	40.53	43.42	38.89	38.02	3.489	3.598	3.697	3.954
LSD$_{(P\leq0.05)}$	20.13				3.25				NS				0.290			

Table 10. Effect of the interaction of wheat varieties, seeding rate and ethephon on biological yield, harvest index and protein content.

Varieties	Biological yield (t ha^{-1})				Harvest index				Protein%			
	S1		S2		S1		S2		S1		S2	
	A0	A1	A0	A1	A0	A1	A0	A1	A0	A1	A0	A1
Abugraib3	8.958	11.057	10.887	10.944	32.008	33.076	31.291	32.381	13.50	13.42	13.49	12.75
Alrasheed	10.432	11.970	13.075	14.261	32.921	32.958	33.763	33.623	11.94	13.34	10.63	10.16
Barcelona	9.662	12.422	11.536	12.379	28.419	31.516	29.853	30.483	13.38	12.41	12.10	11.47
Mawada	9.712	13.161	12.932	12.964	31.333	32.919	30.280	27.923	12.41	12.28	11.57	11.29
Jehan	10.298	11.782	11.471	12.169	32.634	33.328	32.350	32.651	11.15	10.64	11.55	10.24
Wafya	9.260	11.536	10.821	11.348	28.950	29.685	29.515	26.911	13.35	12.94	13.57	12.47
IPA-99	9.663	12.636	11.589	11.656	32.179	33.562	32.101	31.451	13.59	12.68	12.22	12.04
Babyl	10.734	11.86	11.708	12.488	31.542	33.216	30.688	32.868	13.31	11.36	11.92	11.35
Bhooth22	7.795	11.335	9.013	12.789	31.243	32.408	31.320	32.495	12.52	12.19	11.83	11.69
Jihad	9.193	10.02	11.16	13.165	31.040	32.784	32.661	33.052	13.28	12.84	11.40	10.82
Adina	11.398	11.582	11.571	11.969	30.61	31.07	31.95	33.04	12.64	11.70	11.92	11.35
LSD $_{(P\leq0.05)}$	1.021				NS				NS			

under the interaction of (S_2 x E_1) gave highest average by 14.261 t ha^{-1}. While, Bhooth22 under the interaction of (S_1 x E_0) gave lowest average by 7.795 t ha^{-1}.

***Harvest Index*:** The results of Table 5 showed significant differences between wheat cultivars in harvest index. Alrasheed, Jehan and Jihad gave highest average by 32.80%, 32.20%, and 31.80% respectively. Whereas, Wafya gave the lowest average by 28.12%. The results of Table 5 indicated that, foliar application of ethephon have significant effect on harvest index. Foliar application of ethephon significantly reduced harvest index by 2.50%. The results of Table 6 indicated that there is significant interaction between wheat varieties and seeding rates. IPA-99 and Adina under S2 seeding rate gave highest average by 33.22% and 33.07% respectively. While, Wafyah gave the lowest average by 24.04%. The results of Table 8 showed significant effect for interaction of seeding rate and foliar application of ethephon on harvest index. Foliar application of ethephon under both seeding rate increased harvest index. The interaction of S_1 x E_1 gave highest average by 32.64%, while the interaction of S_1 and S_2 seeding rate with no ethephon gave lowest average by 31.08% and 31.41% respectively.

***Protein content*:** The results of Table 5 showed significant effect for wheat cultivars, seeding rate and foliar application of ethephon on protein content. Abugraib3, Wafyah, IPA-99 and Barcelona gave highest average by 13.29%, 13.08%, 12.63% and 12.34% respectively. Whereas, Bhooth22 gave the lowest average by 10.233%. The increased of seeding rate from 140 to 200 kg ha^{-1} reduced protein content by 6.84%. Foliar application of ethephon significantly reduced protein content by 4.35%.

DISCUSSION

***Wheat varieties*:** Wheat growth under desert condition is a big challenge. Were the plants suffering from high temperature, high light intensity, low precipitation, bad structure of soil and insufficient and rapid loss of nutrients (Table 1, 2 and 3). The results of Table 5 showed that wheat varieties differed significantly in all most traits measured. Barcelona produced higher average of spike m^{-2} by 491.36. While, Wafyah produced lowest average by 389.66 spike m^{-2}. Alrasheed variety produced higher average of grains spike^{-1} and 1000 grain weight by 56.18 and 43.17 g respectively. In other hand Wafyah gave lowest average of grains spike^{-1} and 1000 grain weight by 29.63 and 29.15 g respectively. Wheat varieties appeared differences in their genetic ability and its interaction with desert condition, and ultimately lead to their differences in grain yield and components. The same results found by (Alsalami *et al.*, 2021; Pandey *et al.*, 2022; Ullah *et al.*, 2022) which they indicated that wheat varieties defer significantly. For grain yield, Alrasheed variety produced higher grain yield by 4.077 t ha^{-1} because this variety gave higher grains spike^{-1} and 1000 grain weight which reflect positively on grain yield (Table 5). Whereas, Wafyah and Bhooth22 gave lowest average of grain yield by 3.019 and 3.193 t ha^{-1} respectively. For biological yield, both Alrasheed and Mawada gave highest biological yield by 12.435 and 12.192 t ha^{-1}. While Bhooth22 gave lowest biological yield by 10.233 t ha^{-1}. Biological yield is a total biomass of plant above ground and consists of grain yield and straw yield (Donald and Hamblin, 1976). For harvest index, Alrasheed and Jehan varieties gave higher harvest index by 32.80% and 32.12% respectively. Whereas, Wafyah gave the lowest harvest index by 28.12%. The study of (Wheeler *et al.*, 1996) showed that wheat varieties significantly differed in harvest index. Harvest index refer to the ability of plant to convert photosynthesis product to economic yield (Dai *et al.*, 2016). Both, Alrasheed and Jehan varieties have highest ability to convert photosynthesis product to the grain. In addition both wheat varieties appeared positive ability to grow and gave high biological yield under desert conditions.The results of Table 5 showed significant differences among Wheat varieties in protein content. Abugraib3 and Wafyah recorded highest average by 13.29%. While Jehan gave the lowest average by 10.89%. The study of (Hussain *et al.*, 2006; Kindred *et al.*, 2008; BAŞLAR *et al.*, 2012; Eslami *et al.*, 2014) showed that grain protein is different according to wheat varieties. The results mentioned above indicated that Wheat varieties significantly different in their genetic ability and it is response to desert conditions. Wheat varieties exhibit different grain and biological yield production under harsh conditions were both soil and weather completely different as compared to suitable conditions, soil, water and whether (Eslami *et al.*, 2014; Al-Zubaidi and Mohsen, 2022; Zaibel and Mohsen, 2023). Several studies showed differences among wheat varieties as result to their genetic differences and so their interaction with experimental condition (Gomaa *et al.*, 2018)

***Seeding rate*:**

The results of table 5 showed that, the increase of seeding rate from 140 to 200 kg ha^{-1} lead to increase spike m^{-2} from 407.07 to 458.09 which reflect positively to increased grain yield from 3.330 to 3.716 t ha^{-1} in spite of reduced grain per spike from 40.31 to 35.20 and 1000 grain weight from 37.97 to 36.14 g. Moreover, the increase of seeding rate from 140 to 200 kg ha^{-1} (Table 5) increased biological yield from 10.749 to 11.904 t ha^{-1}. While, increased seeding rate reduced protein content. The increased of seeding rate increased plants number per unit area and thus increased competitive between plants on nutrition resource. This results is similar to what found by (Chen *et al.*, 2008; Baloch *et al.*, 2010; Kolb *et al.*, 2012)

***Ethephon*:**

The Results of Table 5 revealed, that foliar application of ethephon from 0 to 2.25 ml l^{-1} significantly increased spikes m^{-2} from 421.38 to 443.78 spikes m^{-2}, grains per spike from 36.43 to 38.08 which reflected positively to increase grain yield from 3.337 to 3.709 t ha^{-1}. The same trend can be

observed for biological yield, foliar application of ethephon increased biological yield from 10.585 to 12.068 t ha^{-1}. While the results of Table 5 recorded reduction in harvest index from 31.53 to 30.74% and in protein content from 12.42 to 11.88%. Ethephon is growth regulator and foliar application of ethephon at tillering stage reduce or prevented growth of apical meristem for the main stem and then enhance plant to produce tillers. So, foliar application of ethephon lead to increased tillers number and spikes m^{-2} which reflect positively to increased grain yield. These results similar to what found by (Ma and Smith, 1992).

***Interaction of Wheat varieties and seeding rate*:** The results of table 6 showed significant effect for the interaction of wheat varieties and seeding rate on all most traits measured. The increased of seeding rate lead to increase spike m^{-2}, grain yield and biological yield for all wheat varieties. In other hand, increased seeding rate reduced grains spike, harvest index and protein content for all wheat varieties. The increased of seeding rate from 140 to 200 kg ha^{-1} increased spikes m^{-2} which reflect positively to increased grain yield for all wheat varieties, in spite of the significant reduction in grains per spike (Table 6). Alrasheed under seeding rate of 200 kg ha^{-1} gave highest grain and biological yield by 4.164 and 13.669 t ha^{-1} respectively. The results of Table 6 showed that in spite of IPA-99 and Adina produced low grain and biological yield under 200 kg ha^{-1} of seeding rate as compared to Alrasheed, but these two varieties have high ability to translocate photosynthesis product and storage food to grain. This is clearly appeared by high average of harvest index by 33.22% and 33.07% respectively. Maybe this is because of the single effect of the two studied factors.

***Interaction of Wheat varieties and Ethephon*:** The results of table 7 showed significant effect for the interaction of wheat varieties and foliar application of ethephon on spike m^{-2}, grains $spike^{-1}$, 1000 grain weight, grain yield and biological yield. Foliar application of ethephon increased spike m^{-2} for all wheat varieties. Ethephon reduce or prevented growth of apical meristem for the main stem and enhance plant to produce tillers which reflect positively to increase spike m^{-2}. The results of table 7 showed that grain component (grains $spik^{-1}$ and 1000 grain weight) of wheat varieties have different response for ethephon foliar application. In one case ethephon foliar application lead to increased grains $spik^{-1}$ like what happened with Jehan, Ibaa99, Bhooth22 and Jihad. While, in other case foliar application of ethephon have no significant effect on grains $spik^{-1}$ like what happened with Alrasheed variety. Foliar application of ethephon have no clear effect for wheat variety especially on 1000 grain weight. Alrasheed and Jihad gave highest average with ethephon by 40.70 and 40.26 g respectively (Table 7). The results of table 7 revealed that foliar application of ethephon increased both grain and biological yield for all wheat varieties, as a results of increased spikes m^{-2} which is one of more important grain yield components. Alrasheed under ethephon foliar applications gave highest grain yield by 4.278 t ha^{-1} because this variety produced highest grains $spike^{-1}$ and 1000 grain weight (Table 7). Same trained can be observed for biological yield as well as grain yield for both Alrasheed and Mauada which they gave highest biological yield by 13.116 and 13.063 t ha^{-1} respectively.

***Interaction of seeding rate and Ethephon*:** The results of Table 8 indicated that the interaction of seeding rate and foliar application of ethephon have significant effect on spikes m^{-2}, grains $spike^{-1}$, grain yield, biological yield and harvest index. High seeding rate of S_2 with ethephon E_1 gave highest spikes m^{-2} by 467.47, while the interaction of S_1 x E_2 gave highest grains $spike^{-1}$. In other hand both interactions of S_2 x E_1 and S_1 x E_0 gave highest grain yield by 3.993 and 3.924 t ha^{-1} respectively. The results showed that S_2xE_1 interaction gave highest biological yield by 12.559 t ha^{-1}. Moreover the interaction of S_1xE_1 gave highest harvest index by 32.64 this indicted that, the addition of ethephon improve translocation of photosynthesis product to grain. Maybe this is because of the single effect of the each single factor.

***Interaction of wheat varieties, seeding rate and Ethephon*:** The results of Table 9 and 10 showed that, the interaction of wheat varieties, seeding rate and ethephon have significant effect on spikes cm^{-2}, grains spike-1, grain yield and biological yield. Barcelona under the interaction of S_2 x E_1 gave highest average by 519.52 spike cm^{-2}. Alrasheed variety under the interaction of S_1 x E_1 and S_1 x E_0 gave highest grains $spike^{-1}$ by 62.04 and 60.20 respectively. Alrasheed under high seeding rate with spraying with ethephon (S_2 x E_1) and with low seeding rate and ethephon (S_1 x E_1) produced highest grain yield by 4.321 and 4.235 t ha^{-1} respectively. This indicated that spraying of ethephon compensate the use of high seeding rate. In fact, this case (spraying of ethephon compensate the increase of seeding rate) is exist with Abugraib3, Alrasheed, Barcelona, Mauada, Jehan and Babyl varieties (Table 9). This is considering a good indicator to reduced seeding rate in such conditions (desert condition) especially when the seeds cost a lot and high expensive or where there is loss of seedling. In addition, Alrasheed under the interaction of S_2 x E_1 gave highest biological yield by 14.261 t ha^{-1} (Table 12). For all wheat varieties, the increased of seeding rate and foliar application of ethephon have positive effect on spike m^{-2}, grain yield and biological yield. While, there is no clear effect for the interaction of seeding rate and ethephon application for all most wheat varieties in grains $spike^{-1}$. In other hand, Wafya under S_1 x E0 gave lowest average of spike m^{-2} by 347.66 spike m^{-2}. For grains $spikes^{-1}$ the results showed that bohooth22 under the interaction of S_2 x E_0 and Wafyah under the interaction of S_2 x E_0 and S_2 x E_1 gave lowest average by 24.52, 25.04 and 25.24 grains $spikes^{-1}$ respectively. For grain yield Wafyah under S_1x E_0 gave lowest average by 2.263 t ha^{-1}. For biological yield Bohooth22 under the interaction of S_1x E_0 gave lowest average by 7.795 t ha^{-1}.

***Conclusion*:** We conclude that, wheat varieties appeared different response to grow under desert conditions according to their genetic and acclimation ability to harsh environments at desert condition. Alrasheed variety gave highest grain spike^{-1} and 1000 grans weight which reflect positively to produce highest grain yield by 4.077 t ha^{-1}. Abugraib3, Wafyah, IPA-99 and Barcelona gave highest average of protein content by 13.29%, 13.08%, 12.63% and 12.34% respectively. Increasing seedling rate at desert agriculture is important for wheat, to increase spike m^{-2} which is one of the most important grain yield component. Moreover, foliar application of growth regulator ethephon lead to enhance grain yield and some components for all wheat varieties at desert agriculture. In addition foliar application of ethephon compensate the increase of seeding rate from 140 to 200 kg ha^{-1} for grain yield trait of some wheat varieties.

***Authors' contributions*:** Mohanad A. Alsulaiman: was managing the experiment at field condition and laboratory works, collected and analyzed data and wrote the manuscript. Kareem H. Mohsen suggested the topic, designed and managing the experiment at field and supervised teamwork. Sundus A. Alabdulla participate in laboratory measurement and suggested the proposal and review the article. Aqeel G. Shiltah and Saeb H. Alressan were managing the experiment at field condition and they are coordinator and representative of the Directorate of Basra Agriculture

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