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Effect of Subsurface Drip Irrigation System and Two Levels Nitrogen Fertilizer on Corn Growth and Yield

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Abstract. The scarcity of irrigation water in Iraq and the great waste of water and saline lands and the dominance of old and unscientific methods of water management when cultivating corn, was the aim of this study is to reduce the amount of fertilizer added to the soil during the growing season for hectare area and the abundance of water large amounts, as well investigate, the effect of irrigation systems, subsurface drip irrigation system(SDIS) and, the levels nitrogen fertilizer (NF) on corn cultivars (Gadiz, IPA5012 and R-106). Completely randomly assigned to three replicates, the Gadiz cultivar outperformed the IPA5012 and R-106 cultivars in a factorial experiment. While the level nitrogen fertilizer (175 kg $N.ha^{-1}$), was significantly superior to the level nitrogen fertilizer (150 kg $N.ha^{-1}$), in all parameters. All interactions were significant, the best results in this study were obtained from the interaction among the level nitrogen fertilizer (175 kg $N.ha^{-1}$) and corn cultivar Gadiz .

Keywords: Corn, Irrigation system (SDIS), Levels nitrogen fertilizer (NF), Corn cultivars, (Gadiz, IPA5012 and R-106).

1. Introduction

Corn comes(Zea Mays L.) in third place after wheat and barley crops in terms of cultivated area and production, and it is called the king of crops because of its economic importance, at the level of nutrition, pharmaceutical and chemical industries [1], corn is grown on large areas of Iraq, and its cultivation is concentrated in Najaf, Karbala, Wasit, Babil and Baghdad, and the yellow corn crop needs high temperatures and abundant water [2], the increase in nitrogen fertilizer levels led to an increase in crop growth and productivity [3,4], increasing the area planted with the corn crop by adopting advanced methods to cover the shortage with the increase in poultry fields, considering the corn crop the main source of livestock and poultry feed [5], the grain yield is the main objective of cultivating this crop, and Iraq is considered to have low productivity compared to world production, the decline in the corn crop productivity leads us to work, to raise the production rate per unit area by using possible methods and means to increase the growth and productivity of this crop [6].

The soil physical properties are affected by irrigation methods, plowing, and degree of soil softening, According to research published in [7,8], soil physical characteristics are reduced when farm machinery is used in accordance with best practices for agricultural processing, which in turn increases crop productivity and quality throughout the growing season. [9], the water movement inside the soil slop as a result of the gradient, during the period of adding water from the droppers to the soil, which is called, (the wetting phase). The movement of water within the soil is controlled by the capillary tensile forces and earth's gravitational forces, soils with small pores are more affected by tensile forces than soils with large pores [10].
The study of [11,12], showed that plants during the growing season require providing a suitable environment for growth (wet roots area) to face the intense heat wave during the summer in the country of Iraq, the growth and spread of plant roots depends on the availability and distribution of humidity content, according to the type of soil, its porosity, and its ability to conserve water for a longer period for the continuation of plant growth [13,14]. Chemical fertilizers, especially nitrogen fertilizers, are an important and limiting factor for the level of productivity, When organic matter and certain essential minerals are depleted in the soil, the need for fertilizers becomes more pressing [15,16], the optimal agricultural process depends on the agricultural cycle in the crops cultivation in a way that ensures the soil properties preservation, however, the agricultural machinery use and equipment that improves soil qualities in a method that increases the vegetative plant growth during the growing season and in end increases its productivity. [17,18], One of the depleting crops, yellow corn uses a lot of nitrogen and other resources while it's growing. To promote plant development and maximize yield, nitrogen fertilizer is a must. [19,20]. The major object of this research is to study the impact of subsurface drip irrigation and nitrogen fertilizer (150kg $N.ha^{-1}$ and 175kg $N.ha^{-1}$) on corn, (Gadiz, IPA5012 and R-106) cultivars .

2. Materials and Methods

Research was conducted in the Al- Hashemia area, which is located 15 km away from the Babylon city, for the year 2020. In the research, irrigation system subsurface drip irrigation system(SDIS) on three corn cultivars (IPA5021,R-106 and Gadiz) under two the nitrogen fertilizer levels (NF) of 150 kg $N.ha^{-1}$and 175kg $N.ha^{-1}$. (Fig .1) Renewable energy (energy clean) was adopted to operate the pumping units.
Soil was worked up to a depth of 22 centimeters using a mold board plow, pushed by a tractor (MSF-285s type), and then subjected to subsurface drip irrigation for an additional 15 centimeters. Soil chemistry and physics were computed and are displayed in Table (1).

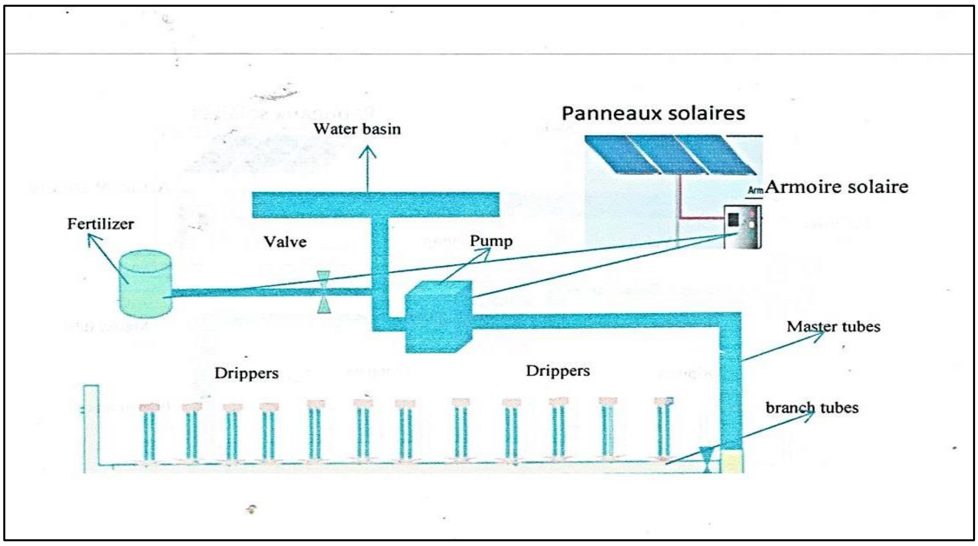

Figure 1. Subsurface drip irrigation system(SDIS).

Figure 2. Subsurface drip irrigation system for corn plants.

2.1. Adding Nitrogen Fertilizers to the Subsurface Drip Irrigation System

The nitrogen fertilizer (N 46%) was added at the rate of 1mg .L^{-1} in the tank of the subsurface drip irrigation system, and left for 24 hours, with good mixing to obtain a high homogeneity between the fertilizer and water.

Urea is a highly mobile molecule that moves with the movement of water in the soil. The movement of urea after irrigation or with fertilized irrigation is similar to the movement of nitrates. the distribution of urea at the end of 27 hours, the injection begins for two hours near the start of irrigation, after addition, urea is converted to ammonium by hydrolysis, and this ammonium is adsorbed on the adsorption surfaces in the soil.

2.2. Calculation of the Injection Rate, for Fertilizer an Area of One Hectare

$$Q_F = \frac{F_{R\times A}}{T_{I\times T_{F\times F_C}}} \tag{1}$$

Where ;Q_F ;fertilizer injection rate L.ha^{-1},F_R ;fertilizer rate kg.ha^{-1} , A; The area to be fertilized ha,T_I Irrigation time hour ,T_F ;ratio of fertilizing time to irrigation time ,F_C ; Fertilizer concentration kg.L^{-1}

$$V = \frac{F_{R\times A}}{F_C} \tag{2}$$

Where; V, Tank capacity

$$X = F_{C\times R} \tag{3}$$

Where; X the amount of fertilizer added to the tank of the drip irrigation system.

$$Q = \frac{F_{pm}}{C\times 10^6} = Q_{F\times F_C} \tag{4}$$

Or

$$Q = \frac{V}{C}\times\frac{Q}{F_C}\times\frac{EPP}{10^6} \tag{5}$$

2.3. Soil Characteristics

Soil properties were determined with a tillage depth of 22 cm in several random locations in the experimental field, according to the method used by Al-Jezaaria et al., [21] and Alaamer et al., [22], Averages of soil moisture, bulk density, and total permeability were determined by taking samples at the beginning, middle, and end of the growing season. [23,24].

$$W = \frac{W_w}{W_s}\times 100 \tag{6}$$

Where: W is soil humidity ratio (%), W_w is mass wet soil(kg), W_s is mass dry soil.(kg)

$$S_{BD} = \frac{M_S}{V_T} \quad (7)$$

Where: S_{BD}: Density of dry bulk (mg. m^{-3})M_S: sample of soil's dry weight (mg), V_T: total volume of the soil sample (m^3).

$$T_{SP} = \left(1 - \frac{P_b}{P_S}\right) \times 100 \quad (8)$$

Where: T_{SP}: total of soil porosity (%), S_{BD}: dry of bulk density (mg.m^{-3}), P_S : partial density (2.65 mg.m^{-3}) . [4] .
Root length
It was calculated according to [6,13] .
Root dry weight
Root fresh weight
Plant vigor index (PVI)
Was calculated according to [11].

$$P_{VI} = \frac{P_L \times G_P}{100} \quad (9)$$

Where ; PVI ;plant vigor index cm, P_L ;plant length cm, G_P;Germination ratio.
Crop growth rate;
Was calculated according to [25,26].

$$G_{CR} = \frac{W_2 - W_1}{T_1 - T_2} \quad (10)$$

Where : G_{CR} crop growth rate g.day-1, W_1 dry weight of the plant, T1, after 15 days of planting ,W_2 dry weight of the plant, T2 after 30 days of planting .
Relative growth rate;

$$R_{GR} = \frac{Log\, W_2 - Log\, W_1}{T_1 - T_2} \quad (11)$$

Grains yield;
The grains yield was calculated [5,17].

$$G_Y = GP \times PD \quad (12)$$

Where ; G_Y;grain yield(t.ha^{-1}),GP; grain rate per plant (kg) , PD; plant density.ha^{-1}.
In this experiment, split-plot design in RCBD with three replication was used, according to program Gestate V.12 . [27] .

Table 1. Soil characteristics, both chemical and physical.

Depth	Texture %			
	Clay	**Silt**	**Sand**	
	48	24	28	Silt Clay loam
	Soil physical properties			
0-22 (cm)	Soil bulk density (Mg m^{-3})	Total soil porosity (%)	Soil penetration resistance (Kpa)	
	1.41	46.79	1643.09	
	1.44	45.76	1676.78	
	1.42	46.11	1722.19	
VA	1.46	44.71	1756.37	
	Soil chemical properties			
	E.C (ds\cm^3)	HP		
	1.42	6.61		

Depth	Texture %			
0-22 (cm)	Clay	Silt	Sand	
		Soluble cation meq\I		
	Na	K	Ca+Mg	
	13.82	12.35	56.62	
	O.C	CEC	CaCo3	O.M
	(%)	(Meq\100g)	(%)	(%)
	0.55	32.81	4	0.64

3. Results and Discussion

3.1. Soil Characteristics

The result showed that soil density values were negative and porosity values were positive. Table 2 shows that the SBD values were reduced by nitrogen fertilizer (150kg N.ha^{-1}) after one month (1.28) and two months (1.31) of the growing season ending., offset by an increase in the TSP, were results,51.44, 50.31 and 49.81%, respectively, after a 1Mon, 2Mon and GSE, with the same conditions for the nitrogen fertilizer (175 kg N.ha^{-1}), which achieved the lowest results for the soil physical properties(density and soil porosity) .Increasing the proportions of the chemical (N46%), substance added to the soil leads to hardening, a decrease in its porosity, an increase in its density, and a impairment in the soil form in this experiment during the growing season [20,6]. The corn cultivar (Gadiz), achieved the best SBD of 1.28,1.30 and1.33Mg.m^{-3}, and the increase in ratios TSP of 51.88, 50.75and 49.81%, with the same conditions for the corn cultivars (IPA5012 and R-106).

Table 2. Impact of nitrogen fertilizer levels and corn cultivars on soil properties.

Cultivars	NF Kg.N.ha^{-1}	Soil bulk density			Total of soil porosity		
		1Mon	2Mon	GSE	1Mon	2Mon	GSE
Gadiz	150	1.27	1.30	1.32	52.07	50.94	50.18
	175	1.28	1.31	1.34	51.69	50.56	49.43
IPA5012	150	1.29	1.32	1.33	51.32	50.18	49.81
	175	1.30	1.33	1.35	50.94	49.81	49.05
R-106	150	1.30	1.33	1.34	50.94	49.81	49.43
	175	1.31	1.34	1.36	50.56	49.43	48.67
ACU	Gadiz	1.28	1.30	1.33	51.88	50.75	49.81
	IPA5012	1.29	1.33	1.34	51.13	49.99	49.43
	R-106	1.31	1.34	1.35	50.75	49.62	49.05
ANF	150	1.28	1.31	1.33	51.44	50.31	49.81
	175	1.30	1.33	1.35	51.06	49.93	49.05
	C	0.02	0.03	0.04	0.13	0.16	0.18
LSD=0.05	NF	0.04	0.05	0.06	0.18	0.21	0.26
	NF*C	0.07	0.08	0.09	0.29	0.32	0.34

3.2. Root Growth Parameters

Using Table 3, we can see that nitrogen fertilizer (N 46 percent) significantly influenced root growth variables. As the nitrogen fertilizer (175kg N.ha^{-1}) gives the highest averages 23.51cm ,0.87 g and 2.81 g, compared to nitrogen fertilizer (150kg N.ha^{-1}), which on record a noteworthy lowering in the roots growth characteristics, during the growing season. Increase in the area of hydration with a decrease in the distance between the drippers and an increase in the roots sawing with the increase in evenness of fertilizer distribution in the root zone [4,9]. All root parameters increased with corn cultivar ((Gadiz) and scored the highest results 23.80 cm, 0.90 g and 2.82 g, as compared with two the corn cultivars (IPA5012 andR-106),which gave the lowest results 22.99 cm, 0.86 g, 2.71 g, 21.68 cm , 0.83g and 2.52 g respectively, the reason for this is due to the genetic behavior of the maize cultivars (Shtewy et al.,2020b). The interaction among nitrogen fertilizer of 175kg N.ha^{-1} and the corn cultivar (Gadiz) was the best (24.48 cm, 0.91 g and 2.98 g). Figure 3 displays the amounts of root growth metrics for both NF and cultivars under contrasting situations.

3.3. Crop Growth Periods Parameters

The results of Table (4) showed the superiority of the maize Cadiz cultivar, over the rest of the cultivars of this study (IPA5012 and R-106), as it gave the highest growth rate (17.169 $g.day^{-1}$) for the fourth growth period 45-65 days, while the R-106 cultivar gave the lowest growth rate of (14.980 g $.day^{-1}$) . The reason for this was the good conditions for the growth associated with the active role of each variety in its genetic behavior [22],[23]. As the nitrogen fertilizer (175kg $N.ha^{-1}$) gives the highest growth rate (16.429 $g.day^{-1}$), compared to nitrogen fertilizer (150kg $N.ha^{-1}$), which on record a noteworthy lowering in the growth rate (15.415 $g.day^{-1}$).The interaction among nitrogen fertilizer (175kg $N.ha^{-1}$) and the corn cultivar (Gadiz) was the best (17.816 $g.day^{-1}$). The (Gadiz)cultivar resulted in the highest relative growth rate(0.198 $g.g.day^{-1}$)for second growth period ,while the two cultivars (IPA5012 and SYN-6) indicated the lowest for all growth periods. As the nitrogen fertilizer (175kg $N.ha^{-1}$) gives the highest relative growth rate(0.192 $g.g.day^{-1}$), compared to nitrogen fertilizer (150kg $N.ha^{-1}$), which on record a noteworthy lowering in the relative growth rate (0.184$g.g.day^{-1}$).The reason for the high growth of these two periods, is the presence of a positive correlation between the relative growth rate and the absolute growth rate [2,3,9]. The interaction among nitrogen fertilizer (175kg $N.ha^{-1}$) and the corn cultivar (Gadiz) was the best (0.203 $g.g.day^{-1}$).

Table 3. Corn root growth metrics as influenced by nitrogen fertilizer and cultivar.

Cultivars	NF $Kg.N.ha^{-1}$	Root length cm	Root dry weight (g)	Root fresh weight (g)
Gadiz	150	23.11	0.88	2.66
	175	24.48	0.91	2.98
IPA5012	150	22.16	0.85	2.53
	175	23.82	0.87	2.88
R-106	150	21.13	0.82	2.46
	175	22.24	0.84	2.58
ACU	Gadiz	23.80	0.90	2.82
	IPA5012	22.99	0.86	2.71
	R-106	21.68	0.83	2.52
ANF	150	22.13	0.85	2.55
	175	23.51	0.87	2.81
	C	0.146	0.101	0.112
LSD=0.05	NF	0.188	0.126	0.221
	NF*C	0.211	0.143	0.322

3.4. Growth and Yield Parameters

PVI was found to be highest for the (Gadiz) cultivar (60.29 cm) and lowest for the (IPA5012 and SYN-6) cultivars (both of which were below 50 cm) (58.46 and 56.03 cm). The average PVI is 60.20 cm higher when nitrogen fertilizer (175kg N.ha-1) is used (150kg N.ha-1), which on record a noteworthy lowering in the PVI (58.06 cm). Because of the cultivar active role and its response to the fertilizer, whom is returned in increasing PVI and the vegetarian growth [11],[13]. The interaction among (Gadiz) cultivar and nitrogen fertilizer (175kg.ha-1) gaves greatest result (64.28cm). From Table (5), the (Gadiz) cultivar done the upper values for all crop growth parameters and output, while (IPA5012 an R-106) cultivars achieved the lower results, were 6.01 t.ha-1, 5.33 t.ha-1and 4.95t.ha-1 respectively. The cause for this is due to the seeds cultivar and the soil wetness existing with the drip irrigation system [16],[21]. The interaction among nitrogen fertilizer (175kg N.ha-1) and the corn cultivar (Gadiz) was the best (6.08t.ha-1). The levels of the yield and growth parameters at dissimilar conditions are shown in Figure 4 for both NF and cultivars.

Table 4. Growth period parameters of maize crops as affected by nitrogen fertilizer amounts and cultivar.

Cultivars	NF Kg.N.ha^{-1}	Crop growth rate				Relative growth rate			
		1-15 days	15-30 days	30-45 days	45-65 days	1-15 days	15-30 days	30-45 days	45-65 days
Gadiz	200	0.028	0.551	2.340	16.522	0.088	0.192	0.124	0.126
	300	0.029	0.613	2.815	17.816	0.091	0.203	0.135	0.132
IPA5012	200	0.026	0.505	2.201	15.204	0.082	0.186	0.115	0.123
	300	0.027	0.593	2.509	16.031	0.086	0.191	0.122	0.128
R-106	200	0.022	0.421	2.119	14.519	0.079	0.175	0.101	0.118
	300	0.024	0.508	2.341	15.441	0.076	0.183	0.114	0.121
ACU	Gadiz	0.029	0.582	2.577	17.169	0.053	0.198	0.130	0.129
	IPA5012	0.027	0.549	2.355	15.617	0.084	0.189	0.119	0.126
	R-106	0.023	0.464	2.230	14.980	0.078	0.179	0.107	0.119
ANF	200	0.025	0.480	2.221	15.415	0.083	0.184	0.113	0.122
	300	0.026	0.571	2.555	16.429	0.084	0.192	0.124	0.127
	C	0.015	0.211	N.S	0.506	0.013	0.123	0.131	0.143
LSD=0.05	NF	0.019	0.265	N.S	0.533	0.022	0.140	0.142	0.150
	NF*C	0.021	0.322	N.S	0.604	0.041	0.152	0.219	0.203

Table 5. Impact of nitrogen fertilizer levels and corn cultivars on yield and growth parameters.

Cultivars	NF Kg.N.ha^{-1}	PVI cm	Grain yield (t.ha^{-1})
Gadiz	150	61.52	5.93
	175	64.28	6.08
IPA5012	150	56.75	5.11
	175	60.17	5.55
R-106	150	55.91	4.86
	175	56.15	5.03
ACU	Gadiz	60.29	6.01
	IPA5012	58.46	5.33
	R-106	56.03	4.95
ANF	150	58.06	5.30
	175	60.20	5.55
	C	0.419	0.122
LSD=0.05	NF	0.582	0.227
	NF*C	0.726	0.319

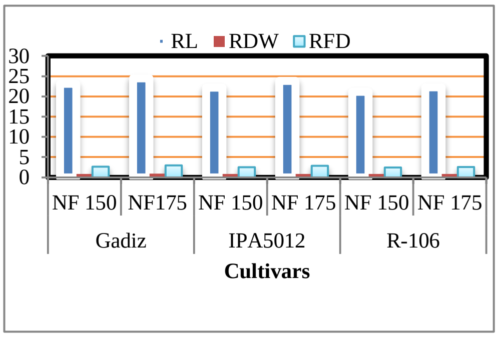

Figure 3. Effect of nitrogen fertilizer levels and corn cultivars on root growth parameters.

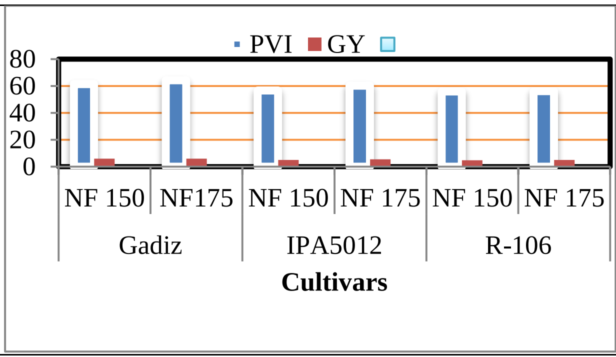

Figure 4. Effect of nitrogen fertilizer levels and corn cultivars on Yield and growth parameters.

Conclusions

Compared to two other cultivars (IPA5012 and R-106), the (Gadiz) variety was vastly superior. Also, nitrogen fertilizer level 175kg N.ha-1 was considerably superior than nitrogen fertilizer level 150kg N.ha-1 in all properties studied. Subsurface drip irrigation system (SDIS), nitrogen fertilizer amount (175kg N.ha-1), and the (Gadiz) cultivar yielded the best overall performance among all of the attributes tested.

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