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Sustainable Use of Sub-Surface Drip Irrigation System for Corn Growth and Productivity

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Abstract. The issue of water conservation and economy in its use in agricultural production is one of the most important issues of sustainability at the present time especially with crops that need to consume large quantities of water, such as corn.The impact of subsurface drip irrigation system (SDIS) on corn cultivars SYN-6 and R-106 was observed based on some technical indicators, under three drip irrigation distances (DID) 22,24 and 26cm. The experiments were conducted in a factorial experiment under complete randomized design with three replications. The R-106 cultivar was significantly better than SYN-6 cultivar in all studied parameters. For drip irrigation distances (DID) of 22cm the soil bulk density, total of soil porosity during growth season, root dry weight and root fresh weight, PVI, biological yield, grain yield, and harvest index were 1.29,1.31,1.33mg.m^{-3}, 51.32,50.56,49.81%,20.33 cm ,0.93g and 2.91 g, 55.19 cm, 7.22 t.ha^{-1}, 5.46 t.ha^{-1},and 62.87%, respectively. The interaction among drip irrigation distances (DID) of 22 cm and the corn cultivar (R-106) was the best in all parameters.

Keywords. Sustainable, corn, subsurface drip irrigation system (SDIS), drip irrigation distances (DID), cultivars (cu).

INTRODUCTION

The world is witnessing major changes in the field of climate, and this will certainly have serious effects on agriculture, especially in countries that suffer from a lack of water supplies and lack of rainfall and with a hot and dry climate in summer, including Iraq. Therefore, it was necessary to follow some strategies that maintain water sustainability, including the use of irrigation methods the modern method of drip irrigation under the soil surface, because surface irrigation consumes about 83% of water resources .The corns are used mainly as animal feed, as they are included in the poultry diet especially varieties environment with yellow seeds, starch is extracted from the seeds, which is used in the textile industry and for various industrial, the white seeds are preferred, the oil is extracted from the seeds and used in vegetable fat. It is useful in nutrition and for people with sclerosis arteries, corn flour is used in bread, especially the white-seeded varieties. It may be mixed with wheat flour to make bread [1, 2]. Corn grown in large areas of Iraq, and its cultivation concentrated in Najaf, Karbala, Wasit, Babil, and Baghdad, and the yellow corn crop needs high temperatures and abundant water [3, 4]..Asuitable bed is prepared for the germination of yellow corn seeds through the use of plowing machines to stir the soil, disc harrows machine to smooth soil, and laser leveling machines for soil leveling. After planting the corn crop, they irrigate regularly it to get an appropriate germination ratio and vegetative growth during the growing season [5, 6].The soil's physical properties are changed by irrigation methods, plowing, and land softening, The study by [7, 8] that following the optimal forms of the agricultural process using machines leads to a decrease in all soil physical characteristics and this was reflected in the increase in productivity and growth characteristics during the growing season [9, 10],the water movement inside the soil slop because of the gradient, during the period of adding water from the droppers to the soil, which is called (the wetting phase). The capillary tensile forces and the earth's gravitational forces control the movement of water within the soil. Soils with small pores are more distressed by tensile forces than soils with large pores.

Plants uring the growing season require providing a suitable environment for growth (wet roots area) to face the intense heatwave during the summer in the country of Iraq, the growth and spread of plant roots depend 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 [12, 13].Determining the distances between the drippers

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and their overlapping creates a constantly wet root area and treating the dry condition as the distance between the drippers decreases, root patterns are important for crops irrigated by the drip irrigation method, as the drip irrigation system is confined to the groove and determines the depth and distribution of the roots according to the volume of moistening [14, 15].The primary goal of this research is to study the effect of Subsurface drip irrigation on corn (R-106),(SYN-6) cultivars at different distances between drippers, in order to maintain sustainable water supply for agriculture.

MATERIAL AND METHODS

Research was conducted in the Hashemia area, which is located 15 km away from the Babylon city, for the agricultural season 2020-2021.In the research,irrigation system subsurface drip irrigation system(SDIS) on two corn cultivars (R-106 and SYN-6) under the drip irrigation distances (DID) of 22, 24, 26 cm. (Fig .1) Renewable energy (energy clean) was adopted to operate the pumping units.

The soil was stirred with a disk plow to a depth of 25 cm, it was pulled by a tractor (MSF-285s type), than extension of subsurface drip irrigation, to a depth of 15 cm(Fig.2).The physical and chemical properties of the soil were calculated, as in Table (I).

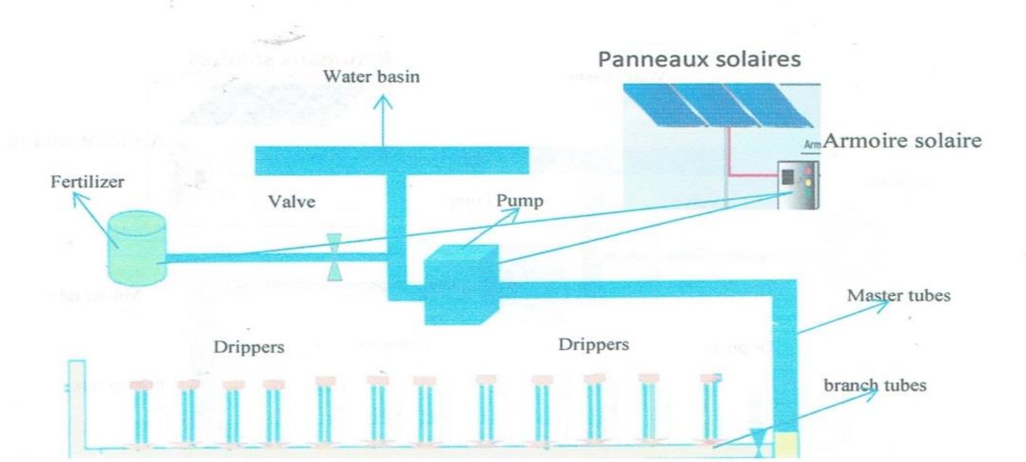

FIGURE 1. Subsurface drip irrigation system (SDIS)

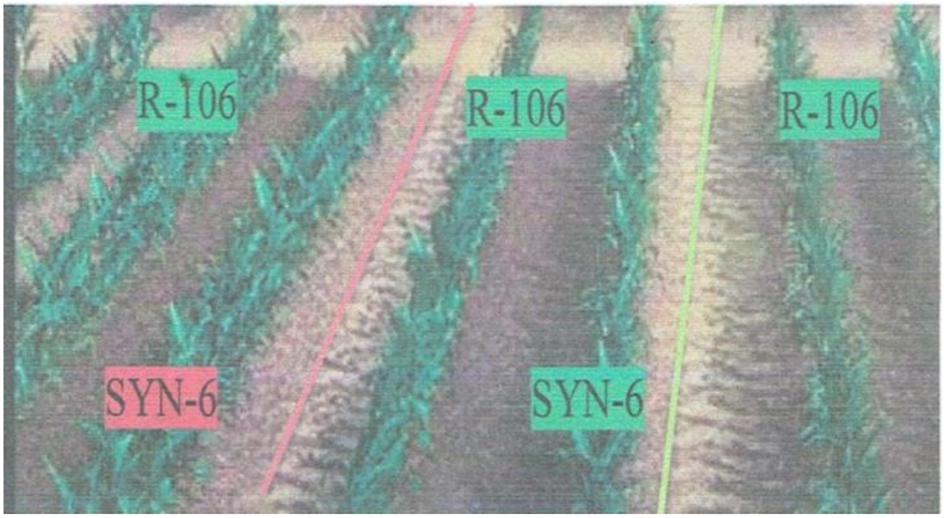

FIGURE 2. Subsurface drip irrigation method for corn plants

SOIL CHARACTERISTICS

Physical properties of soil samples for six sites were taken randomly from the field and for tillage depth determined in the experiment (20), according to the method used by [16, 17], samples were taken to measure soil moisture, bulk density and the total porosity of soil, during the growing season after one month (1Mon), two months (2Mon), and the stage of full maturity growth season end (GSE), and were calculated as averages. [18, 19].

$$. W = \frac{W_w}{W_s} \times 100 \quad (1)$$

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

$$P_b = \frac{M_S}{V_T} \quad (2)$$

Where:P_b: Dry bulk density (mg. m^{-3}), M_S: the weight of the dried soil sample (mg), V_T: total volume of the soil sample (m^3).

$$T_{SP} = \left(1 - \frac{P_b}{P_S} \right) \times 100 \quad (3)$$

Where: T_{SP}: total of soil porosity (%), P_b: dry of bulk density (mg.m^{-3}), P_S : partial density (2.65 mg.m^{-3}) [20].

TABLE 1. The physical and chemical properties of the soil

Depth	**Texture %**			
	Clay	Silt	Sand	Silt Clay loam
	48	24	28	
		Soil physical properties		
	Soil bulk density (mg m^{-3})	Total soil porosity (%)	Soil penetration resistance (Kpa)	
0-20 (cm)	1.40	47.16	1553.23	
	1.43	46.03	1586.78	
	1.41	46.79	1678.12	
	1.45	45.28	1572.7	
VA		Soil chemical properties		
	E.C (ds\cm^3)	HP		
	1.52	6.67		
		Soluble cation meq\I		
0-20	Na	K	Ca+Mg	
	11.42	13.35	56.62	
	O.C (%)	CEC (Meq\100g)	CaCo3 (%)	O.M (%)
	0.55	32.81	4	0.64

ROOT LENGTH

It was calculated according to [21].

ROOT FRESH WEIGHT

Plant vigor index (PVI) was calculated according to [22].

$$P_{VI}=\frac{P_L\times G_P}{100} \qquad (4)$$

Where; PVI; plant vigor index cm, P_L ;plant length cm, G_P;Germination ratio.

GRAINS YIELD

The grains yield was calculated [1, 23].

$$G_{Y}=GP\times PD \qquad (5)$$

Where; G_Y; grain yield(t.ha-1),GP; grain rate per plant (kg) , PD; plant density.ha-1.

BIOLOGICAL YIELD

It was calculated as follows [24].

$$B_{Y=_{Rp\times PD}} \quad (6)$$

Where; B_Y; biological yield(t.ha-1),RP; rate dry weight of the plant (kg) , PD; plant density.ha-1.

HARVEST INDEX

The harvest index was calculated [25].

$$H_{I=\frac{SW}{BY}\times 100} \quad (7)$$

Where; H_I; harvest index(%), B_Y;biological yield(t.ha-1), SW seed weieght.pod-1 (kg).

The data were statistically analyzed by method RCBD in three replications for each treatment, the least significant difference test (LSD) was used to compare among the arithmetic average, at the 0.05 probability level, and the computer program Genstate was used, to analyze the data. [26].

RESULT AND DISCUSSION

Soil Characteristics

Decrease in the drip irrigation distances (DID) leads to a decrease in the values of the soil physical properties (soil density and porosity). From Table (**2**) .The treatment 22 cm gave the best values, density1.29,1.31and1.33Mg.m^{-3} respectively, offset by an increase in the soil total porosity 51.32, 50.56and 49.81 % after a one month, two months, growing season end, as compared to the distances of the subsurface drip irrigation (DID) of 24 and26 cm. The convergence of the distance between the drippers leads to the regularity of the distribution of soil humidity and its increase in the root area and thus improving the characteristics of the soil studied [16, 17]. The corn variety (R-106) achieved the best soil bulk density1.30,1.31and1.32mg.m^{-3},and the increase in ratios soil porosity 51.94, 50.56and 50.18% .with the same conditions for the corn variety (SYN-6).The reason for this is based on the seeds vitality, the cultivar nature and its suitability to climatic conditions[7, 13].

ROOT GROWTH PARAMETERS

Table (3) shows drip irrigation distances (DID) had a significant effect on root growth parameters. As the distance 18 cm gives the highest averages 20.33 cm, 0.93 g and 2.91 g, compared to drip irrigation distances 20 and 22 cm, which recorded a noticeable decrease in the growth characteristics of roots during the growing season. Increase in the area of hydration with a decrease in the distance between the drippers and an increase in the spread of roots with the increase in the area of hydration [20, 6]. All root parameters increased with corn cultivar ((R-106) and scored the highest results 20.46 cm, 0.88 g and 2.89 g, as compared with the corn cultivar (SYN-6),which gave the lowest results 17.45 cm, 0.84 g and 2.82 g. respectively. The interaction among DID of 22 cm and the corn cultivar (R-106) was the best (22.18 cm, 0.96 g and 2.93 g).

YIELD AND GROWTH PARAMETERS

Increase in drip irrigation distances (DID), give decrease PVI being 55.19, 53.51and 50.99 cm respectively. The little of distances between the drippers in the subsurface drip irrigation system, leads to the creation of a water environment increasing the humidification unit) suitable for plant growth during the growing season [5, 9]. From Table (IV). The (R-106) cultivar resulted in the highest PVI (54.55 cm) and at the (SYN-6) cultivar indicated the lowest PVI (51.91 cm).The interaction among (R-106) cultivar and DID of 22cm gave best result (56.13cm). The (R-106) cultivar gave the maximum values for all productivity and crop growth parameters, and results were 6.79 t.ha-1, 5.28 t.ha-1and 63.92%. While (SYN-6) cultivar gave the lowermost results were 6.03t.ha-1, 4.59t.ha-1and 58.81%. The reason for this is due to the seeds cultivar, the soil moisture available with the drip irrigation system [10]. From Table (IV). The increase in drip irrigation distances leads to lower in all yield and crop growth parameters, being 7.22 t.ha-1, 5.46t.ha-1and 62.87% respectively, for different levels of drip irrigation distances. This is due to decreased drip irrigation distances with increasing soil moisture leads to corn grains productivity increase [21, 22]. The interaction among DID of 22 cm and the corn cultivar (R-106) was the best (7.52t.ha-1, 5.82t.ha-1 g and 65.33%).

TABLE 2. Effect of cultivars (Cu) and drip irrigation distances (DID) on soil characteristics

Cu	DID	Soil bulk density (mg.m^{-3})			Total of soil porosity (%)		
		1Mon	2Mon	GSE	1Mon	2Mon	GSE
	22	1.28	1.29	1.30	51.69	51.32	50.94
R-106	24	1.30	1.31	1.32	50.94	50.56	50.18
	26	1.31	1.33	1.34	50.56	49.81	49.43
	22	1.30	1.33	1.35	50.94	49.81	49.91
SYN-6	24	1.33	1.34	1.37	49.81	49.43	48.30
	26	1.34	1.36	1.40	49.43	48.67	47.16
Average of Cu	R-106	1.30	1.31	1.32	51.94	50.56	50.18
	SYN-6	1.32	1.34	1.37	50.18	49.43	48.30
Average of DID	22	1.29	1.31	1.33	51.32	50.56	49.81
	24	1.31	1.33	1.35	50.56	49.81	49.05
	26	1.32	1.35	1.37	50.18	49.05	48.30
	Cu	0.031	0.033	0.036	0.122	0.126	0.128
LSD=0.05	DID	0.038	0.039	0.042	0.133	0.141	0.143
	Cu*DID	0.041	0.043	0.048	0.146	0.155	0.162

TABLE 3. Effect of cultivars (Cu) and drip irrigation distances (DID) on root growth parameters

Cu	DID	Root length (cm)	Root dry weight (g)	Root fresh weight (g)
	22	22.18	0.96	2.93
R-106	24	20.03	0.87	2.88
	26	19.17	0.82	2.86
	22	18.48	0.91	2.89
SYN-6	24	17.22	0.82	2.81
	26	16.67	0.79	2.78
Average of Cu	R-106	20.46	0.88	2.89
	SYN-6	17.45	0.84	2.82
	22	20.33	0.93	2.91
Average of DID	24	18.62	0.84	2.85
	26	17.92	0.81	2.82
	Cu	0.153	0.102	0.113
LSD=0.05	DID	0.217	0.123	0.234
	Cu*DID	0.309	0.148	0.582

TABLE 4. Effect of cultivars (Cu) and drip irrigation distances (DID) on yield and growth parameters

Cu	DID	PVI	Biological yield ($t.ha^{-1}$)	Grain yield ($t.ha^{-1}$)	Harvest index %
R-106	22	56.13	7.52	5.82	65.33
	24	55.44	6.84	5.06	64.28
	26	52.08	6.01	4.97	62.15
SYN-6	22	54.26	6.93	5.11	60.42
	24	51.55	5.88	4.92	59.87
	26	49.91	5.29	3.73	56.13
Average of Cu	R-106	54.55	6.79	5.28	63.92
	SYN-6	51.91	6.03	4.59	58.81
Average of DID	22	55.19	7.22	5.46	62.87
	24	53.51	6.36	4.99	62.08
	26	50.9	5.56	4.35	59.14
LSD=0.05	Cu	0.416	0.246	0.121	0.332
	DID	0.573	0.381	0.226	0.449
	Cu*DID	0.628	0.404	0.314	0.609

CONCLUSION

The (R-106) cultivar was superior significantly to (SYN-6) cultivar. Additionally, the DID of 22 cm was superior significantly than two other 24and 26 cm in all studied properties. Best results obtained of the overlap between the DID of 22cm and (R-106) cultivar, in all studied properties .

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