EFFECT OF IRRIGATION SYSTEM AND SOIL LEVELING STATUS ON YIELD AND WATER USE EFFICIENCY BY MAIZE IN CALCAREOUS SOIL .

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ABSTRACT

Field experiment was carried out to study the effect of two irrigation systems and soil leveling status on the yield and water use efficiency by maize (*Zea mays* L) , Drakhma variety planted in Khalis silty clay calcareous soil during autumn – 2006 season . Strip irrigation system significantly increased leaf area , number of rows /ear and number of grains / row as compared with the sprinkler irrigation system . The results indicated that leaf area , number of rows /ear , number of grains/ear , weight of ear and weight of 1000 grains increased non significantly under the effect of soil leveling practice . Whereas, significant interaction was found between irrigation systems and soil leveling status. Strip irrigation system exhibited significant effect on the most growth and yield characters under soil leveling practice. However, Maximum yield (8677 Kg. Ha^{-}) was obtained at the combined (strip*soil leveling) treatment . On the other aspect, sprinkler irrigation was more efficient system to produce one unit weight of grains and in mean daily water consumption as follows:

(Sprinkler * soil non leveling, 1.77 m^3) >(Sprinkler*Soil leveling,2.02m^3)> (strip * soil leveling, 2.32 m^3) > (strip *soil non leveling , 4.62 m^3. kg^{-}) . Whereas, mean daily water consumption was 8.84 and 10.46 mm . day^{-} under sprinkler and strip irrigation systems respectively.

Key words: Irrigation systems, sprinkler Irrigation, strip Irrigation, maize, yield, water use efficiency.

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INTRODUCTION

In Iraq now many systems are employed to irrigate the crops, according to soil properties, plant species and capabilities of the farmers. Surface irrigation systems (basin, strip and furrow irrigations) have been used for long time which are suitable to farmer experience. In addition, systems like sprinkler and drip irrigations are introduced in Iraq recently and need some skills for working and conservation. However, surface irrigation is suitable to the salt affected soils as well as to heavy and medium texture soils. Whereas, sprinkler irrigation system is more satisfactory in light texture soils (sandy, loamy sand, sandy loam and gypsiferous soils) and in areas with high gradients and highly permeable soils (Iraq Field Guide 2007). Moreover, sprinkler system reduces to large extent water to be lost from the root-soil system against deep percolation. Accordingly, it is more efficient in water reserve by 60 – 85 % as compared to the surface irrigation system (AL-Ashram 2001) , (Mustafa and Dahash 2007) . For instance , rice cultivation in Iraq and other rice productive countries by ponding (submergence) irrigation system is known to be consumed high amounts of water , about 100000 m^3 per hectare (salih etal 1999) . In contrast the above water quantities may be reduced to 25-30 % when rice was grown under intermittent or sprinkler irrigation in filed experiments conducted at Al-Mishkhab rice research station , Najaf province in Iraq .(Iraq Field Guide 2007) . In comparisons between plant species , water use efficiency was found to be more 3 times in maize than wheat under water stress conditions (Al-Taie, 1981). Whereas , it was alike with grape plant (Tayel et al 2007) .Other study indicated that water requirement for one Kg. of maize(grains) yield was 750 litres and 372 litres for one Kg.weight of dry matter. (Elsahookie.1990).

The aim of the present work is to assess the effect of both sprinkler and strip irrigation system with land leveling status on maize growth , yield and water use efficiency for autumn growth season .

MATERIALS AND METHODS

The experiment was conducted at the AL-Khalis research field, Diyala Agriculture Directorate on silty clay calcareous typic Torrifluvent soil . Land area of 1.5 hectare was prepared and half of which was leveled by use of grader machine. The soil was plowed by disc plow and disc harrows implements. Factorial experiment 2*2 with three replications was used in a completely Randomized Block Design. Two irrigation systems (strip (S) and sprinkler (P)) were combined with two land status (surface leveling(L_1) and no surface leveling(L_0). The above land area was subdivided into the following parts, each with area of 3750 m^2 .

1- leveled area under sprinkler irrigation (PL_1).
2- No leveled area under sprinkler irrigation (PL_0).
3- Leveled area under strip irrigation (SL_1).
4- No leveled area under strip irrigation (SL_0).

Static sprinkler irrigation system was installed on the first two above areas . An Eurapian individual hybrid maize (*Zea mays* L) , Drakhma variety was planted in rows 75cm apart and 25cm within the rows , leaving one plant per hill in strips each one with area 50*12.5m on 20-21 July during autumn season , 2006 . All plots received DAP fertilizer and the first dose of urea fertilizer in rates of 200 and 100kg. ha^- respectively with planting time. The second urea fertilizer application in rate 100kg ha^-. was banded to the side of plants one month after full emergence of seedlings. Irrigation practices according to the above two systems were carried out in 4-6 days interval when the moisture level approximates to about 50% of field capacity. The amount of

available water was calculated as a difference between (F.C. 33 k. Basc.) and (W.P 1500 k . Basc) . Gravimetric water content was measured one day before irrigation and 48 hours after irrigations in three replications for each treatment. The amount of irrigation requirements for both sprinkler and strip systems was calculated according to methods mentioned in (Ismaiel , 1988) depending on count of the total definit irrigation hours during the growth time . A soil samples were collected from the field before planting. Some physical and chemical properties of the soil were determined (table .1) soil particle size distribution using hydrometer method (Bouyoucos , 1962) . Soil bulk density using core method (Black 1965) . CaCO3 was equilibrated with 1.0 NHCl and determined by back titration with 1.0 N NaOH (piper , 1971) . Soil PH was measured in 1:2.5 soil water suspension , while EC was measured in soil paste extract according to (Richard , 1954). Each experimental unite contained 6 rows of 5m length and 3.75m width. Plant height and leaf areas per plant (Mc-kee 1964) were measured one month before harvest . Crop was harvested on 15/11/2006 by taking the middle two rows from each experimental unit. Yield and yield components (ear length , ear weight , No . of rows / ear , No. of grains / row, No . of grains / ear weight of 1000 grains , ear diameter and grain weight / ear) were measured after grain drought under lab condition .

All the above measurements were carried out as a mean of five plants from each plot and then computed to one hectare for total grain yield. Data were analyzed statistically; L.S.D test $P \leq 0.05$ was followed for means comparisons.(Steel and Torrie,1981).

Table 1. *Soil physical and chemical properties of the experimental site*.

Soil properties	Values	
	Depth 0 - 30cm	30 – 60
Sand (%)	12	9
Silt (%)	53	55
Clay (%)	35	36
Texture	Silt clay	Silt caly
Φv at F.c (%)	27.08	-
w.p (%)	13.45	-
Bulk density (g cm^{-3})	1.33	1.37
CaCO3 (gk^{-1})	68	96
pH	7.4	7.5
ECe (Dsm^{-1})	2.90	2.61

RESULTS AND DISCUSSION

The data of plant height, leaf area and ear length are presented in table (2). The results indicate to non significant effects between Sand P systems, (L_o)and(L_1)treatments and their interactions on the plant height character. Maximum plant height 202.65 cm / plant was obtained from the combined treatment (SL_O).

(S) treatment has significant effect on leaf area compared with P treatment. Whereas, non significant effect was observed between L_0 and L_1. However, significant effect was observed between the combination treatments. Maximum leaf area is (6696.69 cm^2 / plant) at combined treatment (SL_1). The reason above may be attributed to the high response of leaf growth to the strip irrigation through which great amounts of water were consumed to satisfy the maize plants requirement during the hot summer months. On the other hand, soil leveling exhibited favorable role on the uniformity of irrigation distribution inside the field strips. These results are in accordance with those obtained by Elsahooki and Wassom (1984).

The results in table (2) indicate that strip system has more effect to increase the ear length mean as compared with the sprinkler irrigation system but such increase was not significant. Also , the results

Table2. *Effect of Irrigation method , Soil leveling and their interactions on the leaf surface area , plant height and ear length of maize .*

properties	ear length(cm) strip S	sprinkler p	Mean	Plant height (cm) Strip sprinkler S	s p	mean	Leaf surface area/plant (cm) Strip S	sprinkler p	Mean
Soil leveling L1	19.01	15.75	17.43	186.55	191.9	189.23	6696.69	562.78	6129.7
No soil leveling L0	17.5	17.55	17.53	202.65	192.10	179.4	6286.5	5933	6109.7
	L.S.D P≤0.05 =3.94		N.S	L.S.D P≤0.05 =62.5		N.S	L.S.D P≤0.05 =329.31		N.S
	18.3	16.65	Mean	194.6	192.03	Mean	6491.5	5747.9	Mean
	L.S.D P≤0.05 =2.78			L.S.D P≤0.05 =44.24			L.S.D P≤0.05 =232.86		

Table 3. *Effect of irrigation method , Soil leveling and their interactions on the mean of No. of rows/ear , No of grains .row and ear diameter of maize .*

properties	Ear diameter(cm) strip S	sprinkler p	Mean	No. of grains/row Strip S	sprinkler p	mean	No.of rows/ear Strip S	sprinkler p	Mean
Soil leveling L1	4.9	4.25	4.58	38.5	29.5	189.23	15.5	13.15	6129.7
No soil leveling L0	4.65	14.55	4.6	34.0	34.5	179.4	14.5	14	6109.7
	L.S.D	P≤0.05 =0.62	N.S	L.S.D	P≤0.05 =5.19	N.S	L.S.D P≤0.05 =1.42		N.S
	4.72	4.4	Mean		36.5	Mean		15	Mean
	L.S.D	P≤0.05 =0.45			32			13.58	
				L.S.D	P≤0.05 =3.67		L.S.D P≤0.05 =1.0		

did not indicate to significant effect between L_0 and L_1 treatments . Concerning the interactions between the above treatments, non significant effect in mean ear length was observed between treatments under study. However, The effect of the combined treatments was in the order $SL_1 > PL_0 > > SL_0 > PL_1$. This means that the treatments under investigation have the same effect on the growth of maize ears. These results are agreed with those mentioned by Ismail *etal* . . 1990.

The data in table (3) show the effect of irrigation system, Soil leveling and their interactions on No. of rows /ear, No of grains/ Row and ear diameter. The results indicate to a significant increase in mean values of No. of rows /ear due to the facter(S)as compared with(P) facter and to non significant increase in the No. of grains . row^{-} and in the ear diameter. On the other hand, non significant increase in the all above yield characters was assured to soil leveling practice. However, a significant increase in the above yield components occurred as a result of the interaction between facters studied. Maximum mean values 15.5 rows /ear , 38.5 grains / row and 4.9cm ear diameter were recorded at the treatment (SL_1). The data in table (4) show the effect of irrigation systems,

soil leveling and their interactions on the mean values of grain weight /earand ear weight. The results indicate to non significant increase in the values of the above yield characters between(S)and (P) systems on one hand, and between L_0 and L_1 treatments on the other, the data show non significant interaction effect between the treatments under investigation. However, maximum mean values were160.04 and195.18 g grain weight and ear weight respectively obtained at the combined treatment (SL_1).

The data in Table (5) show that the effect of strip irrigation system increased yield significantly as compared with sprinkler system by about mean value 19% whereas, soil leveling practice did not exhibit significant increase as compared with non leveling treatment. Significant increase was assured in the mean yield per hectare at the combined treatment SL_1 as compared with the other treatments significant increase in maize yield per hectare as compared with both (PL_1) and (SL_0) treatments. Maximum yield was obtained by 8677 Kg .Ha^{-}. At the treatment(SL_1). The results show that strip irrigation system increased the weight of 1000 maize grains non significantly as compared with sprinkler system. Also, neither significant increase in yield was obtained at the leveling treatment as compared with non leveling treatment, nor at the interacted treatments under investigation (table 5).

The above results are attributed to the more suitable of strip irrigation system under soil leveling practice to satisfy the needs of maize crop in a time which was critical for growth, flowering and seed formation . These results are in agreement with those mentioned by (ICT, 2007). Also the results indicate to more agronomic and economic important of sprinkler system on maize yield under non leveling practice than strip system. The results in Table (6) indicate that PL_0 combinative treatment was the most efficient water use with mean

value 1.77m3 to produce 1kg of maize grains followed by PL_1 combinative treatment with mean value 2.02 m3 per kg grains . In comparison, water use

Table 4. *Effect of irrigation method , Soil leveling and their interactions on the weight of grains/ear$^-$ and weight of ear of maize*

properties	Ear weight(gm) strip S	sprinkler p	Mean	wt. of grains/ear (gm) Strip S	sprinkler p	mean
Soil leveling L1	195.18	142.4	168.79	160.02	113.0	189.23
No soil leveling L0	169.2	167.12	168.16	135.58	137.44	179.4
	N.S		N.S	N.S		N.S
	182.19		Mean	157.7		Mean
	154.76			125.22		
	N.S			N.S		

Table 5. *Effect of irrigation method, Soil leveling and their interactions on the weight of 1000 grains/ear and yield of grains kg.hectare$^-$ of maize*

Properties	Yield of grains kg.ha$^-$ strip S	sprinkler p	Mean	wt. of1000 grains (gm) Strip S	sprinkler p	Mean
Soil leveling L1	8677	6026.5	7351.75	308.31	264.15	286.23
No soil leveling L0	7227.51	7330.38	7279.9	273.65	277.60	275.62
	L.S.D P≤0.05=60.82		N.S	N.S		N.S
	7952.25	6678.44		290.98	270.87	Mean
	L.S.D P≤0.05 =86.03			N.S		

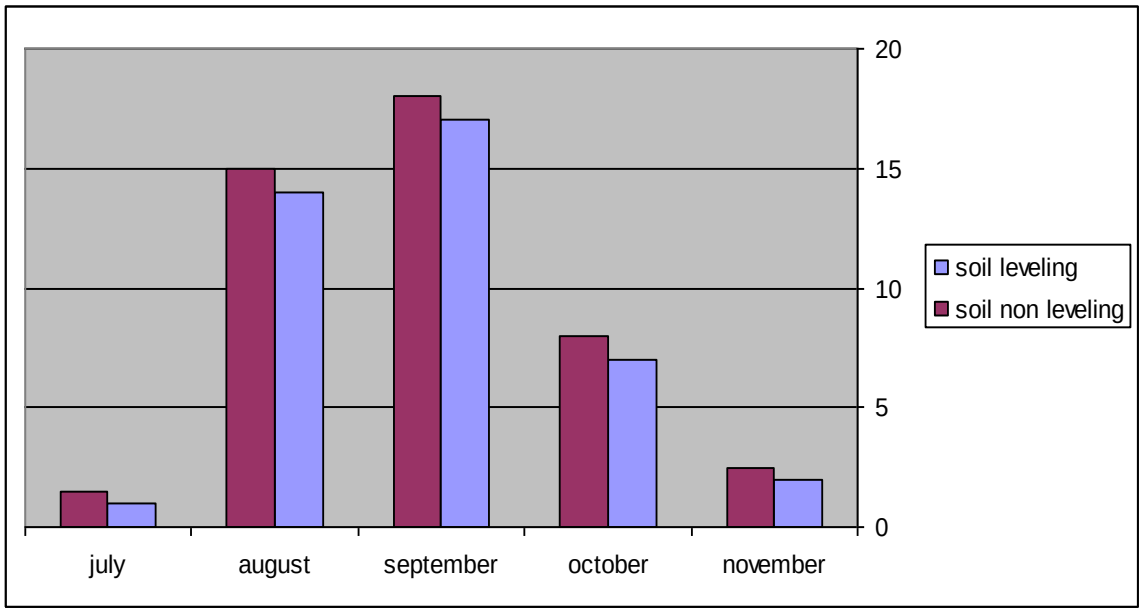
efficiency with values 2.32 and 4.62 m3 per kg grains were recorded under the combinative treatments (SL_1) and (SL_0) respectively. These results approximates to which were obtained by Al-Saad and Al-Kawaz 1983with value 1.13 and Tayel *etal* 2007 with value 1.80 under sprinkler irrigation system . Concerning strip irrigation system , the above results agrees with those obtained by Ismail *etal*. 1990 (2.72 m3. Kg$^-$ grains) as compared with the treatment SL_1 and much

less as compared with treatment SL_0. The difference between those values could refer to the differences in plant variety, ecological and soil conditions. The results in Table (6) show that the mean water consumption values were 8.08mm .day^{-}, 12.84mm .day^{-}, 9.06mm .day^{-} and 8.61mm . day^{-} for SL_1 , SL_0 , PL_1 and PL_0 respectively . The mean water consumption during the whole growth season of maize were 8.84mm.day^{-} and 10.46mm .day^{-} for sprinkler and strip irrigation systems respectively , irrespective of land leveling status . Fig (l-a,b) explains the mean irrigation consumption according to months of growing season . The mean values increased successively to the maximum during September at which flowering and ear formation occur. Maximum values were 17.38, 18.29, 16.2 and 24.3 mm .day^{-} for PL_1 , PL_0 , SL_1 and SL_0 treatments respectively . After that, water consumption had declined gradually according to the crop maturity stages and to the variation of climatic factors that induce to reduction of evapotranspiration requirements. The above results are more than those recorded by Ismail etal . 1990 for maize grown in autumn season under north Iraq conditions.

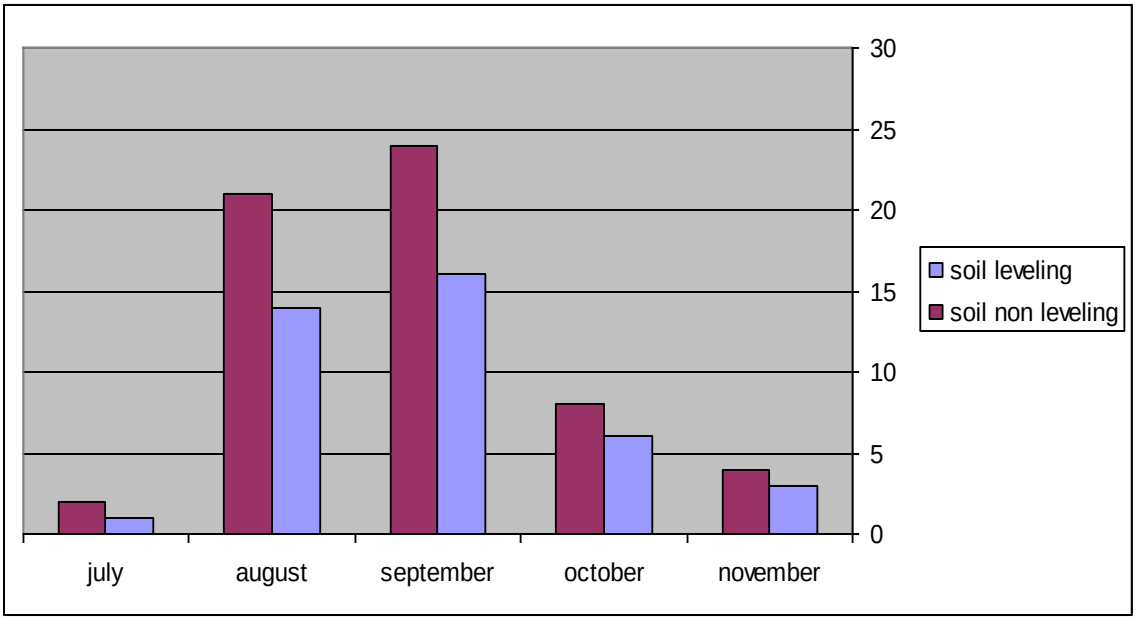
From the present study, it may be recommended that sprinkler irrigation was more efficient for water use per unit weight of maize yield. Strip irrigation is necessary to be used as a sustainable system to support the growth at least during the extreme water consumption stage.

Table 6 . The effect of irrigation systems and soil leveling on the mean water use efficiency and water consumption by maize plants

Irrigation systems	Soil leveling practice	WUE $m^3.kg^-$ grains	WC $mm.day^-$	Mean Wc $mm.day^-$
Sprinkler	No	1.77	8.61	8.84
Sprinkler	Yes	2.02	9.06	
Strip	No	4.62	12.84	10.46
Strip	Yes	2.32	8.08	



A-Sprinkler system



B-Strip system

Fig 1. *Mean irrigation consumption (mm day) distributed according to the months of growing season of maize* .

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تأثير نظام الإرواء وحالة تسوية التربة في حاصل وكفاءة استهلاك الماء للذرة الصفراء في تربة رسوبية كلسيه .

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الخلاصة

أجريت تجربة حقلية لدراسة تأثير نظامي إرواء وحالة تسوية التربة في حاصل وكفاءة استهلاك الماء لمحصول الذرة الصفراء (*Zea maysa L*) صنف دراخما في تربة الخالص الكلسية ذات نسجه طينية غرينية خلال الموسم الخريفي 2006 . أبدى نظام الري الشريطي زيادة معنوية في المساحة الورقية وعدد الصفوف للعرنوص الواحد وعدد الحبوب في الصف بالمقارنة مع نظام الري بالرش . وأشارت النتائج إلى زيادات غير معنوية في بعض صفات النمو والحاصل مثل ارتفاع النبات والمساحة الورقية وعدد الصفوف للعرنوص الواحد وعدد الحبوب في العرنوص ووزن العرنوص ووزن 1000 حبة في حالة تسوية التربة . ووجد تأثير معنوي للتداخل بين أنظمة الري المدروسة وحالة تسوية التربة . فقد أبدى نظام الري الشريطي تأثير معنوي في معظم صفات النمو والحاصل تحت معاملة تسوية التربة . وأن أعلى معدل حاصل كان بمقدار 8677 كغم .هكتار$^{-}$ في المعاملة (ري شريطي × تسوية تربة) .من جانب آخر فأن نظام الري بالرش قد ظهر ذات كفاءة أكبر في تقنين معدل الاستهلاك المائي لإنتاج وحدة واحدة من الحاصل وفي معدل الاستهلاك المائي اليومي وكما يأتي :(ري بالرش × عدم تسوية ، 1.77 م^{3}) > (ري بالرش × تسوية ، 2.02 م^{3}) > (ري شريطي × تسوية تربة ، 2,32 م^{3}) > (ري شريطي × عدم تسوية ، 4،62 م^{3} . كغم$^{-}$ حبوب) .في حين كان معدل الاستهلاك اليومي 8.84 ، 10.46 ملم.يوم$^{-}$ تحت نظامي الري بالرش والري الشريطي على التوالي .