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Grain Yield and Ear Characteristics of Corn as Affected by Irrigation Regimes and Nitrogen Fertilization

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Abstract. This research dealt with the grain yield, its components and ear Characters of hybrid corn cultivar (AGA215) under the influence of three different irrigation treatments and four nitrogen rates (urea). The considered grain yield characters included grain yield kg/ha, weight of 1000 grains, grain protein content, shelling percentage and harvest index, while the ear characters were ear length, diameter, and volume, number of rows per ear, number of grains per ear, number of grains per row and weight of grains and cob per ear. The field experiments were conducted at the Agricultural Research Station of King Abdulaziz University at Hada Al-Sham area during two successive sowing dates (Autumn 1994 and Spring 1995). A split-plot design was used where three irrigation treatments were the main treatments and the sub treatments were 4 N-fertilizer levels. The depletion ratio method was followed to estimate the amount of irrigation water and the corresponding irrigation frequencies for each irrigation treatment. Three depletion ratios (50%, 25% and 10%) were applied, and designated as IR_1, IR_2, IR_3 respectively. As regards nitrogen (urea) treatments, four rates were used (0, 100, 200 and 300 kg/ha) and denoted as N_0, N_1, N_2 and N_3, respectively. The total applied irrigation water was the same for the three irrigation treatments and was equal to 9015 m^3/ha for autumn sowing date, and 8210 m^3/ha for spring sowing date, where only the irrigation frequency and application water for each irrigation were the varying parameters in the treatment.

The results showed that the first sowing date (autumn) gave higher grain yield number of grains per row, weight of grains per ear, and weight of cob per ear, one thousand grain weight, protein content of grain, shelling percentage and harvest index, than the second sowing date (spring). The irrigation treatments significantly affected grain yield variables, where irrigation treatment No. IR3 (10%) had higher values for grain yield, and ear length. Also, the nitrogen treatments significantly affected some grain yield variables; where treatment No. N3 (200 kgN/ha) gave higher values of grain yield, ear length and volume, number of grains per ear, and weight of grains per ear. However, the N4 treatment (300 kgN/ha) gave higher values of number of grains/row, weight of cob and protein content of grain.

1. Introduction

The corn crop is considered as one of the strategic crops over the Kingdom of Saudi Arabia in which the statistics pointed out that corn and sorghum imports of the Kingdom reached 99,589.2 tons in 1990. While it was 441 tons in 1984. This indicates that there is an increase in corn consumption occurred in the Kingdom to meet the requirements of animal production. Moreover, the total number of alive animals imported in 2000 was 17324, that included cattle, sheep, goats and poultry (Ministry of Agriculture, 2002). Moreover, the production of corn in the Kingdom increased during the last decade, in which the production was 3,700 tons in 1988, while it reached 5,800 tons in 2000. The increase in the corn planted area was 2,050 ha in 1988, where it reached 3,333 ha in 2000 (Ministry of Agriculture, 2002).

Water is considered one of the effective factors that affect the chemical fertilization (such as nitrogen) and, consequently, corn productivity researchers were interested in studying the effect of nitrogen fertilization with various water requirements. In experiments, conducted by Boquet *et al*. (1985), when nitrogen rates were applied as liquid fertilizer, results showed that N application increased ear and grain numbers and specific grain weight, but irrigation increased ear number and height, plant height, specific grain weight, but, significantly, reduced grain number/ear. Boquet *et al*. (1989) studied the effect of nitrogen rates on grain yield and its components. They found that the increasing N rate increased grain yield, number of ears, number of grains/ear and grain weight. While, Pirani and Agostinelli (1989) found that maize grain yield was not significantly affected by rates of 0.0 and 230 kg N/ha. Russel (1984) and Milam and Hickingbottom (1986) reported that corn plant height was not affected by nitrogen applications up to 300 kg N/ha. Turget (2000) found that N rates were statistically significant in corn ear height, ear diameter, fresh ear weight, number of ears per plant, fresh ear yield and seed number per ear. Also Sanjeev *et al*. (1997) obtained significant increase in number of grains/ear, 100-seed weight, grain weight/ear up to 180 kgN/ha and grain yield/plant up to 240 kgN/ha. Boquet *et al.,* (1986) mentioned that the increasing water irrigation caused decreasing grain protein content. The optimum nitrogen rate was 89 kg/ha with irrigation and 133 kg N/ha without irrigation. Efimov and Naumenko

(1980) reported that grain protein content increased with increasing nitrogen rates up to 90 kg N/ha with irrigation water.

Moreover, the application water rates and fertilization levels are important for the corn yield production, in which the water availability and fertilization costs in the Kingdom of Saudi Arabia have great influence on the planning of corn planting and the projects of animal production.

The objective of this study was to estimate the optimum irrigation treatment and nitrogen fertilization levels to produce the maximum grain yield and ear characteristics of corn.

2. Materials and Methods

Two field experiments were conducted at the Research Station of King Abdulaziz University in Hada El-Sham, which is located at 120 km North-East of Jeddah, during the period from 14/10/1994 to 6/6/1995. Two factors were investigated to estimate the optimum grain yield and ear characteristics of corn. These factors were, three irrigation regimes (IR_1, IR_2 and IR_3) and four levels of nitrogen fertilization (N_0, N_1, N_2 and N_3). The experiment was laid out in split plot design with three replications. Three irrigation regimes were considered as main plot and four nitrogen treatments as sub-plot. Data was combined over two successive sowing dates. The two sowing dates of the two experiments were 14/10/1994 (Autumn) and 16/2/1995 (Spring), respectively. Land leveling processes were followed to minimize the water losses due to non-uniformity of irrigation water, where good land leveling was made before cultivation in each sowing date.

2.1 Environmental Conditions of the Experiments

2.1.1 Climatic Parameters

The different climatic parameters were recorded at the meteorological station of Hada El-Sham as illustrated in Table (1). These data were used for calculating the evapotranspiration rate for each season. Meanwhile, the different data concerning the crop coefficients were collected from FAO report (1988).

2.1.2 Soil Analysis

Random samples were taken from the experimental area at four different sites and two different layers *i.e.*, 0 to 30 cm, and 30 to 60 cm layers, respectively. Each sample was taken in undisturbed condition in steel cylindrical rings. Soil texture was determined using the hydrometer method as described by Day (1956) at 25ºC using Pyrophosphate as differential factor. The different physical properties of soil samples at different depths were measured using the different experiments methodology as was described by Black *et al*. (1965). Meanwhile, the bulk and particle densities and the soil porosity were measured using the oven dry weight method as was described by Black *et al*. (1965). Data of soil texture analysis are tabulated in Table (2).

TABLE 1. Monthly recorded temperature and humidity at the experimental site during the two growing seasons.

Month	Autumn 1994-1995						Month	Spring 1995					
	Temperature (ºC)			Humidity (%)				Temperature (ºC)			Humidity (%)		
	Min.	Max.	Mean	Min.	Max	Mean		Min.	Max.	Mean	Min.	Max.	Mean
October	19.0	42.0	30.5	21	99	61.0	February	10.3	33.7	22.65	22	97	61.5
November	16.2	39.0	27.1	30	99	65.0	March	10.9	92.2	27.00	17	96	54.50
December	11.0	34.9	24.1	27	98	59.0	April	13.8	44.5	30.15	20	92	54.6
January	15.0	35.5	25.3	27	100	62.0	May	16.3	46.6	33.7	19	92	48.9
February	10.3	33.7	22.50	22	97	61.5	June	22.8	51	36.05	22	92	48.4

TABLE 2. Soil texture and physical properties of soil analysis.

Soil depth	Coarse sand %	Med. sand %	Fine sand %	Silt % clay %	% Error	Uniformity coeff.	Soil tex.	Bulk D (gm/cm^3)	Porosity	Part D (gm/cm^3)
0.30 cm	5.7	42.8	43.8	7.8	0.1%	4.9	Sandy	1.64	0.369614	2.71
30-60 cm	6.6	41.6	47.2	4.2	– 0.4%	6.2	Sandy	1.69	0.254567	2.63

Soil pH and electrical conductivity (EC) were determined by mixing soil with water by 1:1 weight-volume (W:V) ratio using glass rod. The total organic matter (O.M.) in the soil was determined using Walkeley and Black's method as described by Jackson (1973). The soil nitrogen was estimated according to the method of Bremner (1965). The soil nitrogen content was measured by Kjeletec Auto 1030 analyzer. The total quantities of phosphorous, potassium, calcium, magnesium and sodium were determined after they were extracted by digestion method with perchloric and nitric acids (Shelton and Harper, 1941). Phosphorous content was determined at light wave length 640 manometer using Turner spectro-photometer model 2000, whereas, potassium calcium, magnesium and sodium concentrations were measured in the extraction using Perkin Elmer 5000 AAS. Methods of analysis for irrigation water were exactly the same as those described for soil analysis. The data of water and soil chemical analysis were tabulated in Tables (3) and (4).

Table 3. Chemical analysis of irrigation water.

pH	Ec ds^{-1}	Na^+ mg/l	K^+ mg/l	Ca^{++} mg/l	Mg^+ mg/l	Cl^- mg/l	SO_4^- mg/l	NO_3^- mg/l	HCO_3^- mg/l	$CO_3^=$ mg/l
7.40	1.58	164	24.6	160	41	246	221.6	123	246	0

Table 4. Chemical analysis of soil of experimental site.

Soil depth	pH	EC ds^{-m}	O.M. %	N (mg/kg)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)
0-30 cm	7.89	1.61	0.5	0.32	0.129	2.5	3.6	6.3	16.8
30-60 cm	8.25	0.38	0.41	0.3	0.108	2.2	0.9	1.4	6.6
60-90 cm	8.17	0.39	0.41	0.28	0.40	2.0	1.5	5.	3.8

2.2 Land Preparation and Cultural Practices

Experimental land was tilled in each season two perpendicular times using moldboard plow at depth 25-30 cm. Soil was harrowed, with disk harrows, and then leveled. The area was divided into 36 sub-plots, each was 5*5 m. Each sub-plot was prepared to accommodate furrow irrigation system, where it was divided into 6 ridges spaced at 75 cm (furrow dimension) with furrow height of 20 cm. Then, three corn grains of (AGA215 cultivar) were planted/hill at 30 cm apart and after the complete emergence they were thinned to a single seedling/ hill. After sowing soil was fertilized with superphosphate (46% P_2O_5) at the rate of 500 kg/ha potassium sulphate (50% K_2O) was applied at the rate of 400 kg/ha. Both previous fertilizers were applied in single doses. After that, the experimental area received the scheduled irrigation program. The next irrigations were applied according to the irrigation treatments (IR_1, IR_2, and IR_3). A hand weeding method was used to control weeds during the two sowing dates.

2.3 Practical Steps of the Two Trial Conditions

a. Nitrogen Application

Each investigated nitrogen rate was applied as hand place under each plant at three equal doses in 15 days intervals. First dose after 30 days from sowing, 2nd dose after 45 days from sowing, and the last one 60 days from sowing. Four nitrogen treatments are followed (N_0, N_1, N_2, N_3) where they have 0, 100, 200, and 300 kg/ha fertilizer levels, respectively.

b. Irrigation Treatments

Different irrigation treatments were applied to study the effect of irrigation treatments and Nitrogen rates on grain yield and ear Characters of maize during the two successive sowing date. The moisture depletion ratio method was followed for designing the irrigation treatments. The method assumed a constant rate of water losses by evapotranspiration at each irrigation period, while the available water in soil is considered as the main factor for irrigation scheduling design. Following this method, the total quantity of water for irrigation (over the sowing date) was estimated and applied with different irrigation frequencies. Each treatment was based on the allowable depletion ratio from the total available soil moisture. This method was considered one of the best controlled methods for irrigation scheduling, where the different levels of soil moisture stress on crop yield could be illustrated (Jenson, 1983).

Three different depletion ratios were applied for irrigation scheduling processes. These ratios were 50%, 25%, and 10% of the soil total available water, represented as IR_1, IR_2, and IR_3, respectively. The total available water for plant over the soil-root depth was calculated by using the different properties of soil-water. The crop water requirements during the two successive crop seasons were calculated in monthly rate using FAO method which illustrated the growth season as four different periods. The water losses during water application (surface runoff and deep percolation) were considered for estimating the gross irrigation water requirements, where the irrigation efficiency definition was applied.

The steps for calculating the water requirements and irrigation frequencies can be described as follows:

$$\mathrm{TAW} = \frac{FC - WP}{100} * \frac{\rho_b}{\rho_w} * dr \qquad (1)$$

where, TAW is the total available water (cm) in soil root depth *dr* (cm), *FC* and *WP* are the soil moisture content (weight basis) (gm/gm) at field capacity and permanent wilting point, respectively, ρ_b is the bulk density of soil (gm/cm^3), ρ_w is the water density (gm/m^3), and *dr* is the soil root depth (cm).

Assuming that the soil is homogenuous over the depth, the total allowable net water depth D_n (cm) as depletion water depth from soil root depth d_r (cm) can be calculated by using,

$$D^n = R * TAW \qquad (2)$$

where, *R* is the allowable depletion ratio, which was illustrated by 50%, 25%, and 10% for the three irrigation treatments, IR_1, IR_2, and IR_3, respectively.

Meanwhile, the gross irrigation water depth D_g (cm) and the irrigation frequency, *T*, were calculated using the following expressions,

$$D_g = \frac{D_n}{\eta} \tag{3}$$

$$T = \frac{D_n}{ET_c} \tag{4}$$

where, η is the application efficiency of water on farm level, and ET_c is the evapotranspiration of crop (cm/day).

The different irrigation treatments, frequencies and irrigation water requirements were described in Table (5) for the two seasons, respectively.

c. Irrigation System and Network

The surface irrigation, furrow type, was applied at the experimental area as one of the applied irrigation systems at the experimental station of King Abdulaziz University at Hada Al-Sham. The experiment area was divided into thirty six plots each of 5×5 m size. Twelve adjacent plots were considered as one replication. Each replication has 3 irrigation and 4 nitrogen treatments. An underground pipe network was conducted at the experimental area to achieve the required water volume for each treatment basin. A two-inch PVC main pipe line was diverted into secondary network. Each 4 basins were having one Division Box (distributor) having 4 rectangular sharp weir to distribute an equal water quantity for the same irrigation treatment. Moreover, discharge flow meter was installed at the network inlet to measure the input flow and control the water application process.

3. Characters Studied

3.1 Weight of Grain Yield and Ear Characteristics

At the end of the experiment, the yield of corn ear of each treatment was adjusted to yield of grain with 15.5% moisture in terms (kg/ha). The agronomic characters under study were; yield of grain, total weight of 100 ear per plot, harvest index, and shelling percentage. Five ears from each plot were chosen randomly and their mean length, diameter, and volume, number of grains/row, number of grains/ear, number of rows/ear, mean weight of ear and its parts (grain and cob), weight of 1000 grains. Statistical analysis was performed using the MSTAT program.

3.2 Protein Analysis in Grains

The total nitrogen content of grains was determined according to Bremner (1965) method, using Kjeletec Auto 1030 analyzer, where the total protein contents in grains were determined by mutiplying of nitrogen contents by the con-

TABLE 5. Summary of analysis of variance for grain yield and ear characters of hybrid corn cultivar (AGA215) under two sowing dates.

Variable	D.F.	Ear characters								Yield characters				Yield of grains kg/ha
		Length (cm)	Diameter (cm^2)	Volume (cm^3)	Number of rows	Number of grains	Number of grains/row	Weight of grains (gm)	Weight of cob (gm)	1000 Grains weight (gm)	Shelling percentage %	Grain protein content %	Harvest index	
(S)	1	0.483	0.195	2711.7	7.18	15167	650.46**	16.7	7651.66**	207249**	302.4*	14.17**	5748.06**	1530115.82**
R (L)	4	1.564	0.04	3062.2	0.23	1929	4.1	1272.8	112.17	2042.3	46.47	0.33	181.4*	2013014.1*
(I)	2	3.568**	0.604	1684.7	1.08	1132.56	14.12	892.3	477.19*	3049.8	215.12	0.73	45.4	4711650.7**
(SI)	2	3.12**	0.359	14780.4	3.01	2419	10.84	1875.1	154.46	957.9	6.8	0.007	43.9	–93753.4
(E.M.S.) 1	8	0.418	0.359	12794.47	2.34	1838.4	495	555.81	86.008	1203.6	60.1	0.35	52.72	11048172**
(N)	3	37.08**	0.621	77230*	2.2	9680.34*	526.54**	7858.4**	297.66**	2025.5	72.22	42.94**	103.5	932398.3
(SN)	3	7.98*	0.188	12541.2	0.36	10224.74*	231.58**	3346.1	857.14**	1910.3	27	0.074	152.7	989583.7
(IN)	6	0.154	0.311	16324	2.67	2647.6	231.11**	1332.1	124.58	2161.7	91.29	0.485**	58.4	1064373.7
(SIN)	6	0.682	0.713	32920.5	0.51	4338.1	175.28**	2694.2	417.07	2516.4	60.79	0.088	100.67	0.181
(E.M.S.) 2	36	2.044	0.273	669381.9	1.873	2456.121	17.602	1376.399	187.201	2294.743	52.860	0.164	100.667	673920.3

S = Sowing date
I = Irrigation treatment
N = Nitrogen treatment
D.F. = Degree of Freedom
E.M.S. = Error Mean Square
* Significant at 0.05 level
**Highly significant at 0.01 level

version factor 6.25. The statistical analysis was done by using the SAS program.

4. Results and Discussions

4.1 Ear Characters

Ear length, diameter and volume, number of rows per ear and number of grains per ear weight of grains per ear were not significantly affected by sowing dates. On the other hand, number of grains per row and weight of cob per ear were significantly affected by sowing dates. Ear characters were not affected by irrigation treatments except ear length. Ear length and volume, number of grains per row, weight of grains per ear, and weight of cob per ear (at $P < = 0.01$), and number of grains per ear (at $P < = 0.05$) were significantly affected by nitrogen treatments. Ear length, number of grains per ear (at $P < = 0.05$), number of grains per row, and weight of cob per ear (at $P < = 0.01$), were significantly affected by the interaction of sowing date with nitrogen rates. However, the number of grains per row was significantly (at $P < = 0.01$) affected by the interaction of irrigation treatment with nitrogen rate (Table 5).

The mean values for the number of grains per row and weight of grains and cob per ear in the second sowing date were significantly lower than those of the first sowing date. Further, there were no significant differences among all ear characters and irrigation treatments except ear length, where IR_3 (10%) gave higher values for ear length as shown in Tables (5) and (6).

The nitrogen treatments had highly significant effect on most ear characters (Table 5). The fact Table 6 indicates that the rate of 200 kgN/ha gave mean values of the measured variables, ear length, and volume, number of grains and weight of grains per ear, than the other nitrogen levels. On the other hand, the nitrogen rate 300 kgN/ha gave the highest values of number of grains per row higher and of weight of cob per ear compared with the other nitrogen levels (Table 6). Turget (2000) found that N rates were statistically significant in corn ear, ear diameter, fresh ear weight, number of ear per plant, fresh ear yield and grain number per ear. Bouquet *et al*. (1985), obtained an increase in corn ear length when he applied nitrogen at the rate of 44 and 267 kgN/ha with high irrigation water. The ear volume results in relation to nitrogen rates agreed with those of Nimje and Seth (1988) who detected an increase in corn ear volume at the rate of 120 kgN/ha. However, Kruczek (1983), found a decrease in corn ear volume with the addition of nitrogen at a rate of 180 kgN/ha. Results on the number of grains per ear as related to nitrogen rates agreed with those of Okuyama and Silva (1983) who found that the nitrogen rate of 120 kgN/ha gave the optimum grain number in corn ear. On the other hand, Ahmed *et al*. (1965) and Salem *et*

TABLE 6. Mean values for grain yield and ear characters of corn hybrid corn cultivar (AGA215) and their test of significance of the two sowing dates.

Variable		Ear characters								1000 grains weight (gm)	Yield characteristics			Yield of grains (kg/ha)
		Length (cm)	Diameter (cm)	Volume (cm^3)	Number of rows	Number of grains	Number of grains/row	Weight of grains (gm/ear)	Weight of cob (gm/ear)		Protein content (grain) %	Shelling percentage %	Harvest index	
Sowing date	S_1	19.100 A	6.207 A	575.789 A	15.403 A	621.617 A	39.845 A	258.467 A	78.98 A	357.06 A	8.073 A	60.036 A	62.007 A	6471.65 A
	S_2	18.936 A	6.103 A	563.515 A	16.04 A	624.52 A	33.833 B	257.503 A	58.36 B	249.76 B	7.592 A	55.933 B	44.138 B	3653.93 B
Irrigation	IR_1	18.925 B	6.14 A	543.11 A	15.59 A	616.54 A	36.07 A	254.17 A	65.84 A	292.14 A	8.02	55.06 A	52.24 A	4711.8 B
	IR_2	18.688 B	6.2 A	569.72 A	15.61 A	622.47 A	36.85 A	254.77 A	66.35 A	314.68 A	7.79 A	57.85 A	52.91 A	4909.71 B
	IR_3	19.442 A	6.13 A	596.13 A	15.96 A	630.19 A	37.6 A	265.02 A	73.81 A	303.42 A	7.68 A	61.04 A	54.07 A	5566.87 A
L.S.D.		0.4304	–	–	–	–	–	–	–	–	–	–	–	423.61
Nitrogen	N_0	17.567 B	6.21 A	493.61 C	15.44 A	604.73 B	31.07 B	229.12 B	54.34 C	316.6 A	6.53 C	56.37 A	51.56 A	4428.16 B
	N_1	18.133 B	5.88 A	541.78 BC	16.17 A	601.92 B	33.42 B	232.52 B	62.87 BC	294.59 A	7.32 B	57.19 A	52.1 A	4522.91B
	N_2	20.717 A	6.32 A	600.24 AB	15.82 A	637.77 A	40.84 B	264.66 A	73.52 B	307.42 A	7.4 B	57.53 A	53.22 A	5607.75 A
	N_3	19.656 A	6.21 A	642.98 A	15.44 A	647.84 A	42.02 A	275.64 A	83.94 A	295.05 A	10.08 A	60.9 A	55.42 A	5692.36 A
L.S.D.		1.184	–	87.142	–	32.75	2.582	23.948	8.583	–	0.2955	4.954	–	489.14

First sowing date 1 = Autumn
Second sowing date 2 = Spring
I = Irrigation Treatment
IR_1 = 50%
IR_2 = 25%
IR_3 = 10%
L.S.D. = Least Significant Difference at 5%

A = 1st high category
B = 2nd high category
C = 3rd high category
D = 4th category

Nitrogen treatment N_0 = 0 (kg/ha)
N_1 = 100 (kg/ha)
N_2 = 200 (kg/ha)
N_3 = 300 (kg/ha)

al. (1982) did not find any significant difference in grain number of corn ear due to different applied nitrogen rates. Boguet *et al*. (1989) found an increase in the weight of grains per ear with nitrogen application up to 225 kgN/ha. Abdel-Aziz *et al*. (1986) detected an increase in weight of grains per ear at a nitrogen rate of 214 kgN/ha applied in two doses. While, Turget (2000) and Sanjeev *et al*. (1997) detected an increase in grain weight per ear up to 180 kgN/ha.

The interaction effect of sowing dates and nitrogen rates on corn cob weight is shown in Fig. (1-a), where the first sowing date (autumn) dominated the second one (spring), treatments and the nitrogen rate of 300 kg/ha dominated 200, 100, and 0 respectively in a decreasing order.

The interaction effect of sowing dates and nitrogen rates on number of grains per ear is shown in Fig. (1-b), where number of grains per ear simultaneously increased with the increase of nitrogen rates (0, 100, 200 and 300 kg/ha) and the first sowing date (autumn) dominated the second date (spring)

The interaction effect of sowing date and nitrogen rates on corn ear length, is shown in Fig. (1-c), where the first sowing date (autumn) dominated the second date (spring) and nitrogen rate of 200 kg/ha dominated the others.

The interaction effect of sowing dates and nitrogen rates on number of grains per row is shown in Fig. (1-d), where the first sowing (autumn) dominated second date (spring), and the fourth nitrogen treatment 300 kg/ha dominated the other rates (200, 100, and 0 kg/ha).

The interaction effect of nitrogen treatments and irrigation regimes, on number of grains per row is shown in Fig. (2-a), where the number of grains per row simultaneously increased with the increasing of both nitrogen rates (0, 100, 200 and 300 kgN/ha) and the irrigation rates (IR_1, IR_2 and IR_3).

The interaction effect of sowing dates and irrigation regimes on ear length is shown in Fig. (3). where the first sowing date (autumn) dominated the second date (spring) and irrigation level IR_3 (10%) dominated the others.

4.2 Grain Yield and its Components

A. Grain Yield

The treatments of sowing dates and irrigation regimes highly affected grain yield (at $P <= 0.01$). However, the effect of nitrogen rates was significant on such grain yield (at $P <= 0.05$). The effect of the interaction of irrigation and nitrogen was not significant as shown in Table (5). The first sowing date (autumn) significantly surpassed the second one (spring) and gave 6471.65 kg/ha, Table (6) while the second sowing date gave only 3653.93 kg/ha. Reddy and

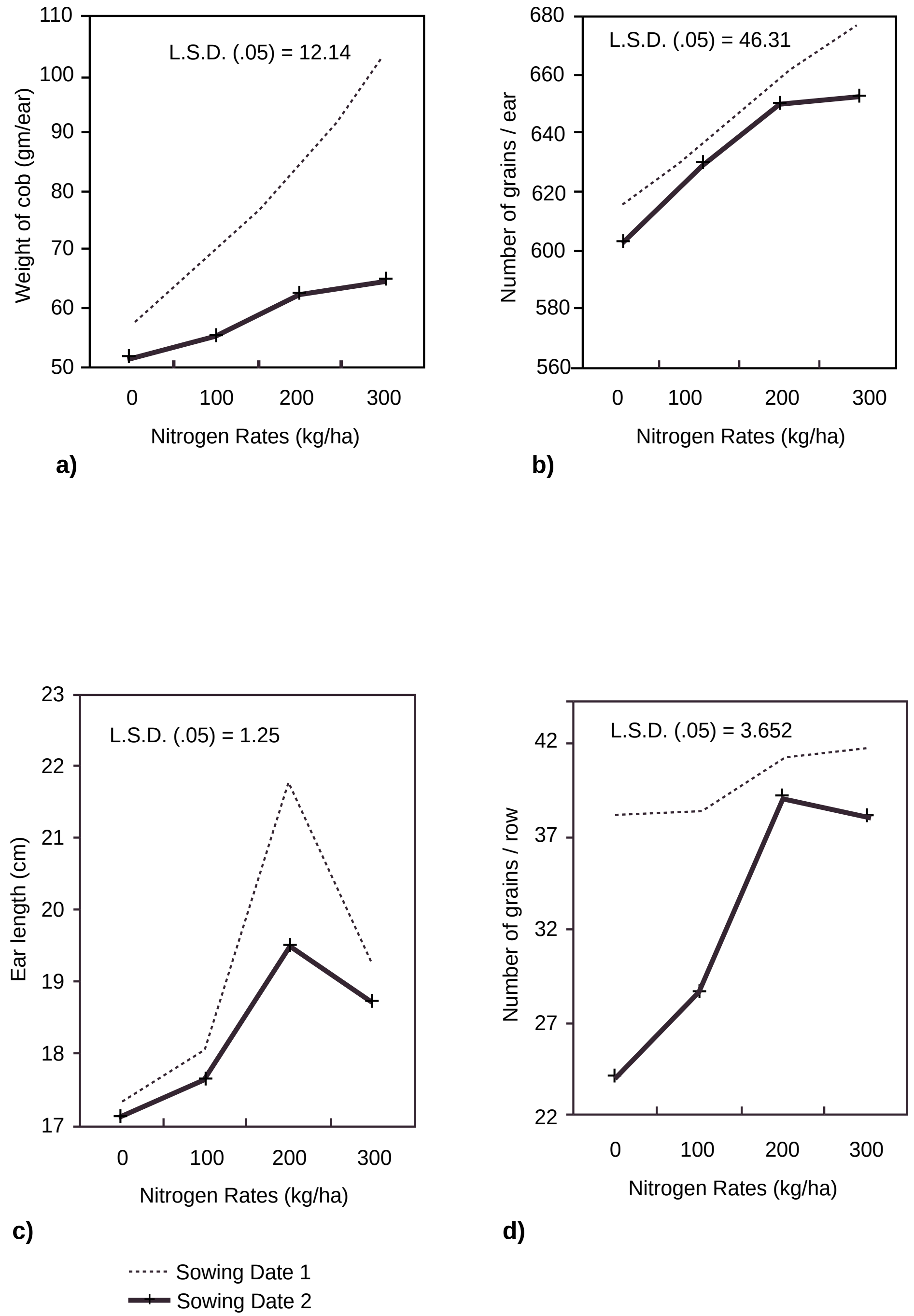

FIG. 1. Effect of different nitrogen rates on a) Weight of cob, b) Number of grains/ear, c) Ear length, and d) Number of grains/raw, during two different sowing dates of corn plant.

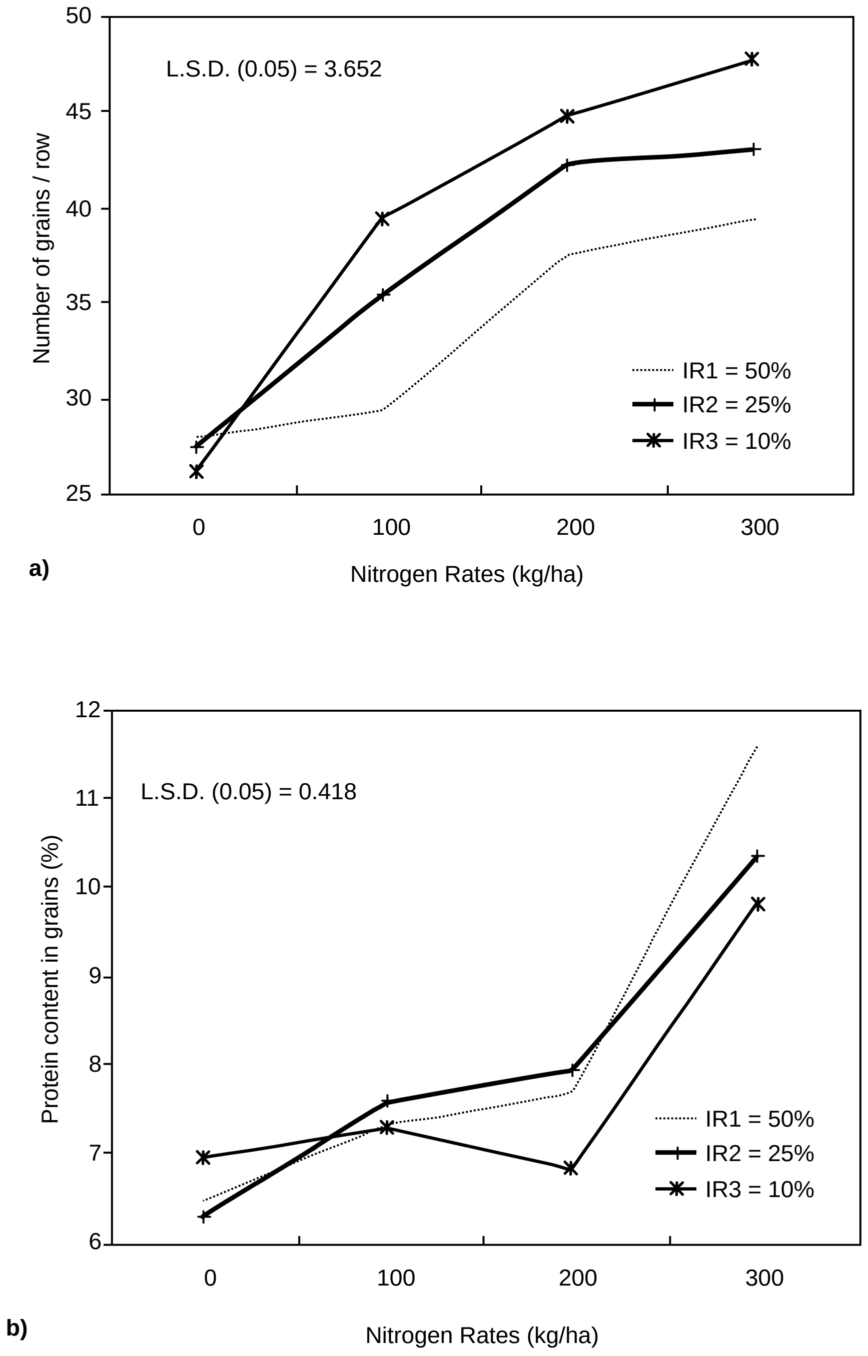

FIG. 2. Effect of different irrigation and nitrogen treatments on a) Number of grains, and b) Protein content in grains of corn plant.

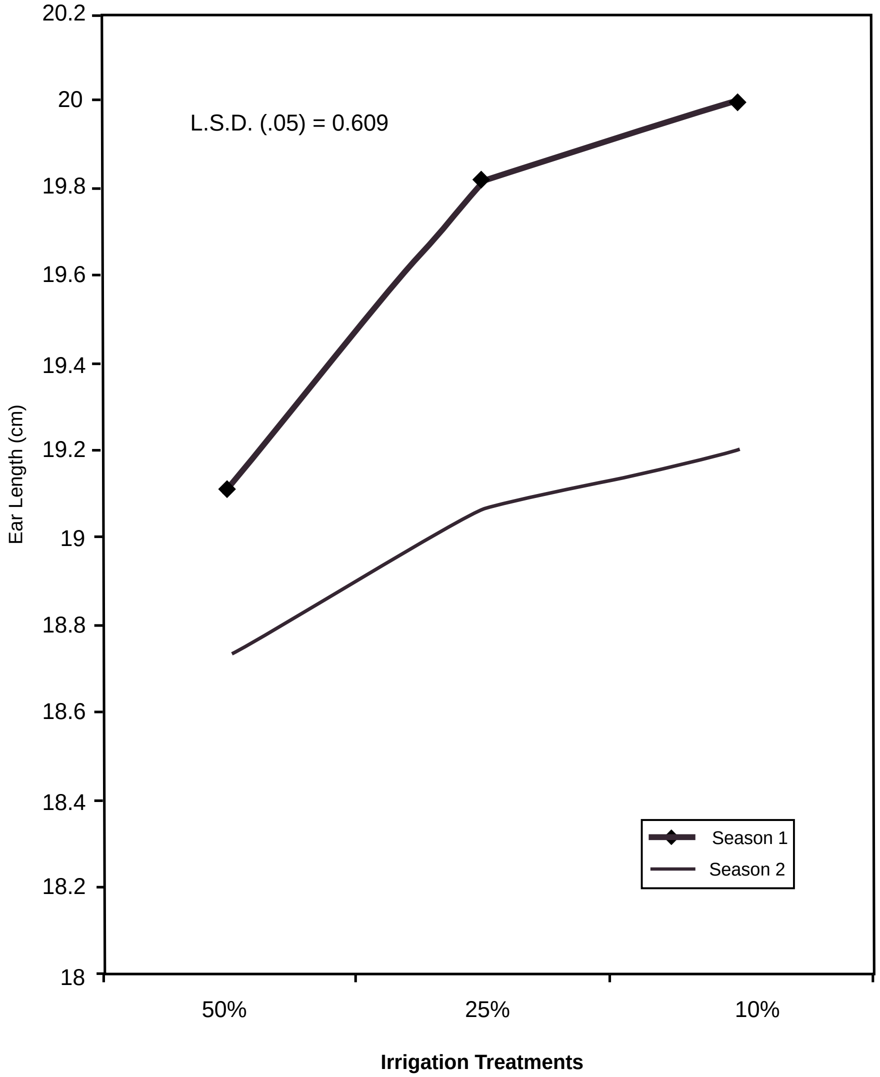

FIG. 3. Effect of different irrigation on ear length during different sowing dates of corn plant.

Patil (1982) reported the superiority of autumn results to spring when applying 120 kg/ha, while Berdnikov and Gul, Chuk (1987), found an increase of maize yield during spring than that during autumn under the same nitrogen rate. Differences in the environmental conditions of sowing date one and two, in terms of temperature (Mack *et al*., 1966), as shown in Table (1), and light intensity (Leonard and Martin, 1963), might had contributed to the difference observed for grain yield production.

Grain yield significantly increased by increasing nitrogen application rates. However, there were no significant differences between the two nitrogen rates, N3 and N4 (200 and 300 kg/ha), which means that 200 kg/ha was adequate to produce the highest grain yield of corn plant (Table 6). Sanjeev *et al.* (1997) obtained significant increase in number of grains/ear, grain weight/ear and grain yield/plant up to 240 kgN/ha. Russel (1984) found that the rate of 60 kg/ha was sufficient to produce maximum grain yield of maize Vance (1987) and Frye and Blevins (1989), found that the maize yield increased in parallel with the increase of nitrogen rates from 0.0 to 100 kg N/ha. In contrast, Pirani and Agostinelli (1989), found no significant difference in maize due to rates 0.0 and 230 kg N/ha rates.

Regarding the irrigation treatments effect on grain yield, the third irrigation treatment (IR_3 =1 0%) gave the highest grain yield (5566.87 kg/ha), followed by IR_2 = 25% (with 4909.71 kg/ha) and IR_1 = 50% with 4711.80 kg/ha. However, there were no significant differences between the two, irrigation treatments IR_2 and IR_1 as seen in Table (6). Panchanathan *et al*. (1987) detected a significant effect of the interaction between irrigation treatments. Nitrogen rates on yield of maize, where he applied 5330, 4490, 4290, ad 3510 m^3/ha irrigation water with nitrogen fertilization from 0 to 180 kgN/ha. But Stutler *et al*. (1981), obtained the highest maize yield with 120 kgN/ha added at different irrigation treatments. Filip and Petrovici (1982), also obtained the highest maize yield with 120 KgN/ha added with 700 m^3/ha water. Petrovici and Ailincai (1984), got the highest maize yield when they added 180 KgN/ha with 1500 and 2100 m^3 irrigation water/ha, while Throat and Ramtake (1988) got the highest yield by adding 160 KgN/ha to 1500, 2100 m^3/ha irrigation water.

B. Yield Components

B.1 Weight of 1000 Grains

There was a highly significant effect of sowing dates and the weight of 1000 grains at the level ($P < 0.01$), while no significant differences were found between both irrigation treatments and nitrogen rates on the weight of 1000 grains of maize plant, as shown in Tables (5) and (6). Autumn sowing date gave a significantly higher value (357.06 gm) than spring sowing date (249.76 gm) of 1000 grains weight. There were no significant differences among the four nitrogen rates, concerning weight of 1000 grains, as shown in Table (6). In contrast, some investigators found an increase of the 1000 grains weight under application of different nitrogen rates; namely Nimje and Seth (1988) and Okuyama and Silva (1983), when added 120 kgN/ha and Boque *et al*. (1989), when 225 kgN/ha were added Abdel-Aziz *et al*. (1986) detected an increase in the weight of 1000 grains of maize by addition of 214 kgN/ha in two doses, and also Sanjeev *et al*.(1997).

B.2 Grain Protein Content

Grain protein content was significantly affected by all studied variables: namely, sowing date ($P < 0.01$), nitrogen rates ($P < 0.01$) and irrigation treatments ($P < 0.05$) beside the irrigation treatments × nitrogen interaction rates ($P < 0.01$), as shown in Table (5).

Grain protein content was significantly higher in autumn sowing date (8.073%) than spring one (7.592%), as shown in Table (6). Isfan (1985), obtained a similar result, where he detected an increase in grain protein content during autumn compared to spring with nitrogen rates from zero to 150 kgN/ha. On the other hand, Hane (1981) obtained a lesser grain nitrogen content in autumn than spring when he added nitrogen from zero to 336 kgN/ha.

The nitrogen rate (300 kgN/ha) gave the highest grain protein content (10.08%), followed by the nitrogen rates (200 kgN/ha) (7.4%), 100 kgN/ha (7.32%) and 0 kgN/ha (6.53%) (Table 2). El-Baisary *et al*. (1980) and Singh *et al*. (1986) obtained the highest grain protein content under the application of 144 kgN/ha nitrogen rate at different doses.

As regards to the irrigation rates effect, the first irrigation ($1R_1 = 50\%$) resulted in the highest grain nitrogen content (8.02%), followed by the second irrigation ($IR_2 = 25\%$) with (7.79%) and the third irrigation ($IR_3 = 10\%$) which gave the least grain nitrogen content (7.68%) although the differences were not significant between IR_1 and IR_2 and IR_3 as seen in Table (6). Boquet *et al.* (1986) obtained a decrease in grain nitrogen content with an increase of irrigation water, where the optimum nitrogen rate was 89 kgN/ha when it was added with irrigation water, and 133 kgN/ha without irrigation. While, Efimov and Ncumenlco (1980) found an increase of grain nitrogen content with an increase in nitrogen application up to 90 kgN/ha with irrigation.

Figure (2-b) illustrates the interaction effects of irrigation treatment nitrogen rates on grain protein content. It showed an increase of grain protein content with an increase in nitrogen rates (from 0, 100, 200 and up to 300 kgN/ha) and decrease of irrigation treatments (from $IR_1 = 50\%$, $IR_2 = 25\%$ to $IR_3 = 10\%$).

B.3 Shelling Percentage

The sowing dates significantly affected shelling percentage of corn ($P < 0.01$), as shown in Table (5). Autumn sowing date was significantly higher than that of spring sowing, where the shelling percentages for the two sowing dates were 0.36% and 0.3%, respectively. With regard to the irrigation treatments, irrigation three (IR_3 = 10%) gave the highest shelling percentage (61.04%), followed by irrigation two (IR_2 = 25%) with 57.85% and then irrigation one (IR_1 = 50%) with 55.06%, also the differeces were not significant as shown in Tables (5) and (6). While no such effect was noticed for the applied nitrogen rates.

B.4 Harvest Index

There was a significant effect of the sowing dates and the harvest index on corn ($P < 0.01$), as shown in Table (5). Sowing date one (autumn) dominated the (spring) date and gave 62%, while sowing date two gave 44.14% as harvest index (Table 6). While, no such effect was noticed for applied nitrogen rates and irrigation regimes (Tables 5 and 6).

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محصـول الحبـوب وصفـات الكـوز للذرة الشاميـة تحت تأثير معاملات الري والتسميد النيتروجيني

سمير جميل السليماني

قسم زراعة المناطق الجافة ، كلية الأرصاد والبيئة وزراعة المناطق الجافة

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المستخلص . يتناول هذا البحث دراسة محصول الحبوب وصفاته وكذلك صفات الكوز لنبات هجين الذرة الشامية (صنف أجا٢١٥) وقد استعمل تصميم القطع المنشقة وكان عدد المكررات ثلاثة خلال موسمي الدراسة . حيث كانت المعاملات الرئيسة ثلاثة معاملات ري والمعاملات الشقية أربعة معدلات سماد نيتروجين . وتشمل الصفات المدروسة محصول الحبوب ووزن ١٠٠٠ حبة ومحتوى الحبوب من البروتين ونسبة التصافي (التفريط) ودليل الحصاد بينما كانت صفات الكوز المدروسة طول وقطر وحجم الكوز ، عدد الصفوف في الكوز ، عدد الحبوب في الكوز ، عدد الحبوب لكل صف ، ووزن القولحة والحبوب لكل كوز ولقد أجريت التجارب بمزرعة البحوث الزراعية التابعة لجامعة الملك عبد العزيز بمنطقة هدى الشام خلال موسمين متتاليين هما (خريف ١٩٩٤م ، ربيع ١٩٩٥م) ولقد استخدمت طريقة نسب الاستنزاف لتقدير كميات الري التي استعملت ، وزمن تكرار الري المناظرة لكل واحدة من معاملات الري . وقد تم استعمال ثلاث نسب استنزاف وهي ٥٠٪ ، ٢٥٪ ، ١٠٪ ورمز لها (IR_3 , IR_2 , IR_1) على التوالي. أما فيما يتعلق بمعاملات النيتروجين (يوريا) فقد استخدمت أربعة معدلات هي صفر ، ١٠٠ ، ٢٠٠ ، ٣٠٠ كجم / هكتار ورمز إليها (N_3 , N_2 , N_1 , N_0) على التوالي. ولقد صممت جدولة الري بحيث كانت كمية المياه المستخدمة لكل موسم ثابتة لمعاملات الري المختلفة وهي (٩٠١٥ م^3 / هكتار / موسم الخريف) و (٨٢١٠ م^3 / هكتار/ موسم الربيع) للموعدين الزراعيين على التوالي، بينما كانت فترات تكرار الري ومعدلات استخدام المياه هي

المختلفة في كل معاملة ري . أما بالنسبة لمحصول الحبوب وصفات الكوز فأوضحت النتائج تفوق موعد الزراعة الأول (الخريف) على موعد الزراعة الثاني (الربيع) حيث كان الأعلى في إنتاج الحبوب وعدد الحبوب في الصف ، ووزن الحبوب في الكوز ، ووزن القولحة بالكوز ووزن الألف حبه ومحتوى البروتين في الحبة ونسبة التصافي(التفريط) ودليل الحصاد . ولقد كان هناك تأثير معنوي لمعاملات الري على متغيرات إنتاج الحبوب بينما تميزت معاملة الري الثالثة IR_3 بأعلى قيم لإنتاج الحبوب وطول الكوز . وكذلك أثرت معاملات النيتروجين معنوياً على بعض متغيرات إنتاج الحبوب حيث أعطت معاملة النيتروجين N_3 (٢٠٠ كجم/ هكتار) أعلى قيم لإنتاج الحبوب ، وطول وحجم الكوز ، وعدد الحبوب في الكوز ، ووزن الحبوب لكل كوز . اما المعاملة رقم N_4 (٣٠٠ كجم/ هكتار) فأعطت أعلى قيم لعدد الحبوب في الصف الواحد ، ووزن القولحة ومحتوى البروتين في الحبوب .