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Effect of Different Rates of Nitrogen and Irrigation on Dry Matter and Nitrogen Content of Corn at Different Growth Stages During Two Sowing Dates

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Abstract. One field experiment was conducted at Hada Al-Sham Experimental Station, King Abdulaziz University, to study the effect of three different rates of irrigation, based on depletion ratios of 50%, 25%, 10% (IR_1, IR_2, IR_3) and four different rates of nitrogen fertilization (urea), zero, 100, 200, 300 kg/ha (N_0, N_1, N_2, N_3) of hybrid corn plant (AGA Seed 215 Cultivar). Total dry matter accumulation and its parts (leaves, stems, ears, and tassels) as well as the nitrogen content in different plant parts at different growth stages during two successive sowing dates (autumn 1994 and spring 1995) were determined. The irrigation scheduling processes were designed under constraint of equal total seasonal applied water for different irrigation treatments, which were 90.15 cm/sowing date one (9015 m^3/ha/sowing date one) and 82.1 cm/sowing date two (8210 m^3/ha/sowing date two) for two sowing dates, respectively. The first sowing date outcome had a significantly higher leaf area index and dry weight (ear, tassel and total), plant nitrogen percentage (stem, ear and total). However, the nitrogen percentage of tassel was significantly higher in second sowing date . All plant variables (dry matters) were higher under the fourth plant stage (maturation) except tassel dry weights. The nitrogen treatment affected significantly some growth variables, where the N_3 treatment gave higher values of dry weight (3202.9 kg/ha for ear, 232.3 kg/ha for tassel and 6438.2 kg/ha for total), and nitrogen percentage (1.98 gm/kg for leaf, and stem), while N_2 treatment gave higher values of nitrogen content in plant and its parts, (2.9 gm/kg for total, 2.84 gm/kg for leaf, 1.97 gm/kg for stem, 1.67 gm/kg and 1.56 gm/kg for tassel). There was no significant effect for the irrigation regimes or interaction treatments (nitrogen treatment and irrigation regimes) on all the studied plant variables.

1. Introduction

The growth of plants is proportional to the amounts of water present. However, the growth of plant is restricted both at very low and very high levels of soil moisture.

The nitrogen is considered a movable element in soil. Thus increasing soil water content up to the field capacity which would increase the nitrogen availability and movement in soil. This process would increase the total dry matter production for most field crops. However, increasing the soil water content over the field capacity will increase the leaching of nitrogen in soil.

Water is considered as a limited factor of production along with the chemical fertilizer. Therefore, many workers studied the effect of different nitrogen applications in relation with various quantities of irrigation water on corn yield parts and dry matter. El-Saidi *et al.* (1979) found that corn yield and its components are significantly affected by nitrogen application up to 214 kg N/ha with irrigation water 6848 m^3/ha. Wordruff *et al.* (1984) studied the effects of water table depth (0.35, 0.7 or 1 m) and nitrogen application with 0.0, 112, 224, and 336 kg N/ha combinations on corn. They found a significant water table depth × N rate interaction for ear yield but not for straw yield. The relationship between N rate and ear yield was described by regression for each water table depth except the 1 m depth, for this depth ear yield was not affected by N. The N rate required for maximum ear yield was increased with decreasing water table depth. Prasad *et al.* (1987) found that Leaf Area Index (LAI) increased with increasing irrigation frequency and N rate. Nitrogen application increased corn plant height, stem diameter, leaf area index and grain yield as well as some of its components (Stivers *et al.*, 1961; Bole and Frayman, 1975; El-Sharkawy *et al.,* 1976; Gagro, 1977; Kosware, 1977; Abdel-Rahman, 1978 and Ibrahim *et al.*, 1979). But Ahmed *et al.* (1965) and Salem *et al.* (1982) did not find any significant effect of nitrogenous fertilizer on leaf area index, ear weight, number of grains per ear and number of rows/ear. While, Krishnamurthy *et al.* (1974) and Ellias *et al.* (1979) did not observe significant effect of the nitrogenous fertilizer of application on plant height and leaf area index.

The optimum nitrogen rate has an effect on total dry matter weight. Overman *et al.* (1994) found an increase in total dry matter (T.D.M.) of maize plant with increase of nitrogen fertilization. Okuyama and Silva (1983) found that the application of 120 kg N/ha increased dry weight, number of grains per ear and 1000-grain weight, similar results was found by Nimje and Seth, (1988). While Mahmoud *et al.* (1980) mentioned that application of 178.5 kg N/ha increased dry weight. Myers (1988), reported that economic rate of nitrogen fertilizer was 110 kg N/ha. Chung *et al.* (2000) said that composed plus an adequate amount of chemical N fertilizer could produce higher dry matter yield and N accumulation in corn than the conventional chemical N fertilizer treatment. Maize dry matter yield increased significantly with increasing level of N up to 120 mg N/kg soil. Bhujbal and Souza (1992) obtained the highest total dry matter yield and Phosphorus uptake by maize when they applied nitrophosphaste (26% N+3.5% P_2O_5) to the soil.

Stanchev and Ivanova (1985) mentioned that increasing irrigation rates with nitrogenous fertilizers decreased nitrogen content of corn plant. Saad *et al.* (1981) found that highest percent of nitrogen was obtained by applying 119 kg N/ha. While, it was 120 kg N/ha by Gangwar and Kalra (1988). Moreover, higher nitrogenous rates 224 kg N/ha increased plant Nitrogen content (Taber and Cox (1983)). Shafshak *et al.* (1981) found that the highest percent of protein occurred at rate of 190 kg N/ha. The same findings were reported by El-Hattab and Gheith (1984) at rate 214 kg N/ha.

Hane (1981) studied the effect of applied nitrogenous fertilizers 0.0-252 kg N/ha at autumn and 0.0-33 kg/ha at spring on corn growth or yield and yield components. He found that the nitrogen content of leaves, straw and grains were lower when N was applied at autumn sowing date than at spring one. The rate of nitrogen uptake was lower with increasing the rate of nitrogenous fertilizer. But, Isfan (1985) reported that the nitrogen grains content was highest when applied at autumn sowing date. He added that the rate of nitrogen uptake increased with increasing nitrogenous fertilizers at rates from 0.0 to 150 kg N/ha at autumn sowing date and from 0.0 to 200 kg at spring one.

Still there is a lack of informations about the optimum rates and time of application concerning the nitrogenous fertilizers and irrigation water required to corn plants.

The objective of this study was to evaluate the effect of sowing dates, nitrogen fertilizations and irrigation regimes on nitrogen content and dry matter production of different plant parts (leaf, stem, cob, tassel) at different stages of plant growth.

2. Materials and Methods

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-Spring 1995). The depletion ratio method was followed to estimate the amount of irrigation water and the corresponding irrigation frequencies for each irrigation treatment. Split Complete Randomized Plot Design Method combined over two successive sowing dates with three replications, was followed as experiment design, where the main plot was the plant stages and the submain plot was the irrgation treatments, and sub-sub main plot was nitrogen rate treatments. Four plant stages (Vegetative, Tasseling, Milky, and Maturation) were considered as main plot, and three depletion ratios 50%, 25% and 10% (IR_1, IR_2, IR_3) were applied as sub-main plot treatments. As regards to nitrogen (urea) treatments, the applied four different rates 0, 100, 200 and 300 kg/ha, (N_0, N_1, N_2 and N_3) were considered as sub-sub main plot treatments. Nitrogen was converted into urea (46% N) according to the amounts of applied nitrogen in each treatment.

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 report by FAO and Ministry of Agriculture and Water (1988).

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	19.00	42.00	30.50	21.00	99.00	61.00	February	10.30	33.70	22.65	22.00	97.00	61.50
November	16.20	39.00	27.10	30.00	99.00	65.00	March	10.90	92.20	27.00	17.00	96.00	54.50
December	11.00	34.90	24.10	27.00	98.00	59.00	April	13.80	44.50	30.15	20.00	92.00	54.60
January	15.00	35.50	25.30	27.00	100.00	62.00	May	16.30	46.60	33.70	19.00	92.00	48.90
February	10.30	33.70	22.50	22.00	97.00	61.50	June	22.80	51.00	36.05	22.00	92.00	48.40

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 and physical properties were tabulated in Table (2).

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

Soil depth	Sand %	Silt & clay %	% Error	Uniformity coeff.	Soil tex.	Bulk D (gm/cm^3)	Porosity %	Part D. (gm/cm^3)
0-30 cm	92.30	7.80	0.1%	4.90	Sandy	1.64	36	2.71
30-60 cm	95.40	4.20	– 0.4%	6.20	Sandy	1.69	25	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 phosphorus, potassium, calcium, magnesium and sodium were determined after they were extracted by digestion method with perchloric and nitric acids (Shelton and Harper, 1941). Phosphorus 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 Atomic Absorption Spectrometer 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	1.610	0.50	0.32	0.129	2.50	3.60	6.30	16.8
30-60 cm	8.25	0.380	0.41	0.30	0.108	2.20	0.90	1.40	6.60
60-90 cm	8.17	0.390	0.41	0.28	0.400	2.00	1.50	5.90	3.80

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. Land was leveled, then it was harrowed with disk harrows. The area of the experiment was 900 m^2, and was divided into 36 plots each one has an area 25 m^2 , where each replicate was having 12 plots. Each 4 plots represent one irrigation treatment as sub-plot, where each plot represents nitrogen treatment as sub-sub plot. The furrow irrigation system was applied, where each plot was divided into 6 rows spaced at 75 cm with 20 cm row height, as furrow dimension. Then, 3 seeds of corn (*Zea corn* L. cultivar AGA 215) were planted/hill at 30 cm apart and after the complete emergence they were thinned to a single seeding/hill.

After sowing land was fertilized with Superphosphate (46% P_2O_5) at rate of 500 kg/ha, Potassium sulphate (50% K_2O) was applied at the rate of 400 kg/ha. Both previous fertilizers were applied on single doses. After that, the experimental area received the sowing irrigation. The next irrigation water application were added according to the irrigation treatments (IR_1, IR_2, IR_3). A hand weeding method was used to control weeds during the two sowing dates.

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 after 60 days from sowing.

Samples were collected from four growth stages (vegetative, tasseling, milky and maturation). Five plants were chosen randomly from each experimental unit (12 treatments $\times$ 3 replications). Plant height was measured in chosen plant samples, where they were cut off at the soil surface. The five plants of each growth stage were divided into leaves and stems in addition to ears and tassels in the last three growth stages, for determining the fresh weight of each plant component. The area of one plant of each growth stage was measured using leaf area meter (Licor 1000). Then they were dried to calculate the leaf area (LA) of the five plants as follows:

$$\text{L.A.} = \frac{\text{Area of one plant} \times \text{dry wt. of leaves of 5 plants}}{\text{Dry wt.of one plant}} \quad (1)$$

Drying was made by using oven at 75ºC during two days for leaves and tassels and 2-3 weeks for ears and stem. Dry weights for each previous component were determined.

The total nitrogen content of each plant sample was determined according to Bremner (1965) method, using Kjeletec Auto 1030 analyzer. The statistical analysis was done by using the SAS program .

3. Results and Discussions

3.1 Dry Matter Production

The sowing date, growth stages and the interaction treatments sowing date × growth stages affected significantly the total dry matter (T.D.M.) and its parts (leaves, stems, ears, and tassels) at the level ($p < 0.01$), while nitrogen treatments significantly affected ears, tassel and total dry weight. On the other hand, leaves dry weight was significantly affected by the interaction of sowing date × nitrogen treatments and growth stages × nitrogen treatments as shown in Table (5).

The total dry matter (T.D.M.) and its parts such as ears and tassels were significantly higher in first sowing date (autumn) than the second (spring) sowing date. This result was in contrast to what Hane (1981) had reached, where the T.D.M. at autumn sowing date was less than that of the spring sowing date. Differences in the environmental conditions of sowing date one and two, in terms of temperature (Mack *et al.*, 1966) and light intensity (Leonard and Martin, 1963), might had contributed to the difference observed for total dry matter production. On the other hand, leaves dry matter was higher in sowing date two than sowing date one, but stem dry matter was not affected by sowing date, (Table 6).

Total dry matter and its parts (leaves and stem) were highest in the physiological maturity stage followed by the milky stage, tasseling stage, and vegetative stage, respectively, (Table 6). The ear dry matter (E.D.M.) was highest in the physiological maturity stage followed by the milk stage and tasseling stage. On the other hand, the tassel dry matter was highest at the tasseling stage, followed by the milky stage and the physiological maturity stage, (Table 6). As shown in Fig. (1 b, c and e), the effect of growth stage and sowing date on total dry matter and its parts (stems and ears), where the T.D.M. increased with the increasing of growth stage. Meanwhile, the sowing date one was always superior. The leaf dry matter increased with the increasing of growth stage, where the second sowing date was superior, (Fig. 1.d). However, the tassel dry matter decreased with growth development, where sowing date two dominating sowing date one (Fig. 1a).

The T.D.M. and its parts were not significantly affected by the water irrigation treatments. No significant differences were obtained between the T.D.M and the nitrogen treatments, as seen in Table (5 and 6).

Ear, tassel and total dry weights were significantly affected by the Nitrogen treatments, but the leaf and stem dry weights were not affected. Ear and tassel and total dry weights increased with increasing nitrogen rates from 0 to 300 kg

TABLE 5. Summary of analysis of variance for dry matter production and its parts, the nitrogen content, leaf area, and plant height of two sowing dates of corn.

Source of variation	dF	Leaf area index (m^2/m^2)	Plant height (cm)	Dry weight (kg/ha)					Nitrogen (mg/kg)				
				Leaf	Stem	Ear	Tassal	Total	Leaf	Stem	Ear	Tassal	Total
Sowing date	1	10.526**	4364**	16640396**	256658 NS	164916503**	670498**	69602849*	0.063 NS	1.840**	0.7692**	2.170**	195.36**
Rep (season)	4	0.164	1232	297965	4532733	6379951	7205	19447880	0.018	0.025	0.0253	0.0455	1.375**
Plant stage (A)	3	0.797**	9.5405**	57667691**	142913321**	220208658**	60143**	1298099739**	28.98**	2.155**	0.1567*	1.753**	162.817**
S × A	3	0.401**	688 NS	5227532**	9642609**	123280741**	44395**	174013595**	4.42**	5.408**	0.4826**	1.660**	172.259**
Error (a)	12	0.112	710	259343	921396	4458074	8654	5798929	0.028	0.056	0.0454	0.052	0.134
Irrigation (B)	2	0.007 NS	1841 NS	13160 NS	204891 NS	361267 NS	847 NS	66702 NS	0.023 NS	0.082 NS	0.0275 NS	0.008 NS	0.008 NS
S × B	2	0.170*	491 NS	7041 NS	93487 NS	393979 NS	607 NS	137880 NS	0.03 NS	0.0 NS	0.1650*	0.003 NS	0.063 NS
A × B	6	0.092	1139 NS	195037 NS	60137 NS	76281 NS	1972 NS	102441 NS	0.045 NS	0.037 NS	0.0157 NS	0.007 NS	0.022 NS
S × A × B	6	0.074 NS	555 NS	112591 NS	65227 NS	1000465 NS	836*	620335 NS	0.045 NS	0.01 NS	0.0114 NS	0.005 NS	0.012 NS
Error (B)	32	0.035	730	99461	761966	414029	1706	1671568	0.062	0.157	0.0457	0.038	0.089
Nitrogen (C)	3	0.059 NS	987 NS	46819 NS	148298 NS	1995696*	12941**	2873061**	0.85**	2.877**	0.7800	0.692**	1.154**
A × C	9	0.035 NS	894 NS	142488*	237170 NS	147727 NS	1342 NS	732479 NS	0.28**	0.595**	0.0520 NS	0.043*	0.258*
B × C	6	0.646 NS	652 Ns	40193 NS	113523 NS	306743 NS	785 NS	512726 NS	0.04 NS	0.066 NS	0.0773*	0.019 NS	0.055
A × B × C	18	0.08 NS	946 NS	61821 NS	238870 NS	456088 NS	405 NS	994006 NS	0.052 NS	0.03 NS	0.0435 NS	0.005 NS	0.102 NS
S × C	3	0.019 NS	1552 NS	367501**	272792 NS	150964 NS	2400 NS	1327982 NS	0.051**	0.096**	1.6085**	0.792**	2.630**
S × A × C	9	0.05 NS	392 NS	77053 NS	258728 NS	271033 NS	1284 NS	626126 NS	0.019**	0.501**	0.1783**	0.185**	0.426**
S × B × C	6	0.032 NS	657 NS	7002 NS	122035 NS	401153 NS	557 NS	483642 NS	0.023 NS	0.061 NS	0.030 NS	0.011 NS	0.113
S × A × B × C	18	0.103**	590 NS	59566 NS	168250 NS	377706 NS	382 NS	796034 NS	0.028 NS	0.03 NS	0.0411 NS	0.007 NS	0.097 NS
EMS	144	0.049	632	73644	153583	507903	1002	704990	0.043	0.06	0.0360	0.018	0.134

D.F. = Degree of Freedom
E.M.S. = Error Mean Square
* = Significant at 0.05 level
** = Highly Significant at 0.01 level.

TABLE 6. The dry matter production and its parts, the nitrogen content, leaf area and plant height and their test of significance for corn experiment.

Treatment	Variable	Leaf area (m^2/m^2)	Plant height (cm)	Dry weight (kg/ha)					Nitrogen (gm/kg)				
				Leaf	Stem	Ear	Tassal	Total	Leaf	Stem	Ear	Tassal	Total
Sowing date	S_1	0.650 A	211 A	1263 B	2321 A	3832 A	266 A	6658 A	2.7 A	1-80 A	1.33 B	3.59 A	
	S_2	0.267 B	203 B	1744 A	2261 A	2084 B	155 B	5675 B	2.79 A	1.64 B	1.46 B	1.53 A	1.94 B
Plant stage	G_1	0.54 A	42.4 C	205.19 C	209.2 C			414.4 D	2.39 C	1.48 C			1.939 B
	G_2	0.53 A	234.9 B	1709.84 B	2948 B	1412 C	241.3 A	6291.2 C	3.24 B	1.71 B	1.48 B	1.31 B	2.044 B
	G_3	0.49 A	272.4 A	1854.46 B	2709.8 B	2607.4 B	2067.4 B	7378.6 B	3.39 A	1.77 B	1.506 A	1.37 B	2.064 B
	G_4	0.31 B	281.6 A	2246.1 A	3297.8 A	4856.4 A	183.9 B	10584.2 A	2.09 D	1.90 A	1.57 A	1.61 A	2.93 A
L.S.D.		0.122	9.67	184.93	348.57	811.49	35.75	874.47	0.061	0.086	0.081	0.088	0.370
Irrigation	IR_1	0.46 A	202.9 A	1514.94 A	2250.94 A	2250.6 A	5028.2 A	207.4 A	6197.4 A	2.79 A	1.73 A	1.51 A	1.44 A
	IR_2	0.48 A	209.3 A	1505.13 A	2281.5 A	2960.9 A	210.4 A	615.1 A	2.78 A	1.72 A	1.54 A	1.42 A	2.76 A
	IR_3	0.44 A	211.3A	1491.62 A	2341.5 A	2886.6 A	214.2 A	6153.6 A	2.76 A	1.70 A	1.54 A	1.43 A	2.75 A
L.S.D.		0.05	7.94 A	92.72	256.64	221.34	14.21	380.12	0.078	0.116	0.07	0.067	0.088
Nitrogen	N_0	0.43 A	203.3 A	1493.73 A	2325.4 A	2788.8 B	197.9 BC	6059.2 B	2.64 B	2.64 C	1.50 D	1.42 C	1.29 D
	N_1	0.43 A	206.8 A	1487.62 A	2226.4 A	2822.4 B	201.3 B	5981.9 B	2.74 B	1.63 C	1.43 C	1.41 C	2.65 B
	N_2	0.48 A	209.2 A	1492.29 A	2293.1 A	3020.1 BA	201.2 B	6188.9 BA	2.84 A	1.97 A	1.67 A	1.56 A	2.90 A
	N_3	0.48 A	212.1 A	1541.95 A	2319.7 A	3202.9 A	232.3 A	6438.2 A	2.89 A	1.76 B	1.56 B	1.46 B	2.84 A
L.S.D.		1.111	8.28	89.39	129.1	271.8	12.07	276.6	0.068	0.044	0.072	0.052	0.121

Season 1 = Autumn
Season 2 = Spring
IR = Irrigation Treatment
IR_1 = 50%
IR_2 = 25%

G_1 = Vegetative growth
G_2 = Tasseling growth
G_3 = Milky growth
G_4 = Maturation growth

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

L.S.D. = Least significant difference at 5%
A = 1st high category
B = 2nd high category
C = 3rd high category
D = 4th high category

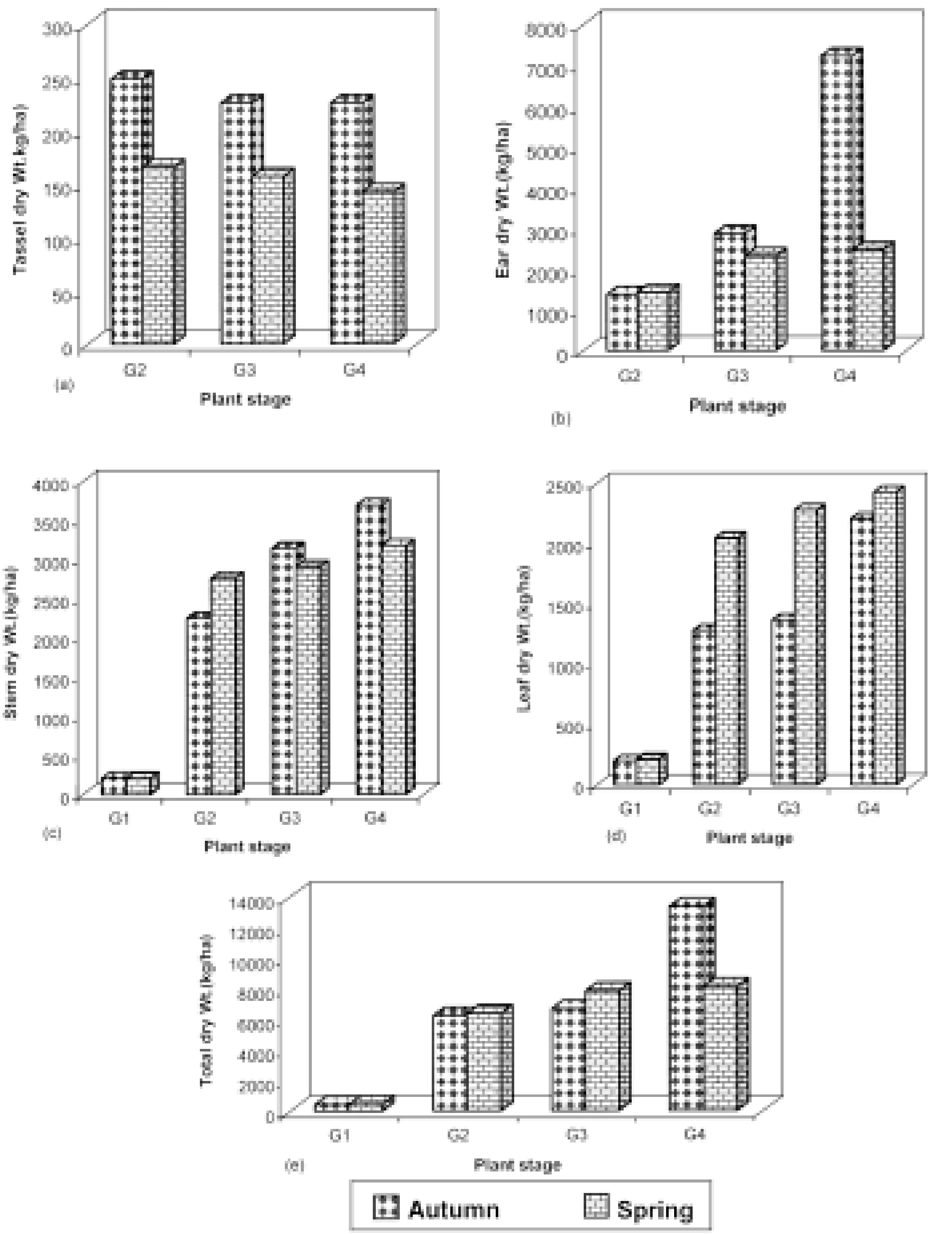


FIG. 1. Effect of different growth stages on (a) tassal dry weight, (b) Ear dry weight, (c) stem dry weight, (d) leaf dry weight, and (e) total dry weight during two different sowing dates of corn plant.

N/ha. Similar results were previously reported by the investigators Myers (1988), Okuyama and Silva (1983), Bhujbal and Souza (1992), and Chung *et al.,* (2000) they found an increase in total dry matter of maize plant with increase of nitrogen fertilization. Other researches showed that a successive increase of corn plants T.D.M. with the increase of nitrogen up to 178,5 kg/ha (Mahmoud *et al.,* 1980), up to 214 kg/ha (Abdel-Aziz *et al*., 1986) added in two doses, and up to 120 kg/ha (Chung *et al.* 2000). Also, Overman *et al.* (1994), found an increasing in T.D.M. of corn with increasing of nitrogen fertilization. Quiles-Belen *et al.* (1988), pointed out that, when the corn stand density reached 40,000 plants/ha, 120 kgN/ha was considered the optimum as regard to the T.D.M. production. Solaiman *et al.* (1975), obtained the highest T.D.M. at a nitrogen fertilization of 300 kgN/ha when the stand density was 50,000 plants/ ha. In contrast, Pirani and Agostinelli (1989), found no increase in the T.D.M. of corn with increase of nitrogen even up to 230 kg N/ha. Nitrogen application showed no significant effect of corn ear dry weight. Roy and Singh (1986) produced similar conclusions, where they demonstrated on increasing in ear dry weight at a rate of 100 kgN/ha. Abdel-Aziz *et al.* (1986), also found an increase in the corn ear dry weight when he applied 214 kgN/ha in two doses. The highest yield in ear was reached by Anwarhan (1984) when he added 120 kgN/ha to corn stand with 6000 plants/ha intensity. Similar results were previously reported by Chung *et al.*, (2000). In contrast, Salem *et al.* (1982) and Ahmed et al. (1965) found no increase in ear dry weight with increase of nitrogen rates.

Leaf dry matter increased with the increasing of Nitrogen rates from 0 to 300 kgN/ha, where the sowing date one dominated sowing date two (Fig. 2).

3.2 Leaf Area index

Significant differences were obtained between the total leaf area of corn plant and the sowing date ($p < 0.01$), the growth stages ($p < 0.01$), the interaction treatment sowing date $\times$ growth stages ($p < 0.01$) and the interaction sowing date $\times$irrigation treatments ($p < 0.05$). No such effect was noticed for both nitrogen and irrigation treatments on the total leaf area, as seen in Table (5).

The leaf area of the corn plant was higher in sowing date (autumn) one (0.650 m^2/m^2) than sowing date (spring) two (0.267 m^2/m^2). The leaf area of the corn plant was significantly the lowest in the fourth growth (maturity) stage (0.31 m^2/m^2) followed by the third growth (milky) stage (0.49 m^2/m^2), then the second growth (tasseling) stage (0.53 m^2/m^2) and the first growth (vegetative) stage (0.54 m^2/m^2), respectively in an increasing order. Howerver, there was no significant effect between G1, G2 and G3 on leaf area index as seen in Table (6).

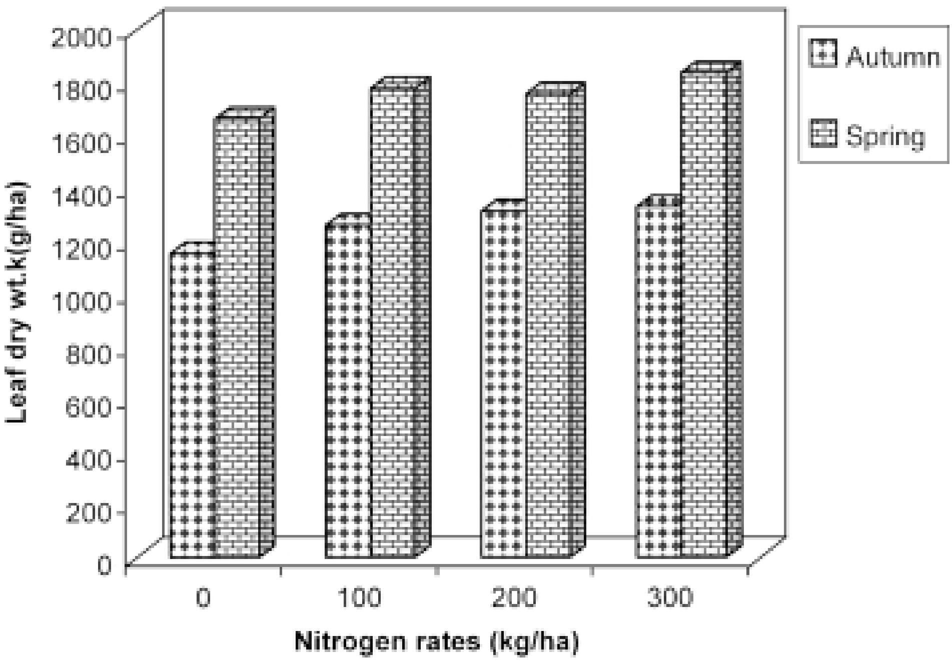
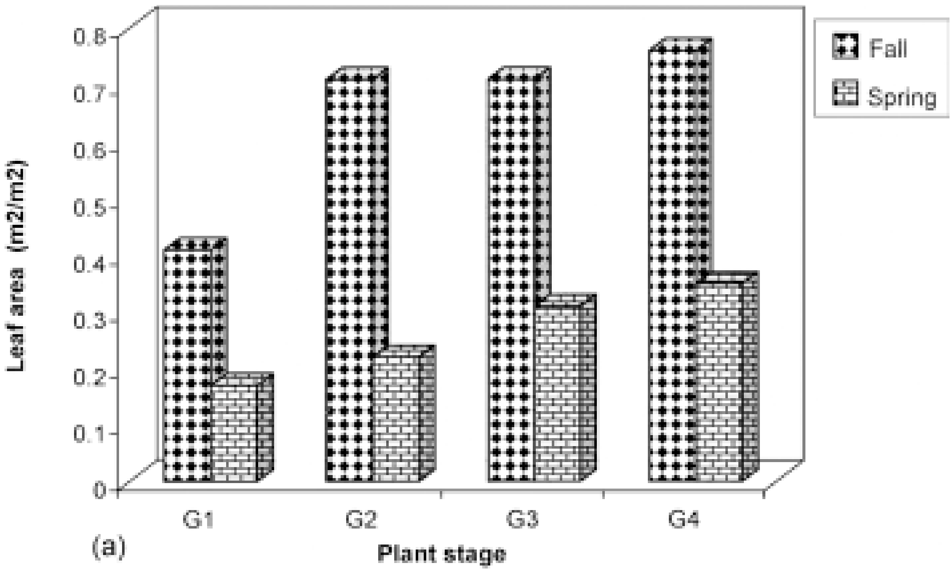


FIG. 2. Leaf dry weight as affected by different nitrogen rates during two different sowing dates of corn plant.

The application of different levels of nitrogen did not affect the leaf area of corn plant. Similar results were reported by Ahmed (1965), Krishnamurthy *et al.* (1974), Ellias *et al.* (1979), and Salem *et al.* (1982). But other investigators like Prasad *et al.* (1987), found that corn leaf area index increased with the increasing of nitrogen where the optimum leaf area was at application rate of 150 kgN/ha. Yakout *et al.* (1980), obtained the highest leaf area of corn plant with an application of 180 kgN/ha. The investigators Panda and Hati (1970), Tregubenko and Fillipov (1972), Bole and Frayman (1975), Shortal and Libharal (1975), Rathore *et al.* (1973), Koswara (1977), Gagro (1977) and Abdul-Rahman (1978), generally pointed out that adding nitrogen fertilizer increased the corn plant leaf area.

Fig. (3a), illustrates the combined effect of sowing date $\times$ growth stages on leaf area index. The leaf area index increased respectively with the increasing of growth stages from one to four, where sowing date one was always dominating sowing date two.

Fig. (3b), illustrates the effect of the interaction treatment sowing date $\times$ irrigation treatments on leaf area index. The leaf area index increased, respectively with the increasing of irrigation water from IR_1 to IR_3, where sowing date one was always dominating sowing date two.



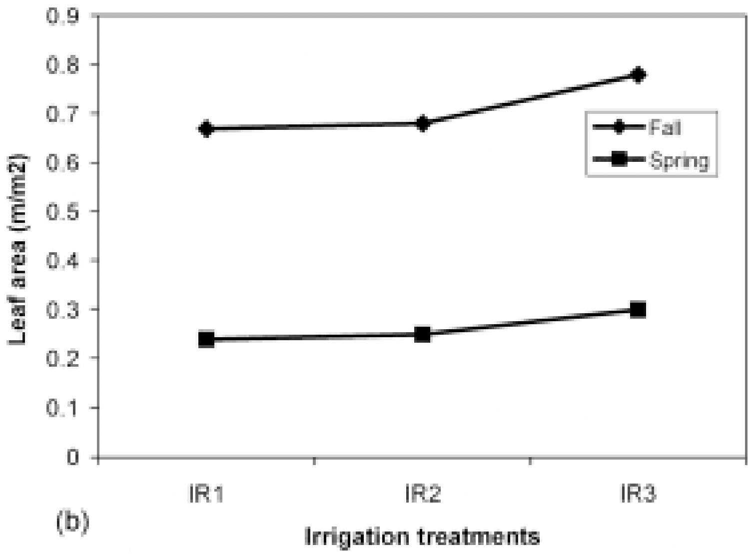


FIG. 3. Leaf area as affected by (a) growth stages, and (b) irrigation treatments during two different sowing dates of corn plant.

3.3 Plant Height

Plant height was significantly affected by sowing date and the growth stages at ($p < 0.01$), as seen in Table (5).

Corn plant height was significantly higher in sowing date (spring) two (211 cm) than sowing date (autumn) one (203 cm). The corn plant height was highest at the fourth growth (maturity) stage (281 cm) followed by the third growth (milky) stage (272 cm) then the second (tasseling) stage (235 cm) and the first growth (vegetative) stage (42 cm), respectively in a decreasing order, as seen in Table (6).

Application of different nitrogen levels did not show any significant effect on corn plant height, as seen in Table (6). Some investigators reported similar results, like Lucas (1986), where he added 150 kgN/ha to a corn stand with plant intensity between (19000-111000) plants/ha. Also, Krishnamurthy *et al.* (1974), Ellias *et al.* (1979), Russell (1984) and Milam and Hickingbottom (1986), found no significant effect for nitrogen applications even up to 300 kgN/ha on the corn plant height. But, Ogunlela *et al.* (1988) obtained a significant effect on corn plant height by nitrogen application at a rate of 150 kgN/ha and a plant intensity range 25000-75000 plants/ha. Also, some other researchers, demonstrated that increasing of nitrogen application rates, increased the plant height, like Stivers *et al.* (1961), Bole and Frayman (1975), El-Sharkawy *et al.* (1976), Koswara (1977), Gagro (1977), Abdel-Rahman (1978), Ibrahim (1979) and Abdel-Aziz *et al.* (1986).

There was no significant effect for the irrigation treatments on the corn plant height (Table 5 and 6). However, Boquet *et al.* (1985) obtained a significant effect on corn plant height, when he used high rate of irrigation water with 267 kgN/ha nitrogen rate.

3.4 Nitrogen Content in Different Plant Parts

The main effect of treatments: sowing date (S), growth stage (G), and nitrogen rate (N) were having a significant effect on N contents of all plant parts (Table 5). Meanwhile, the interaction effect of treatments sowing date × growth stages (SG), and sowing date × nitrogen rates (SN), were having the same effect on the nitrogen contents in all plant parts. Moreover, the interaction treatment growth × nitrogen (GN), has a significant effect on all plant parts nitrogen contents except the ear and tassel plant parts as seen in Table (5).

The results of test of significant study were shown in Table (6) where the first sowing date (autumn) was superior in nitrogen contents for stem, ear, and total than the second sowing date (spring). Meanwhile, the second sowing date was having a higher content of nitrogen in tassel than the first sowing date. The fourth plant stage (G_4) was having higher content of nitrogen than the other plant stages, where the third plant stage was following the stage four in nitrogen contents, then the second stage. The irrigation treatments did not affect significantly the nitrogen contents in all plant parts.

Nitrogen rate N_3 (200 kg/ha) was superior in nitrogen content at all plant parts. Generally, as shown in Table (6), as the level of nitrogen rate increases, the results of nitrogen content in plant parts increases too. Similar result was reported by Chung *et al.*(2000).

As for the applied nitrogen rates, corn stem nitrogen content was significantly lower at zero N. level (1.51 mg/kg) followed by 100 kgN/ha level (1.63 mg/kg), then 300 kgN/ha level (1.76 mg/kg) and 200 kgN/ha level (1.98 mg/kg), respectively in an increasing order, as seen in Table (6). This result was not much similar to the results obtained by Zhou *et al. (*1997), El-Baisary *et al.* (1980) and Moursi and Saleh (1980), when the highest observed nitrogen absorbed by the plant was at the rate of 143 kgN/ha which was applied in two times. On the other hand, Harada *et al.* (1996) mentioned that most of the nitrogen was absorbed by corn plant accumulate in the plant stem.

Fig. (4) illustrates the interaction effect of sowing date × nitrogen rates on nitrogen content of plants and its parts (tassel, stem and leaf). Nitrogen content of plants and its parts increased with the increase of applied nitrogen rates from 0 to 200 kgN/ha, where sowing date one was always dominating sowing date two. However, leaf nitrogen content increased with the increasing of nitrogen rate, but the sowing date two was always superior .

Fig. (5) illustrates the effect of the interaction treatment sowing date ×growth stages on stem, leaf, ear, tassel, and total nitrogen content. The nitrogen content increased respectively with the increasing of growth stages from one to four, where the sowing date one was dominated sowing date two. However tassel nitrogen content increase respectively with the increasing of growth stages but the sowing date two was dominated sowing date one.

Fig. (6) shows the combined effect of growth stages × nitrogen content on plant stems and leaves, where they increased respectively with the increasing of growth stages from one to four and the increasing of nitrogen rate from 0 to 200 kg/ha.

Fig. (7) shows the combined effect of sowing dates ×irrigation treatments on corn ear nitrogen content. The ear nitrogen contents decrease respectively with the increasing of irrigation water, where sowing date one was dominated sowing date two.

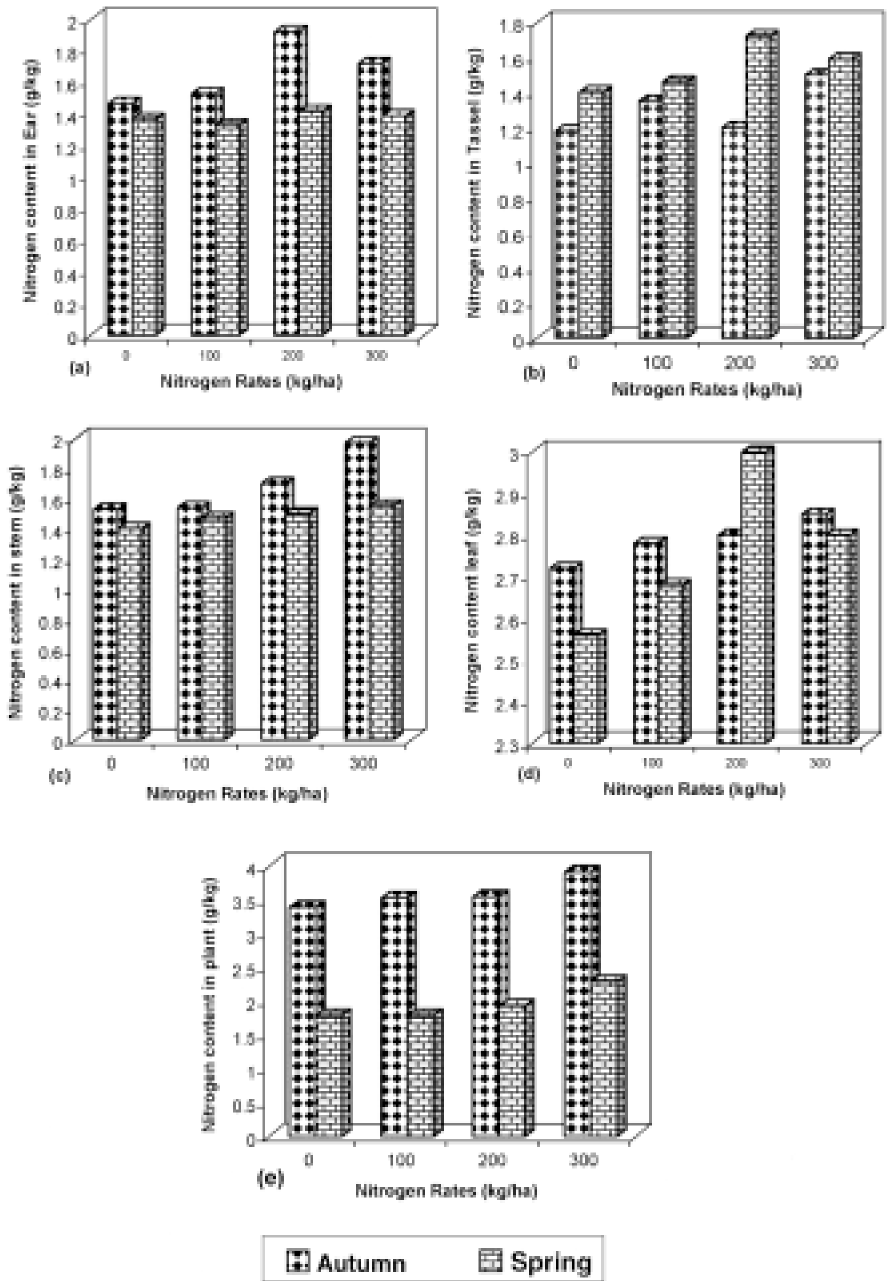


Fig. 4. Effect of different nitrogen rates on nitrogen contents in a) ear, b) tassel, c) stem, d) leaf, and e) plant, during different sowing dates of corn plant.

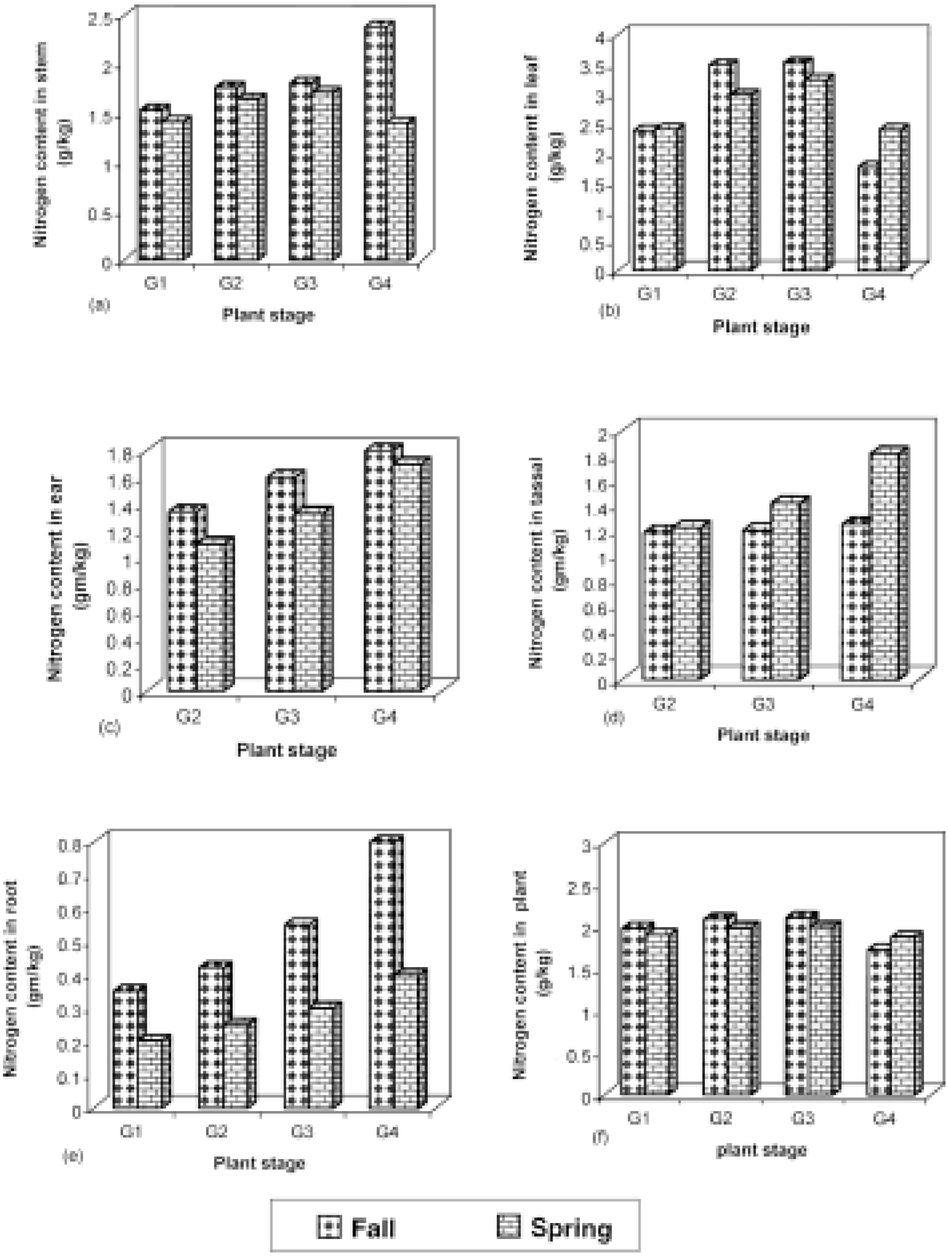
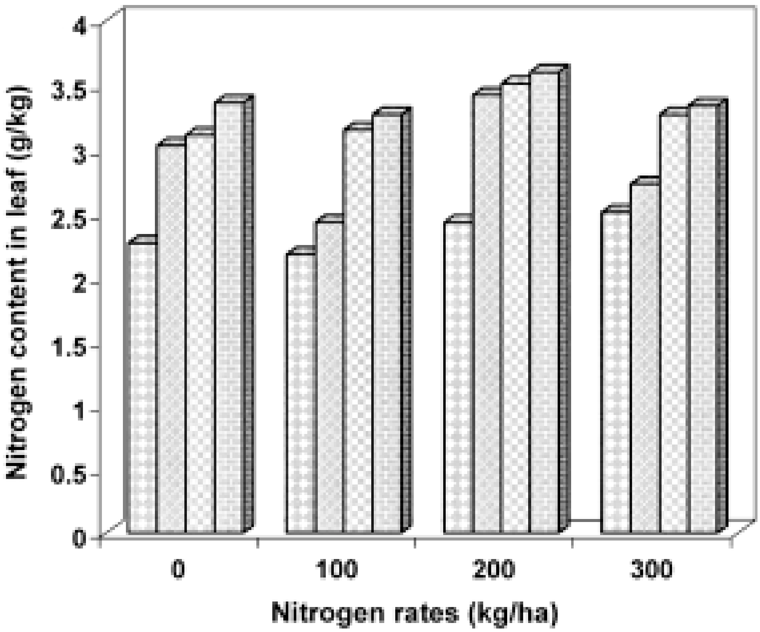


FIG. 5. Nitrogen content during different growth stages in (a) stem, (b) leaf, (c) ear, (d) tassal, (e) roots and (f) total plant, during two different sowing dates of corn plant.



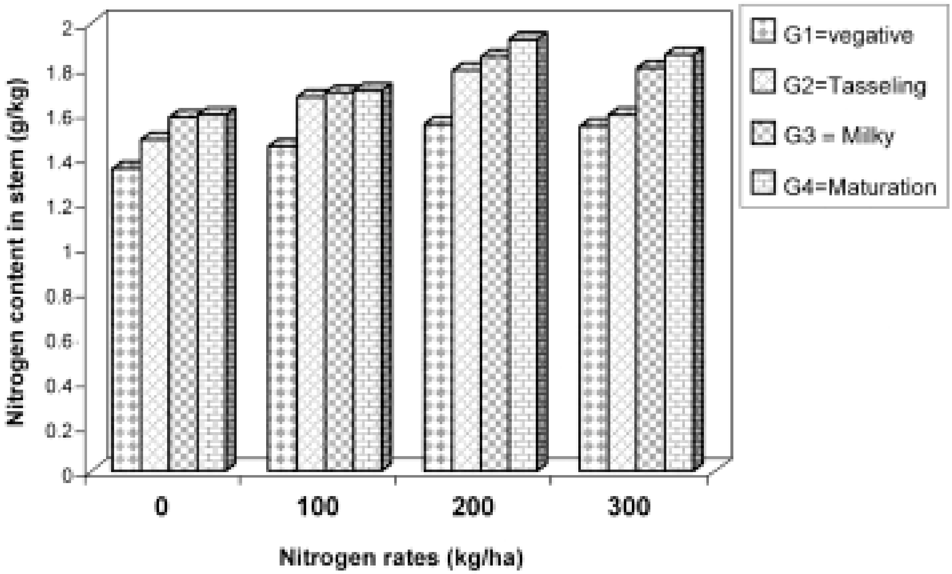


Fig. 6. Effect of different nitrogen treatments on nitrogen content in (a) leaf, (b) stem, and at different growth stages of corn plant.

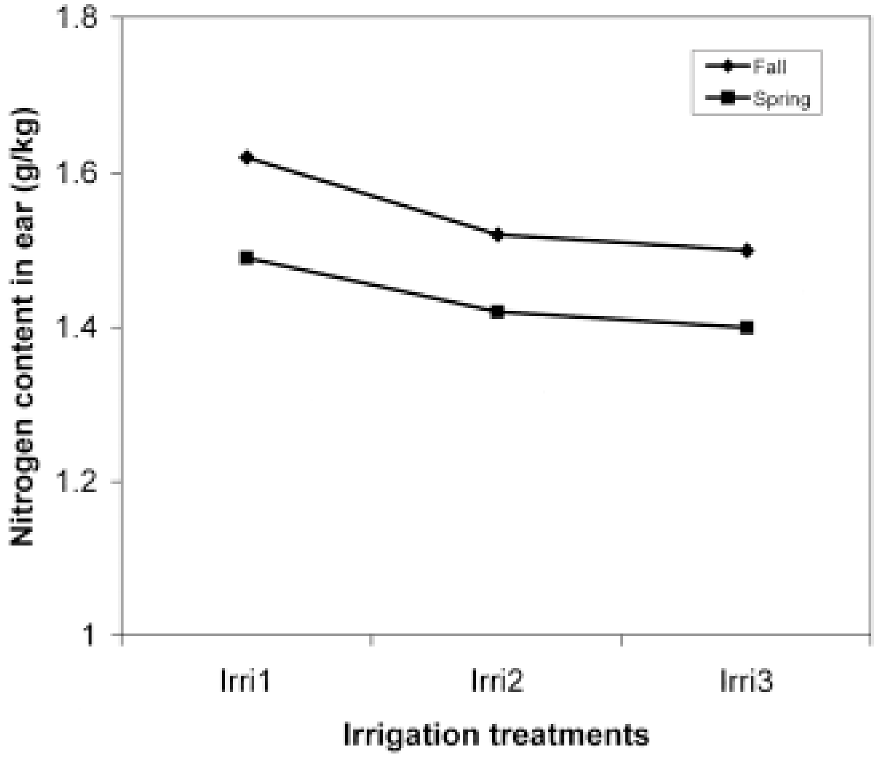


Fig. 7. Effect of different irrigation treatments on nitrogen content in ear during two different sowing dates of corn plant.

The results indicated a continuous increasing of nitrogen content in plant leaves up to 200 kgN/ha application rate. Similar results were observed by El-Baisary *et al.* (1980); Moursi and Saleh (1980) and Chung *et al.*, (2000) who found an increase in corn leaves nitrogen content with an increase of nitrogen application. But, Mello *et al.* (1988), found no such significant influence on leaves nitrogen content in response to nitrogen rates applications.

4. Conclusions

The effect of sowing date on the different growth parts of corn was observed, where highly significant effects were found. The mean values of variables which were higher in autumn sowing date, were leaf area, total dry weights of ear, tassel, and total nitrogen contents in stem and ear.

The nitrogen rates have highly significant effects on most of plant growth variables. The nitrogen rate 300 kgN/ha gave higher values of dry weights, nitrogen contents in leaf, and stem. Meanwhile, the nitrogen contents in ear and tassel were higher under nitrogen rate 200 kg N/ha. There was no significant effect for the interaction treatments (nitrogen treatment and irrigation regimes) on all the studied plant variables.

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تأثير معاملات مختلفة من النيتروجين والري على تجميع المادة الجافة والمحتوى النيتروجيني لنبات الذرة الشامية خلال مراحل النمو المختلفة لموعدين زراعيين

محمد الشربيني كيوان* ، سمير جميل السليماني**

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جـــدة – المملكة العربية السعودية

المستخلص . تم القيام بتجربة حقلية بمحطة الأبحاث الزراعية بهدى الشام التابعة لجامعة الملك عبد العزيز وذلك لدراسة تأثير ثلاثة معدلات مختلفة من الري مبنية على نسب الاستنزاف ٥٠٪ ، ٢٥٪ ، ١٠٪ (IR_1 , IR_2 , IR_3) وأربعة معدلات سماد نيتروجين (يوريا) هي صفر ، ١٠٠ ، ٢٠٠ ، ٣٠٠ كجم / هكتار (N_0 , N_1 , N_2 , N_3) ، على تجميع المادة الجافة الكلية لهجين الذرة الشامية (صنف أجا ٢١٥– AGA seed 215) وأجزاؤه المختلفة (أوراق – سيقان – كيزان – شوشة) وعلى المحتوى النيتروجيني لأجزاء النبات المختلفة خلال موعدين زراعيين (خريف ١٩٩٤م وربيع ١٩٩٥م) . ولقد صممت جدولة الري بحيث كانت كمية المياه المستخدمة لكل موسم ثابتة لمعاملات الري المختلفة وهي ٩٠,١٥ سم (٩٠١٥م^3 / هكتار/ موسم الخريف) و١٠٨,٨٢ سم (٨٢١٠ م^3 / هكتار/ موسم الربيع) للموعدين الزراعيين على التوالي . كان للموسم تأثير معنوي عالي حيث تميز الموسم الأول (الخريف) بالزيادة في مساحة الأوراق والوزن الجاف (الكوز ، الشوشة ، الوزن الكلي) ومحتوى النيتروجين بالنبات وأجزاءه (الساق ، الكوز) . بينما تميز الموسم الثاني (الربيع) في محتوى النيتروجين في الشوشة. وقد كانت المرحلة الرابعة (النضج) أعلى في كل صفات النبات والمادة الجافة ما عدا وزن الشوشة. أظهرت المعاملات المختلفة للنيتروجين تأثيراً معنوياً

على بعض صفات النمو حيث أعطت المعاملة N_2 أعلى قيم للوزن الجاف لكل من الكوز (٣٢٠٢,٩ كجم/ هكتار) والشوشة (٢٣٢,٣ كجم/ هكتار) والنبات الكامل (٦٤٣٨,٢ كجم/ هكتار)، وأعطت المعاملة N_2 أعلى معدل إنتاجية فيما يتعلق بمحتوى النيتروجين في النبات الكامل (٢,٩ جم/ كجم) وأجزاءه (أوراق ٢,٨٤ جم/ كجم - سيقان ١,٩٧ جم/ كجم - كوز ١,٦٧ جم/ كجم - شوشة ١,٥٦ جم/ كجم). ولم يكن لمعاملات الري أو التفاعل في معاملات الري والنيتروجين أي تأثير معنوي على جميع الصفات المدروسة.