RESPONSE OF MAIZE HYBRIDS TO IRRIGATION TREATMENTS AT SEMI-ARID ENVIRONMENT

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ABSTRACT

This experiment was carried out during season of 2020 and 2021 at Erbil governorate to study the forage and grain yield performance of three maize hybrids *Zea mays* L. as influenced by irrigation skipping at different times. The experiment was laid out in split-plot design with three replications. The irrigation treatments were located at the main plots, and the hybrids were distributed at the subplots. Highly significant effects of irrigation treatments were recorded for forage, grain yield and most of its components at both seasons and their average. The differences among hybrids were not significant for forage yield at both seasons. It was significant for grain yield as the average of both seasons only. The fresh and dry forage yield was affected more by the skipping irrigation during the last two periods of skipping, and the same for the grain yield. That there are no significant differences between the control and skipping during the first period, as the significantly outperformed the grain yield in the last two periods of skipping.

Key words: kernel yield; forage yield; yield components, drought, climate change, food security

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استجابة بعض هجن الذرة الصفراء لمعاملات الري في البيئات شبه الجافة لمحافظة اربيل

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المستخلص

اجريت هذه الدراسة في الموسم الخريفي 2020 و 2021 لدراسة كفاءة ثلاثة هجن من الذرة الصفراء *Zea mays* L. لحاصلي العلف الجاف وحاصل الحبوب ومكوناته تحت تأثير انقطاع مياه الري خلال فترات متباينة. طبقت التجربة وفقاً لتصميم القطع المنشقة وبثلاث مكررات. وضعت معاملات انقطاع الري في القطع الرئيسية, بينما وزعت الهجن في القطع المنشقة. هناك تأثيرات عالية المعنوية لمعاملات الري في حاصلي العلف والحبوب ومعظم مكوناته لكلا الموسمين ومتوسطهما. لم تحصل فروق معنوية بين الهجن الثلاث في الحاصل العلف الاخضر والجاف, بينما هناك فروق معنوية بين الهجن في الحاصل الحبوب وذالك كمتوسط الموسمين فقط. تأثرت حاصلي العلف الاخضر والجاف بانقطاع المياه في الفترتين الاخيرتين اكثر مما في الفترة الاولى, وكذلك الحال بالنسبة الى حاصل الحبوب, بحيث لا توجد هناك فروق معنوية في حاصل معاملة المقارنة و معاملة الانقطاع في الفترة الاولى, بحيث تفوقوا معنوياً على حاصل الفترتين الاخيرتين في انقطاع

الكلمات المفتاحية: انتاجية العرنوص , حاصل العلف, حاصل الحبوب, مكونات الحاصل، جفاف، تغير مناخي، امن غذائي

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INTRODUCTION

Crop production in arid and semi-arid regions faces the challenge of ensuring high yields with a limited supply of water. This raises the question to which extent irrigation supply can be reduced without detriment to yield (32). Maize (*Zea mays* L.) is a multipurposes crop with wide adaptability to different agro-climatic conditions. The grown in most parts of the world, up to 3000m above mean sea level (11, 39). This crop is preferred by farmers due to its grain production potential being the highest among cereals (7, 18), its dual-purpose use (grain and fodder) (19, 42); used as a cash crop (specialty corn: green ear, baby corn, sweet corn, and popcorn) (18), and raw materials for industry. Maize are not a food crop but an industrial crop, as only 12–13% of its production was used for human consumption globally (6). It was cultivated at area of nearly 150 Mha in approximately 160 countries, which constitutes 36% (782 Mt) of the global grain production (5). The total maize grain produced in the world, approximately 70–80% is used as feed (40). Global climate change was predicted to increase ambient temperatures and also the frequency and severity of drought in various growing regions that are highly dependent on maize (16, 43). Drought stress is a major constraint in modern agriculture (38) and especially for C4 plants such as maize (*Zea maize* L.) with high water demand and short growing season. With ongoing climate change, models predict increasing frequencies and severity of drought spells; therefore, a better understanding of the role of the recovery process in overall drought resistance is important (8, 9, 10, 32). With the warming of the climate in recent years, drought has become more and more critical to maize production, and has become the most important abiotic factor threatening maize production (4, 16, 36). Breeding drought-resistant varieties is an essential means to cope with climate change. Drought adversely affects cereal yields worldwide, with maize (*Zea mays* L.) having greater sensitivity to drought stress than wheat (*Triticum aestivum* L.) (21) and (22).Breeders have explored the genetic variability associated with tolerance against drought and heat stresses, which are among the most limiting factors for crop production (30).

MATERIALS AND METHODS

The response of maize hybrids (Z*ea mays* L.) to soil moisture stress in the semi-arid environment of the Erbil region for the growth period and growth stages were conducted in two field experiments during the summer season of 2020 and 2021.

Location of the experiment

The governorate of Erbil is located at the north of Iraq. A Field Experiment of Gerda-Rasha, College of Agriculture Engineering Sciences/ University of Salaheddin (Lat 36^o 11’ 356’’; N, Long 44^o 01’ 987’’; E, 418 masl.), 5km south of Erbil city. The present study was designed to compare three skipping irrigation treatments on different dates with well-watered conditions, and evaluate the influence of drought conditions in three maize hybrids DKC6664 (H_1), DKC5401 (H_2) and DKC6589 (H_3) with respect to growth, forage and, kernel yield and its related characters at two successive seasons. At the location, a composite soil sample of about 5 kg was obtained by mixing subsamples from 6 sites using a shovel. Each the soil sample was freed from plant roots and other debris. All the samples were dried at room temperature for seven days. Each sample was cleaned using a 2 mm stainless-steel sieve. Factorial experiment within split plot was used Full and deficit irrigation as the main plot was replicated three times. The water deficit of various degrees was imposed at different growth stages with the irrigation treatments. There were three maize growth stages which are vegetative (S1), tasseling (S2), and milking (S3) stages. The four levels of irrigation treatments were: full irrigation (I1), add half of irrigation at emergency until tassling stage (17), add half of irrigation at tassling until milk stage (18), add half of irrigation at milk until physiological stage (19). Table 1 exhibits the details of the irrigation treatments. Table 2 shows the sum of water applied at different treatments for both seasons.

Table .1 Details of the irrigation treatments

Irrigation treatments symbol	Description
I1	Full irrigation (non-stopping irrigation)
I2	Add half of irrigation at emergency until tassling stage
I3	Add half of irrigation at tassling until milk stage
I4	Add half of irrigation at milk until physiological stage

Table 2. Total number of irrigations along with the gross depth of applied water as influenced by different irrigation treatments during the maize growing season

Irrigation treatments	Number of irrigations	Total applied water			
		Liters (L)	(mm)	($m\ ha^{-1}$)	ET_a($m^3\ ha^{-1}$)
Season 2020					
I1	18	6213.46	690.38	6903.84	767.08
I2	15	5322.06	591.34	5913.40	657.044
I3	15	4896.77	544.08	5440.85	604.538
I4	16	5114.82	568.31	5683.13	631.458
Season 2021					
I1	19	6391.62	710.18	7101.80	789.088
I2	16	5575.27	619.47	6194.74	688.304
I3	16	5149.94	572.21	5722.15	635.794
I4	17	5367.98	596.44	5964.42	662.713

The sub-plot factors encompassed the genotypes which, were hybrids DKC 5401, DKC6589 and, DKC 6664. The size of each sub-plot was 3m by 3m and consisted of four rows, 0.75 m apart. The spaces between plants within the row 0.25 m. Cultural practices before planting and delineating the plots, an area with a gentle slope was selected and irrigated. The field was then plowed with a moldboard plow at the optimum water content for tillage. In both seasons, three maize seeds at a depth of 2-5 cm were placed in each hole on July 1st, 2020, and 2021. After two weeks, the seedling was thin out to one per hole. Nitrogen fertilizer in the form of Urea (21%N) applied one before the second irrigation and the other before flowering at a rate of 40 kg ha^{-1} as recommended. Hand weeding practiced as needed. There was not treated with any pesticide.

Erbil governorate climate

The climate of Erbil governorate is considered a semi-arid environment: cold and wet in winter, hot and dry in summer. The average temperature from July to August is between 42-39°C and42-41 1n 2020 and 2021, respectively, and often reaching nearly 50 °C. In October means high temperatures are 32 and 30°C in 2020 and 2021, respectively, and slightly cooling down in November. The rainfall is limited to the winter and spring months (Kurdistan Regional Government, 2020 and 2021; Table 3).

Table 3. Agrometeorological parameters at Gerda-Rasha research center 2020 – 2021

Season	Month	Air temperature °C		Average humidity (%)	Average wind speed (ms^{-1})	Precipitation (mm)
		Minimum	maximum			
2020	July	31.0	42.2	14.0	4.5	0
	August	28.7	39.8	15.4	4.1	0
	September	26.9	38.9	16.0	3.5	0
	October	20.0	32.5	18.6	3.0	2.3
	N0vember	13.7	21.5	35.0	3.5	37
	December	10.1	20.2	58.0	3.2	29.3
2021	July	31.0	42.0	13.4	4.2	0
	August	30.4	41.9	13.7	4.4	0
	September	24.1	36.3	18.2	3.6	0
	October	19.4	30.3	24.0	3.5	12.5
	N0vember	12.9	23.4	36.9	3.1	3.3
	December	7.6	15.8	63.1	3.5	72.1

Watering schedules

As recommended by Allen et al (2), irrigation scheduling was based on an allowable root zone water depletion of 55% (p = 0.55) during the whole growing cycle. SOTERA digital meter was used to measure the water flow.

Analytical methods and laboratory

The results of the studied soil parameters are show in Table 3. Particle size fractionation and distribution were conducted by the international pipette method as recommended by Black et al (14). EC and acidity (pH) of soil sample were measured in 1:10, soil to H2O ratio suspension according to (43) by using these models of instruments; pH-meter (model WTW 330i/ Germany); EC-meter (model WTW 330i/Germany). The percent of organic carbon (o.m%) in soil samples was determined by the Walkley-Black method (wet oxidation by potassium dichromate K2Cr2O7 and concentrated H2SO4) as described by (14). The content of organic matter (O.M.) was calculated as follows: % Organic matter = % organic carbon × 1.724 (factor). The percent of the total (CaCO3%) was determined by the acid-neutralization method according to the method 23c of U.S. Salinity Laboratory Staff, 1954. A small auger 5 cm in diameter (30) was used to observe soil water content. The average water requirement (consumptive crop use) was calculated from soil moisture. The soil moisture was brought to field capacity when the available soil moisture was depleted by 55%. The net depth of applied water was calculated from (35):

$$dn = \frac{(Wfc - Wwp)}{100} \frac{pb}{pw} P\, D \qquad \textbf{Eq.1}$$

where:

dn = net depth of applied water (mm)

FC = Soil water retention at -33 kPa

ωPW = Soil water retention at -1500 kPa

ρb = Average soil bulk density of root zone (gcm^{-3})

ρw = Water density (gcm^{-3})

P = Depletion fraction = 0.55

D = Root zone depth (mm)

Table 4. Physicochemical properties of the soil sample for the location of both experiment

Physicochemical properties		Average value
Particles size distribution (kg^{-1})	Sand	25.2
	Silt	42
	Clay	32.8
	texture	Clay loam
pH		7.2
EC (micro siemens cm^{-1}) or (dS cm^{-1})		0.48
O.M ($g\ kg^{-1}$)		9.8
CaCO3 ($g\ kg^{-1}$)		304

Statistical analysis

Statistical analysis for all measured variables was performed using the XLSTAT software (XLSTAT, 2017) (44). For; direct comparison of treatments, the least significant difference tests (LSD) at levels of 0.05 and 0.01 were used. For; testing the main effects of deficit irrigation on maize genotypes in a semi-arid region, the data were subjected to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Data in Table (5) illustrates the mean squares of studies characters at both seasons and their average. The analysis of variance (ANOVA) severally displays great significant change within the irrigation treatments and hybrids acts for most investigated characters. The effect of irrigation treatments was highly significant for the characters fresh forage yield, dry forage yield, ear weight, ear diameter, number of kernels/row, kernel yield, while it was significant for plant height, number of leaves/plant, ear height, ear length, number of rows/ear, but it was not significant for the other studied trails, during the first season. In the second season, the effect of irrigation treatments was highly significant for fresh forage yield, dry forage yield, number of kernels/row, and kernel yield, at the same time, it was significant for plant height, number of leaves/plant, leaf area, ear height, ear length, ear weight, ear diameter and number of rows/ear. As the average of both seasons, all studied characters responded high significantly to the irrigation effect except for 1000 kernels weight which responded significantly. Regarding the effect of hybrids, it was found that this effect was highly significant for plant height, number of leaves/plant, leaf area, still, it was significant for stem diameter, ear height, and 1000 kernels weight, and did not significant for others at the first season. In the second season, the differences among hybrids were highly significant for plant height, number of leaves/plant, leaf area, ear weight, ear diameter, and number of rows/ear, but it was significant for stem diameter, ear height, number of kernels/row and 1000 kernels weight, but did not significant for the others. On the average of both seasons, the differences among hybrids were highly significant for all characters except for fresh and dry forage yield, and ear length, which did not significant. The effect of the interaction between irrigation treatments and hybrids was highly significant for ear diameter and a number of rows/ear, at the same time it was significant for dry forage yield, ear weight, 1000 kernels weight, and kernel yield, and it was not significant for the others at the first season. In the second season, the interaction effect was highly significant for the number of rows/ears, the number of kernels/row, and kernel yield, at the same time it was significant for the characters plant height, fresh forage yield, ear weight, and ear diameter, but did not significant for the others. In the average of both seasons, the interaction effect was highly significant for all characters, exception forage dry yield which was significant, and not for leaf area and ear length. Significant effect of interaction between soil moisture content (irrigation levels) and maize varieties was obtained for growth, yield, and yield components except number of ears/ plant, ear length, no. of rows/ear, ear grains weight, grain yield /plant and shelling% in the combined analysis (33).

Table 5a. Mean squares of variance analysis for some growth characters at both season and their average

S. O. V.	d.f	Plant height cm	N0. leaf	Leaf area cm^2	Stem diameter cm	Forage yield t/ha	Dry yield t/ha	Ear height cm
				Season 2020				
Blocks	2	183.630	0.680	2936.0280	0.124	1.389	0.191	45.671
Irrigation	3	606.930*	5.418*	15880.380	0.185	319.707**	32.287**	214.093*
E(a)	6	105.122	0.739	3487.491	0.046	10.809	0.299	42.213
Hybrid	2	924.610**	5.401**	36229.750**	0.179*	1.549	0.428	173.364*
Irrigation*hybrid	6	344.856	1.012	2778.593	0.093	19.125	1.174*	94.424
E(b)	16	131.472	0.657	3981.643	0.034	7.775	0.288	34.808
				Season 2021				
Blocks	2	180.207	1.196	3103.004	0.142	4.480	1.487	39.254
Irrigation	3	626.749*	4.061*	16271.820*	0.216	304.512**	41.433**	223.678*
E(a)	6	105.641	0.426	3399.959	0.046	12.505	2.600	43.118
Hybrids	2	929.046**	4.296**	36099.610**	0.221*	1.675	2.132	190.781*
Irrigation*hybrid	6	336.478*	1.194	2791.377	0.096	22.594*	4.631	92.458
E(b)	16	105.881	0.450	3904.727	0.047	5.667	2.758	36.692
				Average of both season				
Season	1	889.013	108.045**	36041.650*	1.063*	13.851	0.470	934.560**
Block/L E(a)	4	181.919	0.938	3019.516	0.133	2.934	0.839	42.462
Irrigation	3	1233.592**	9.427**	32150.710**	0.400**	623.411**	72.553**	437.573**
Irrigation*Season	3	0.087	0.052	1.483	0.0006	0.809	1.167	0.197
E(b)/L	12	105.381	0.583	3443.725	0.046	11.657	1.450	42.665
Hybrid	2	1853.644**	9.653**	72327.850**	0.398**	2.928	1.395	363.501**
Hybrid*Season	2	0.013	0.045	1.516	0.001	0.296	1.165	0.643
Irrigation*Hybrid	6	681.246**	2.155**	5568.620	0.189**	40.766**	4.709*	186.735**
Irrigation*Hybrid*S	6	0.087	0.052	1.350	0.0004	0.953	1.096	0.147
E(c)/S	32	118.676	0.553	3943.185	0.040	6.720	1.523	35.750

Continued

Table 5b. Mean squares of variance analysis for some yield characters at both season and their average

S. O. V.	d.f	Ear length cm	Ear weight g	Ear diameter cm	No. row/ear	No. kernel/row	1000 kernel weight g	Kernel yield t/ha
				Season 2020				
Blocks	2	10.112	218.914	0.040	0.035	20.143	895.774	0.966
Irrigation	3	62.063*	347.961**	0.074**	6.390*	160.941**	1978.614	32.164**
E(a)	6	7.680	27.888	0.007	0.780	3.523	800.943	0.951
Hybrids	2	4.448	339.220**	0.290**	10.730**	36.471	3658.288*	7.187
Irrigation*hybrids	6	2.569	112.929*	0.040**	7.388**	29.596	2046.821*	11.442*
E(b)	16	7.550	41.007	0.007	1.447	12.055	687.716	2.921
				Season 2021				
Blocks	2	13.337	244.401	0.074	0.043	21.010	2196.670	0.169
Irrigation	3	71.019*	297.861*	0.092*	6.904*	172.163**	2419.017	33.698**
E(a)	6	12.281	33.857	0.010	0.727	3.712	1063.686	1.587
Hybrids	2	1.904	403.386**	0.309**	10.843**	31.363*	5796.723*	5.459
Irrigation*hybrids	6	4.600	145.425*	0.045*	7.598**	32.843**	2252.860	11.234**
E(b)	16	8.502	46.449	0.011	0.893	7.067	1535.382	1.727
				Average of both season				
Season	1	153.416*	2069.818*	0.513*	41.861**	946.125**	38493.880**	76.446**
Block/L E(a)	4	11.725	231.658	0.057	0.039	20.576	1546.222	0.568
Irrigation	3	132.802**	644.430**	0.165**	13.284**	332.979**	4239.453*	65.810**
Irrigation*Season	3	0.279	1.392	0.001	0.011	0.125	158.179	0.052
E(b)/L	12	9.981	30.872	0.008	0.753	3.617	932.314	1.269
Hybrids	2	5.827	741.212**	0.599**	21.562**	67.710**	9247.002**	12.587**
Hybrids*Season	2	0.525	1.394	0.0004	0.011	0.125	208.008	0.059
Irrigation*Hybrids	6	6.926	256.967**	0.085**	14.975**	62.314**	4123.657**	22.622**
Irrigation*Hybrids*S	6	0.243	1.387	0.0004	0.011	0.125	176.023	0.054
E(c)/S	32	8.026	43.728	0.009	1.170	9.561	1111.549	2.324

Data results in Table 6 show the effect of irrigation treatments at both seasons and their average on studied characters. A treatment of full irrigation I1 produced the highest value for all characters compared to the skipping treatment at different dates during both seasons and their average. A minimum value changes according to characters and skipping treatment. The lowest values of most growth characters occurred at skipping treatments of I2 and I3 as the average of both seasons, in contrast, for fresh and dry forage yield and kernel yield with most of its related components, the lowest values exhibited at the last skipping treatment I4.

Table 6. Effect of irrigation treatments for some growth characters and yield component at both seasons and their average

Irrigation treatment	Plant height cm	No. leaf	Leaf area cm^2	Stem diameter cm	Forage yield t/ha	Dry yield t/h a	Ear height cm	Ear length cm	Ear weight g	Ear diameter cm	No. raw/ ear	No. kernel/ raw	1000 kernel weight g	Kernel yield t/ha
							Season 2020							
I1	154.622	13.278	571.244	1.711	42.304	11.871	66.811	16.274	34.535	2.535	16.577	25.322	299.533	8.433
I2	140.878	11.600	470.467	1.643	37.265	9.516	62.544	10.960	27.597	2.318	16.055	23.800	263.688	7.544
I3	137.222	12.056	538.067	1.383	30.262	7.884	58.655	13.664	24.595	2.440	15.811	20.255	286.466	5.015
I4	137.511	11.668	531.478	1.630	29.935	7.850	55.544	10.674	19.671	2.347	14.588	15.811	284.600	4.562
LSD 0.05	11.82	0.992	n.s	n.s	3.792	0.631	7.494	3.196	6.090	0.096	1.019	2.165	n.s	1.125
							Season 2021							
I1	161.844	15.567	616.244	1.967	42.750	12.261	74.033	19.396	44.424	2.712	18.177	32.655	343.555	10.433
I2	147.878	14.111	514.356	1.893	38.471	8.701	70.033	13.960	38.597	2.483	17.555	31.133	308.133	9.766
I3	144.111	14.556	583.167	1.611	31.537	7.917	65.655	16.664	35.595	2.616	17.311	27.588	341.400	7.015
I4	144.511	14.178	576.478	1.868	30.517	7.595	62.655	13.230	30.671	2.528	16.088	22.811	326.177	6.573
LSD 0.05	11.85	0.75	67.261	n.s	4.079	1.860	7.574	4.042	6.712	0.117	0.983	2.222	n.s	1.453
							Average of both season							
I1	158.2	14.43	593.74	1.84	42.53	12.07	70.42	17.84	39.48	2.63	17.38	28.99	321.55	9.43
I2	144.38	12.85	492.42	1.77	37.87	9.11	66.29	12.46	33.1	2.4	16.81	27.47	285.91	8.54
I3	140.67	13.31	560.62	1.49	30.9	7.9	62.16	15.16	30.1	2.53	16.56	23.93	313.97	6.02
I4	141.31	12.93	553.98	1.75	30.23	7.72	59.1	11.95	25.17	2.44	15.34	19.31	305.44	5.55
LSD 0.05	7.45	0.55	42.62	0.15	2.47	0.87	4.74	2.29	4.035	0.067	0.63	1.38	22.17	0.818

At both seasons and their average, under drought condition, the significant differences among skipping treatments were found to be low in reduction of biomass compared to the treatment of control I1. A water requirement of maize is most significant during the late vegetative to early reproductive stage, with drought stress during these stages causing severe yield loss (15, 28). (46) reported that under drought stress, plant height, ear length, rows ear^{-1}, row grains, 1000 kernel weight could be used as identification index of drought resistance of maize in different periods. Results in Table 7 show the mean of studied characters in both seasons and their combined. Significant differences represent among hybrids for all trails except fresh and dry forage yield; and ear length in both seasons and they're combined, while there were no significant differences among hybrids due to a number of kernels/row in the first season, and for kernel yield in both seasons. Hybrid DKC6664 produced the highest value for plant height at both seasons and they're combined, ear height at the second season, and the average of both seasons. Hybrid DKC 5401 exhibited the maximum significant value for the traits number of leaves/plant; leaf area; stem diameter; ear weight and 1000 kernels weight at both seasons and their combined, and number of kernels/row in the second season and the average of both seasons and kernel yield as the average of both seasons only and ear height during the first season. Hybrid DKC 6589 produced the maximum significant value for the ear diameter and the number of rows/ear in both seasons and their average. Mehasen and El-Gizawy (33) indicated that maize varieties exhibited significant differences for kernel yield and all studied yield attributes in both seasons and they're combined. Significant differences in yield and yield attribute were also reported by others (13, 22, 23, 24, 25, 26, 35, 36); they, also confirmed that the differences among varieties in their performance might be due to the genetic differences among them. Significant phenotypes differences were seen between maize lines under stress for a maximum number of traits, and This variation was because of differences in the genetic constitution of the lines, which depends on the variability in the source populations from which the lines were obtained and developed (3, 42).

Table 7. Effect of hybrids for some growth characters and yield components at both seasons and they're average

Hybrid	Plant height cm	No. leaf	Leaf area cm^2	Stem diameter cm	Forage yield t/ha	Dry yield t/ha	Ear height cm	Ear length cm	Ear weight g	Ear diameter cm	No. row/ear	No. kernel/row	1000 kernel weight g	Kernel yield t/ha
							SEASON 2020							
H_1	148.25	12.167	467.783	1.56	35.254	9.437	63.066	12.375	20.475	2.280	15.858	21.208	265.666	5.499
H_2	146.96	12.817	575.616	1.72	34.549	9.333	63.100	13.564	30.040	2.364	14.767	23.083	300.550	6.908
H_3	132.45	11.475	540.041	1.48	35.022	9.070	56.500	12.740	29.284	2.586	16.650	19.600	284.500	6.759
LSD 0.05	9.923	0.701	54.612	0.15	n.s	n.s	5.106	n.s	5.524	0.082	1.041	n.s	22.696	n.s
							SEASON 2021							
H_1	155.25	14.667	512.825	1.81	36.248	9.496	70.650	15.375	30.641	2.451	17.433	28.541	309.933	7.674
H_2	154.05	15.167	620.650	1.97	35.565	8.664	70.133	16.158	41.040	2.540	16.267	30.166	353.416	8.908
H_3	139.45	13.975	584.208	1.70	35.643	9.195	63.500	15.906	40.284	2.763	18.150	26.933	326.100	8.759
LSD 0.05	8.905	0.581	54.082	0.18	n.s	n.s	5.242	n.s	5.898	0.092	0.817	2.300	33.000	n.s
							Average of both season							
H_1	151.76	13.41	490.31	1.7	35.75	9.47	66.86	13.88	25.56	2.37	16.65	24.88	287.8	6.59
H_2	150.51	13.99	598.14	1.85	35.06	8.99	66.62	14.86	35.54	2.45	15.52	26.63	327.01	7.91
H_3	135.95	12.73	562.13	1.6	35.33	9.14	60.00	14.33	34.78	2.68	17.4	23.27	305.34	7.76
LSD 0.05	6.421	0.438	37.015	0.118	n.s	n.s	3.524	n.s	3.897	0.059	0.637	1.822	19.648	0.898

Data present in Table 8 illustrate the impact of the interaction between irrigation treatments and hybrids for the studied characters at both seasons and their combination. In the first season, was highly significant for ear diameter and number of rows/ear, but it was significant for dry forage yield, ear weight, and number of rows/ear, while did not significant for the others. A maximum dry forage yield was produced for hybrid 1 under the first irrigation treatment (full irrigation) reached 11.970 t/h, but the lowest dry yield exhibited by hybrid 3 coupled with the third irrigation treatment 7.233 t/h. maximum ear weight was 45.893gr produced by the interaction between the hybrid 2 and the full irrigation treatment, at the same time the minimum value was 14.927gr produced by the hybrid 2 coupled with the last irrigation treatment. Highest value for ear diameter and number of rows/ear was 2.786cm and 17.697 rows respectively, exhibited by the interaction between the hybrid 3 under the full irrigation treatment for both. Lowest value for ear diameter was 2.200 cm produced by the interaction between the hybrid 2 under the second irrigation treatment, still for a number of rows/ear, the lowest value was 12.433 rows shown by the hybrid 2 under the last irrigation treatment. The minimum value for 1000 kernels weight was 335.800gr recorded by the hybrid 2 under the last irrigation treatment, while the lowest value was 236.600gr for the interaction hybrid 1 with the same irrigation treatment. Maximum kernel yield reached 11.126t/h for hybrid 2 under the full irrigation treatment. Still, the lowest yield was 3.166t/h obtained by the interaction of hybrid 1 with the last irrigation treatment. In the second season, this effect was highly significant for the number of rows/ear, number of kernels/row, and kernel yield, but it was significant for plant height and ear diameter, while it does not significant for the others. The maximum value for the traits plant height, fresh forage yield, ear diameter, and a number of rows/ear produced by the interaction of hybrid 3 under the full irrigation, recording 196.433cm, 45.246t/h, 2.963cm, and 13.130t/h, respectively. Lowest value for plant height was recorded by hybrid 3 under the third irrigation treatment with 127.333, but the lowest value for forage yield, ear weight, and kernel yield was 28.783t/h, 25.927gr, and 5.200t/h, respectively recorded by the interaction of hybrid 1 under the last irrigation treatment. Highest value for ear weight, number of kernel/row, and kernel yield reached 56.893gr, 35.900 kernels, and 13.130t/h respectively, recorded by the hybrid 2 under full irrigation. The lowest value for a number of rows/ear and number of kernels/row was 13.933 row and 20.933 kernels respectively, by the hybrid 2 under the last irrigation treatment. Regarding the average of both seasons, the interaction effect was highly significant for all traits except dry forage yield it was significant, and leaf area, and ear length were not significant. The hybrid 3 under full irrigation exhibited maximum value for plant height, fresh forage yield, ear height, ear diameter, number of rows/ear, and 1000 kernels weight recording 165.933cm; 45.088t/h; 71.733cm; 2.874cm; 18.717row and 343.900gr respectively, while the highest values for the traits the number of leaves/plant; stem diameter; ear weight; number of kernels/row and kernel yield recorded by hybrid 2 under full irrigation reached 14.733 leaves, 1.923cm; 51.393gr; 32.233 kernels and 12.128t/h respectively. Lowest values for plant height and ear height were 123.833 and 55.267cm recorded by the hybrid 3 under the third irrigation treatment. A minimum number of leaves/plant was 11.650 leaves obtained by hybrid 3 under the second irrigation treatment, while the lowest value for stem diameter was 1.275cm recorded by hybrid 1 under the third irrigation treatment. The minimum value for fresh forage yield, dry forage yield, ear weight, and kernel yield was 28.504; 7.198t/h; 20.427gr, and 4.183t/h, respectively recorded by hybrid 1 under the last irrigation treatment. Lowest value for ear diameter and 1000 kernel weight was 2.273cm and 273.233gr recorded by hybrid 1 under the second irrigation treatment. A lowest value for a number of rows/ear and a number of kernel/rows was 13.183 and 17.766, respectively recorded by hybrid 2 under the last irrigation treatment. Kränzlein et al (29) reported that under drought, did not significant differences in biomass were observed between all hybrids. Growth parameters such as plant height, fresh and dry weight of shoot was baldly desolated by the water stress levels (5). The plant biomass is minimized by the water deficit condition, but it produces strafe shoots more than roots (47). Drought affects the seedling of maize root and shoot growth, creates different environmental disorders (1). The grain weight was important and highly correlated with grain yield in corn (13). The number of kernels/ear is agronomic trait one of the important traits correlated to grain yield, directly and indirectly (12, 13).

Table 8. Effect of interaction between irrigation treatment and hybrids at both seasons and their average

Irrigation and hybrids		Plant height cm	No. leaf	Leaf area cm^2	Stem diameter cm	Forage yield t/ha	Dry yield t/ha	Ear height cm	Ear length cm	Ear weight g	Ear diameter cm	No. row/ear	No. kernel/row	1000 kernel weight gm	Kernel yield t/ha
								Season 2020							
I1	H1	153.667	12.833	493.900	1.793	41.220	11.970	66.533	14.550	19.487	2.220	17.300	24.267	286.467	6.390
	H2	147.767	13.800	595.933	1.790	40.763	11.710	65.667	17.333	45.893	2.600	14.467	28.567	290.733	11.126
	H3	162.433	13.200	623.900	1.550	44.930	11.933	68.233	16.940	38.227	2.786	17.967	23.133	321.400	7.773
I2	H1	150.133	12.500	432.833	1.550	38.656	9.893	65.200	10.420	23.513	2.203	15.600	21.167	250.733	6.270
	H2	150.333	11.900	498.767	1.730	35.196	8.946	67.433	11.886	28.923	2.200	15.267	24.967	273.200	7.560
	H3	122.167	10.400	479.800	1.650	37.943	9.710	55.000	10.573	30.357	2.553	17.300	25.267	267.133	8.800
I3	H1	146.567	11.933	463.400	1.150	32.913	8.513	67.667	13.053	23.973	2.380	16.033	22.133	288.867	6.166
	H2	144.767	12.967	607.433	1.750	29.706	7.906	56.533	14.526	26.340	2.403	16.900	24.200	302.467	5.396
	H3	120.333	11.267	543.367	1.250	28..167	7.233	51.767	13.413	23.473	2.536	14.500	14.433	268.067	3.483
I4	H1	142.667	11.400	481.000	1.780	28.226	7.373	52.867	11.480	14.927	2.320	14.500	17.667	236.600	3.166
	H2	145.500	12.600	600.333	1.626	32.530	8.770	62.767	10.510	19.007	2.253	12.433	14.600	335.800	3.546
	H3	124.867	11.033	513.100	1.483	29.050	7.406	51.000	10.033	25.080	2.470	16.833	15.567	281.400	6.973
LSD 0.05		n.s	n.s	n.s	n.s	n.s	0.929	n.s	n.s	11.084	0.164	2.082	n.s	45.393	2.958
								Season 2021							
I1	H1	160.667	15.333	538.900	2.043	41.656	12.423	74.200	17.550	27.153	2.397	19.100	31.600	328.533	8.393
	H2	155.433	15.667	640.933	2.056	41.346	12.183	72.667	20.033	56.893	2.777	15.967	35.900	335.733	13.130
	H3	169.433	15.700	668.900	1.800	45.246	12.176	75.233	20.606	49.227	2.963	19.467	30.467	366.400	9.776
I2	H1	157.133	15.000	477.833	1.800	40.980	10.206	73.533	13.420	34.513	2.343	17.100	28.500	295.733	8.936
	H2	157.333	14.433	543.767	1.980	35.610	6.210	74.567	14.886	39.923	2.377	16.767	32.300	316.533	9.560
	H3	129.167	12.900	521.467	1.900	38.823	9.686	62.000	13.573	41.357	2.730	18.800	32.600	312.133	10.803
I3	H1	153.567	14.433	508.567	1.400	33.573	8.333	74.667	16.053	34.973	2.556	17.533	29.467	330.533	8.166
	H2	151.433	15.467	652.567	2.000	32.190	8.040	63.533	17.526	37.340	2.580	18.400	31.533	380.600	7.397
	H3	127.333	13.767	588.367	1.433	28.850	7.380	58.767	16.413	34.473	2.713	16.000	21.767	313.067	5.500
I4	H1	149.667	13.900	526.000	2.030	28.783	7.023	60.200	14.480	25.927	2.510	16.000	24.600	284.933	5.200
	H2	152.000	15.100	645.333	1.877	33.116	8.223	69.767	12.176	30.007	2.430	13.933	20.933	380.800	5.543
	H3	131.867	13.533	558.100	1.700	29.653	7.540	58.000	13.033	36.080	2.647	18.333	22.900	312.800	8.970
LSD 0.05		17.811	n.s	n.s	n.s	4.120	n.s	n.s	n.s	11.797	0.184	1.635	4.601	n.s	2.274
								Average of both Season							
I1	H1	157.167	14.083	516.400	1.918	41.438	12.196	70.366	16.050	23.320	2.308	18.200	27.933	307.500	7.391
	H2	151.600	14.733	618.433	1.923	41.054	11.946	69.667	18.683	51.393	2.688	15.217	32.233	313.233	12.128
	H3	165.933	14.450	646.400	1.675	45.088	12.054	71.733	18.773	43.727	2.874	18.717	26.800	343.900	8.774
I2	H1	153.633	13.750	455.333	1.675	39.818	10.049	69.366	11.920	29.013	2.273	16.350	24.833	273.233	7.603
	H2	153.833	13.165	521.267	1.855	35.403	7.578	71.000	13.386	34.423	2.288	16.017	28.633	294.866	8.560
	H3	125.667	11.650	500.633	1.775	38.383	9.698	58.500	12.073	35.857	2.641	18.050	28.933	289.633	9.801
I3	H1	150.067	13.183	485.983	1.275	33.243	8.423	71.167	14.553	29.473	2.468	16.783	25.800	309.700	7.166
	H2	148.100	14.217	630.000	1.875	30.948	7.973	60.033	16.026	31.840	2.491	17.650	27.866	341.533	6.396
	H3	123.833	12.517	565.867	1.341	28.508	7.306	55.267	14.913	28.973	2.624	15.250	18.100	290.567	4.491
I4	H1	146.167	12.650	503.500	1.905	28.504	7.198	56.533	12.980	20.427	2.415	15.250	21.133	260.766	4.183
	H2	148.750	13.850	622.833	1.751	32.823	8.496	66.267	11.343	24.507	2.341	13.183	17.766	308.300	4.544
	H3	128.367	12.283	535.600	1.591	29.351	7.473	54.500	11.533	30.580	2.558	17.583	19.233	297.100	7.971
LSD 0.05		12.843	0.877	n.s	0.237	3.056	1.454	7.049	n.s	7.797	0.118	1.275	3.645	39.306	1.797

Data results in Table (9) indicate the effect of seasons in studied characters; this, effect was highly significant for a number of leaves/plant; the number of rows/ear; the number of kernels/row; 1000 kernels weight, and kernel yield, while it was significant for leaf area, stem diameter, ear length, ear weight, and ear diameter, but did not significant for the others. It was observed that the second season predominated the first season by 15.72; 8.54; 15.34; 11.82; 22.65; 40.30; 6.99; 9.64; 33.80 and 32.24% for the trails number of leaves/plant; leaf area; stem diameter; ear height; ear length; ear weight; ear diameter; the number of rows/ear; the number of kernels/row and kernel yield respectively. Vice versa, the first season exceeded the second season in only 1000 kernel weight by 16.41%.

Table 9. Effect of seasons of growth characters and yield component

season	Plant height cm	No. leaf	Leaf area cm^2	Stem diameter cm	Forage yield t/ha	Dry yield t/h a	Ear height cm
2020	142.558	12.152	527.813	1.591	34.941	9.280	60.888
2021	149.586	14.602	572.561	1.835	35.819	9.118	68.094
LSD 0.05	n.s	0.633	35.954	0.238	n.s	0.599	4.263
season	**Ear length cm**	**Ear weight gm**	**Ear diameter cm**	**No. row/ear**	**No. kernel/row**	**1000 kernel weight gm**	**Kernel yield t/h**
2020	12.893	26.598	2.416	15.758	21.297	283.572	6.387
2021	15.812	37.322	2.585	17.283	28.547	329.816	8.448
LSD 0.05	2.240	9.958	0.156	0.130	2.968	25.728	0.493

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