GROWTH AND YIELD OF MAIZE UNDER IRRIGATION METHODS AND SOME PHYSICAL TREATMENTS

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ABSTRACT

A field experiment was conducted to study the effect of irrigation methods and physical treatments on growth and yield of maize in the karma area, Kut district, Wasit Governorate. The field experiment was conducted by using split plot arrangements in randomized complete block design with three replication was used. The experiment comprised of three irrigation methods, surface (S), furrow (F) and drip (D), while three physical treatments in addition to the control treatment, M0: no mulch, M1: mulch with wheat stubble (15 t. ha^{-1}), M2: Polymer granules buried with soil and M3: Mulch with wheat stubble + Polymer granules buried with soil. The results of this study showed that no significant effect on plant height, stem diameter, leaf area, leaf area index, number of rows per ear, No. of grains per row, No. of grains per ear, grain yield, biological yield and harvest index between irrigation methods, but grains weight, had significant influence, whereas the highest grains weight was found in furrow irrigation (193.5 gm).

While physical treatments significantly affected on plant height, stem diameter, leaf area, leaf area index, number of rows per ear, No. of grains per ear, grain yield and biological yield, the highest plant height (164.8 cm), leaf area (670.9 cm^2), leaf area index (5.57), number of row per ear (16.58), No. of grains per ear (760.6), grain yield (13.99 t. ha^{-1}) and biological yield (37.15 t. ha^{-1}) were obtained from M1. As regards the highest stem diameter was (33.32 mm) in M3, but the No. of grains per row and harvest index were not significantly affected by physical treatments. The interactions were non-significant for all plant parameters.

Key words: Irrigation methods, physical treatments, growth and yield of maize.

Part of thesis M.Sc. for second researcher.

Introduction

Iraq is located within the arid and semi-arid region of the world, which has the lowest annual rainfall rate that does not exceed 100-150 mm, its concentrated fall in winter, part of fall and spring, while absolutely no rainfall in summer.

Major current and future problems with fresh water resources arise from the pressure to meet agricultural, human and industrial needs of a fast-growing economy that generates growing imbalances between demand and supply of water. (8).

The pressure of using water in agriculture sector is increasing to create ways to improve water use efficiency and taking a full advantage of available water. Adoption of modern irrigation techniques is needed to be emphasized to increase water use efficiency. Today irrigation methods are being used that rely on modern technologies that provide more control over the quantity and distribution of water in the root zone from through maintain a fixed percentage of moisture and sustainability of that ratio to use less quantity to compare with traditional ways (surface or furrow irrigation). Drip irrigation is the most effective way to convey directly water and nutrients to plants and not only save water but also increases yields of crops. (11).

The efficient use of water by modern irrigation systems is becoming increasingly important in arid and semi-arid regions with limited water resources.

Drip irrigation is defined as "the slow, frequent application of small volumes of irrigation water to the base or root zone of plants". It is an efficient method for minimizing the water used in agricultural and horticultural crop production. These systems commonly use designed to only wet the root zone and maintain this zone at or near an optimum moisture level. Hence, there is a potential to conserve water losses by not irrigating the whole field. (7).

Potential merits of drip irrigation method as stated (4), increased beneficial use of available water, enhanced plant growth and yield, reduced salinity hazard to plant, improved fertilizer and other chemical applications, limited weed growth reduced operation labour, improved cultural practices.

Mulch is one of the management practices, which improve the water use efficiency of soil. Any material dispersed on the surface of soil to protect it from solar radiation, evaporation or raindrops is called mulch. Mulching can affect the soil temperature and soil water content and directly effect on the grain yield of crops. Mulching can conserve soil water and decrease temperature because they increase residue accumulation and reduce soil disturbance on the soil surface, the mulching materials on the soil surface act as a shade, serve as a barrier against moisture loss from the soil (28).

Mulch provides a better soil environment, moderates soil temperature, increases soil porosity and water infiltration rate during intensive rain and controls runoff and erosion as well as suppresses weed growth. (27).

The use one of the ways to increase fertilizer use efficiency with limited water supply in soil is (a superabsorbent polymer) of that provides water and necessary nutrients to crop roots during the growth period of the plant. (12).

In arid and semiarid regions of the world, use of superabsorbent polymers (SAP) may effectively increase water use efficiency in crops when polymers are incorporated with soil, it is presumed that they retain large quantities of water and nutrients, which are released as required by the plant. Thus, plant growth could be improved with limited water supply. (15).

Maize (*Zea mays* L.) is the major irrigated summer cereal crop in Iraq it's very higher consumer to the amount of irrigation water applied, the seasonal water use about 750- 900 mm therefore accurately irrigation methods and practices seem to be very important with this crop under irrigation water rarity conditions.

Based on the above notes the objectives of this study to evaluate:

1- The drip irrigation method for corn production compared with traditional methods (surface and furrow) which practices in the middle region of Iraq.

2- Water use efficiency (WUE), the growth and yield of corn in response to drip irrigation method in the region.

3- The use of mulching (wheat stubble) and moisture preservative (Polymers granules) in irrigation, water use efficiency and water productivity under different irrigation methods.

Materials and methods

Site Description

A field experiment was conducted for maize growing during the autumn season of 2016 in a private farm in the karma area, Kut district, Wasit province, (33.26 N, 45.91 E, 19 m above mean sea level). The soil on the site was clay loam and classified under a typic Torrifluvent. The site was planted with sorghum in the previous season. The climate of study area is dry temperate characterized by sever summer and mild autumn. The annual maximum temperature is 45.83c^0 and the minimum temperature is 27.14 c^0. There was no falt during the experiment time.

Experimental Field Preparation

The field was prepared by ploughing twice by using moldboard plow, and the direction of the second plough was adverse the first, the depth of 20-30 cm followed by cultivations and leveling, then soil sampling was done at 0-10, 10-20, 20-30 and 30 - 40 cm depth, using a composite sampling method. The soil samples were processed by air drying and passing through a 2 mm sieve, some physical and chemical properties were determined by using standard procedures (19), which are analyzed by the soil laboratory belong to Wasit Agriculture Directorate. The table (1) Shows physical and chemical properties of experimental soil.

Table (1) Some physical and chemical properties of soil field experiment (depth 0 - 40 cm) for the season 2016.

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Characteristics		Values	measuring unit
pH		7.8	
Electrical conductivity (EC)		0.9	ds. m^{-1}
Available Nitrogen		10.0	mg. kg^{-1}
Available Phosphorus		10.0	mg. kg^{-1}
Available Potassium		118.0	mg. kg^{-1}
Field capacity		0.29	cm^3. cm^{-3}
Wilt point		0.15	cm^3. cm^{-3}
Available water		0.14	cm^3. cm^{-3}
Bulk density		1.36	Mg. m^{-3}
Soil components	Sand	36 %	
	Silt	37 %	
	Clay	27 %	
Soil texture		Clay Loam	

analyzed by laboratory belong to Wasit Agriculture Directorate.

Experimental Design and treatments

A field experiment was conducted by using a randomized complete block design with split plot arrangements and three replications, each experimental plot was area 3m x 3.5m, and included the following factors:

First- Irrigation methods include three treatments, which are randomly assigned to the main plot:

Flat surface (S) means irrigation the experimental plots that grown on row. The furrow (F) means irrigation the experimental flat plots which grown on row then furrowed by furrower machine thirty days after emergence. (26). While Drip (D) means irrigation the experimental plots by using drip irrigation system (one line with emitters beside one rows of plant).

Second - Physical treatments include three treatments in addition to the control treatment, were randomly assigned to the sub plot:

(M0) Without Mulch soil surface (control), (M1) means mulch soil surface with wheat stubble (15 t. ha^{-1}), (M2) means buried 1 gm of polymer granules with soil to 10 cm depth in the location of the seed hills before sowing the seeds directly, (M3) means mulch soil surface with wheat stubble (15 t. ha^{-1}) + buried 1 gm of polymer granules.

The irrigation system has a typical control unit consisted of a pump, fertilizer tank, centrifugal sand separator, disc filters, control valves pressure gauges and a flow meter. Each plot had one valve to control water application. Main supply pipe of 50 mm diameter and length 12 m to deliver the desired discharge, and was sub-main or lateral of 16 mm diameter (GR) and length 4 m connected in a parallel way to the main, and dripper discharge was 8 L. h^{-1} at 0.75 bar operating pressure. Drip laterals were placed at the center of adjacent crop rows of 0.75 m apart in the experimental plots.

Cultural practices

Monarch maize hybrid (F1) seeds its imported from Netherland was planted on 25 July 2016, at 0.75 m row spacing and an average seeding rate of 4.8 seeds per m^2. All treatment plots received the same amount of fertilizer application at rates of 30 gm DAP (Di Amino Phosphate, 18:46:0). m^{-1} and the incorporated into the soil at planting, all plots received 40 gm per m^2 in the form of urea (46% N), which was applied in banding along the rows on two doses, first when four weeks after sowing and second after 30 days of the first one. Weed and pest control was carried out as needed, and was harvest on 9/11/2016 after the completely maturity.

Plant Parameters

Plant height (cm)
Stem diameter (mm)
Leaf area (cm^2)
Leaf area index
No. of rows per ear
No. of grains per row
No. of grains per ear
Weight of 500 grain
Grain yield (t. ha^{-1})
Biological yield (t. ha^{-1})
Harvest index

Statistical analysis:

Analysis of variance (ANOVA) was used to analyze the effects of the different treatments. ANOVA was performed at a

0.05 level of significance to determine whether the treatments were different. Multiple comparisons were made between the significant effects using the least significant difference (LSD) test at $\alpha = 0.05$.

Statistical model for the p, m split plot in r replicates is. (2).

$y_{iju} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + II_{u(i)} + II_{j(ui)} + \varepsilon_{iju}$

where:

$i = 1,2, \ldots, p$, $j = 1, 2, \ldots, m$, $u = 1, 2 \ldots, r$

and

y_{iju} = the response in block u for the treatment combination a_1b_1

μ = over all mean effect.

α_i = the effect of ith level of factor A.

β_j = the effect of jth level of factor B.

$(\alpha\beta)_{ij}$ = the interaction effect of ith level of factor A and jth level of factor B.

$II_{u(i)}$ = the effect of uth block for the ith level of A and is NID $(0, \sigma^2 II)$.

$II_{j(ui)}$ = joint the effect of jth level of B and block u receiving the ith level of A independent of $II_{u(i)}$ and is NID $(0, \sigma^2 II)$.

ε_{iju} = a random component of error associated with ijuth sub-plot and each ε_{iju} is NID$(0, \sigma^2_{\varepsilon})$.

The results

Plant height, Stem diameter, Leaf area and Leaf area index

The data shows that plant height, stem diameter, leaf area and leaf area index of maize was significantly affected ($p \leq 0.0.5$) by physical treatments, while irrigation methods and interactions are not significant affected, shown in table (2) indicates that highest average of plant height was (164.8 cm) with mulch wheat stubble (M1) followed by treatment (M3) with non-significant difference between them and followed by treatment (M2) which was a significant difference, while control treatment (M0) gave the lowest mean (150.8 cm). These results were similar with many previous studies (9, 17, 18 and 20). They reported that mulching soil surface with wheat straw caused increase in maize plant height. That highest average of stem diameter was (33.32 mm) with mulch wheat stubble and moisture conservator (M3) followed by treatment (M1) and without a significant difference, while control treatment (M0) gave the lowest average (29.23 mm). A similar result was obtained by (16). They indicated that mulch practices had a significant effect on stem diameter. And the table illustrate that the highest average of leaf area was (670.9 cm^2) with mulch wheat stubble (M1), compared with control treatment (M0) gave the lowest mean (588.0 cm^2), which agreed with the result of (3, 13 and 21). They concluded that mulching lead to increase the leaf area. While that the highest average of leaf area index was (5.57) with mulch wheat stubble (M1), while the control treatment (M0) gave the lowest average (4.55). These results are similar to (14 and 23). They reported that the leaf area index of maize plant was significantly affected with mulch wheat straw.

Table.2. Effect of physical treatments on the average of plant height, stem diameter, leaf area and leaf area index of maize during the autumn season 2016.

Treatments	Plant height (cm)	Stem diameter (mm)	Leaf area (cm^2)	Leaf area index	
S	162.2	31.32	634.2	5.10	
F	154.2	31.57	626.7	4.90	
D	161.8	31.22	639.4	5.35	
M0	150.8	29.23	588.0	4.55	
M1	164.8	32.10	670.9	5.57	
M2	157.9	30.82	605.1	4.81	
M3	164.3	33.32	669.6	5.55	
LSD (0.05)	N.S	N.S	N.S	N.S	I =
	4.779	1.258	36.933	0.332	M=
	N.S	N.S	N.S	N.S	I × M=

The number of rows per ear, No. of grains per row, No. of grains per ear and grain weight

The results of statistical analysis which illustrate in table (3) show that the number of rows per ear and No. of grains per ear for maize were significantly affected ($p \leq 0.0.5$) by physical treatments, while were not influenced by irrigation methods and interactions.

Table (3) observes that the highest average No. of rows per ear was (16.58 rows) with mulch wheat stubble (M1) followed by treatment (M3) and without a significant difference, while control treatment (M0) gave the lowest average (15.47 rows). These results are in agreement with (24 and 29). They reported that mulch significantly affected No. of rows per ear for maize plant. That the highest average N0. of grains per ear was (760.6) with mulch wheat stubble (M1), compared with control treatment (M0) which gave the lowest average (690.4). These results were similar with which obtained by (17 and 30). Who concluded that N0. of grains per ear had significantly affected by mulch with wheat straw. While that No. of grains per row for maize were not significantly affected ($p \leq 0.0.5$) by irrigation methods, physical treatments, and interactions.

As for that 500 grain weight of maize was significantly affected ($p \leq 0.0.5$) by irrigation methods, while physical treatments and interactions did not significant effect on 500 grain weight.

Table explains that the highest mean of 500 grain weight was (193.5 gm) with furrow irrigation (F) followed by treatment (S) and without a significant difference and followed by treatment (D) which is significant difference. A similar result was obtained by (22 and 25).

Table.3. Effect of irrigation methods, physical treatments and interactions on the average of the number of rows per ear, No. of grains per row, No. of grains per ear and grain weight of maize during the autumn season 2016.

Treatments	Number of rows per ear	No. of grains per row	No. of grains per ear	Weight of 500 grain	
S	15.83	44.59	706.5	187.0	
F	15.60	45.55	710.5	193.5	
D	16.33	45.20	737.8	178.2	
M0	15.47	44.67	690.4	181.9	
M1	16.58	45.89	760.6	184.9	
M2	15.56	45.46	707.4	183.4	
M3	16.09	44.44	714.7	194.5	
LSD (0.05)	N.S	N.S	N.S	9.202	I =
	0.775	N.S	42.959	N.S	M=
	N.S	N.S	N.S	N.S	I × M=

Grain yield, Biological yield and Harvest index

The data explains that grain yield and biological yield of maize was significantly affected ($p \leq 0.0.5$) by physical treatments, while irrigation methods and interactions did not significant affected. As regards the harvest index were not significantly affected by irrigation methods, physical treatments, and interactions. Table (4) explains that the highest average of grain yield was (13.99 t. ha^{-1}) with mulch wheat stubble (M1) followed by treatment (M3) with non-significant difference between them, compared with control treatment (M0) which gave the lowest average (12.40 t. ha^{-1}). These results are similar with those found by (17, 20 and 30). They reported that the grain yield of maize was increased by mulch with wheat straw. Also that the highest average of biological yield was (37.15 t. ha^{-1}) with mulch wheat stubble (M1) followed by treatment (M3) and without a significant difference, while control treatment (M0) gave the lowest average (32.56 t. ha^{-1}). These results are similar with (17 and 30). They concluded that mulch soil with wheat straw significantly affected on biological yield of maize.

Table.4. Effect of irrigation methods, physical treatments and interactions on the average of grain yield, biological yield and harvest index of maize during the autumn season 2016.

Treatments	Grain yield (t. ha^{-1})	Biological yield (t. ha^{-1})	Harvest index	
S	12.86	34.84	36.92	
F	13.07	35.14	37.51	
D	13.24	34.65	38.26	
M0	12.40	32.56	38.17	
M1	13.99	37.15	37.69	
M2	12.64	33.22	38.17	
M3	13.19	36.58	36.23	
LSD (0.05)	N.S	N.S	N.S	I =
	0.816	2.953	N.S	M=
	N.S	N.S	N.S	I × M=

Discussion

The results of this study indicated that the grain yield of maize (phurat hybrid) was not affected by irrigation methods. This due to that they did not differed markedly in their yield structure (No. of rows per ear, No. of grains per row and then No. of grain per ear) which were presented in tables (table 3). Furthermore, all plants in this experiment gave one ear per plant, this may be because the breeding of the grown hybrid (one ear per plant), drip irrigation treatment gave less grain weight ($p \leq 0.05$) which were showed in table (table 3), whereas furrow irrigation treatment had more grain weight ($p \leq 0.05$).

In spite of the differences in grain weight among irrigation methods there was no significant difference in grain yield this due to compensation phenomenon in cereal crops whereas the grain weight was reduced whenever the number of grains per ear was increased (10), they were stated in table (table 3).

The grain yield components except (grain weight) were not affected by different irrigation methods because there was no significant difference in biological yield and harvest index (table 4). This due to a lot of growth parameters which were not affected by irrigation methods such as plant height, stem dimeter, leaf area and it's index (table 2). The results indicate that growth of maize were not affected by drip irrigation method in spite of the quantity of water added in this method was, less than surface and furrow irrigation, by (49.31% and 49.35%) respectively . This due to that drip irrigation, which played role to maintain available soil moisture of rhizosphere, through significant amount and good distribution.

The highest mean of grain yield (13.99 t. ha^{-1}) was obtained when we mulched soil surface with wheat stubble (M1), mulching + moisture conservator treatment (M3) gave 13.19 t. ha^{-1} (table 4). The increase of grain yield in mulching treatment (M1) resulted from increase of grain number per ear (it was 9.23%) compared with control treatment (M0) as in (table 3) while there were no significant differences between physical treatment in grain weight (table 3) therefore the grain number per ear determined the significant differences of grain yield between treatment in this study.

The increase of grain yield per plant with mulching which reflected in increase of total grain yield (table 4) was due to the increase in leaf area and leaf area index (tables 2) which mean a lot of interception area. Stem diameter (table 2) which mean that a lot of dry matter storage in stems (as source) and a lot of vascular tissues which mean more transportation and partitioning of net assimilation. The highest dry weight means a lot of pollen grains which enhanced silk pollination under field condition and then a lot of grain number (table 3).

The improvement of some growth characters when mulched soil surface with wheat stubble that reflected on increase the growth and dry matter accumulation, the increase of growth parameters due to the increase of plant ability to uptake water and nutrients which act to increase the turgor pressure of cells and stomata conductance that led to continuous of CO_2 diffusion to plant tissues then the carboxylation will be enhanced furthermore transportation and distribution of metabolic products from source to sink. (1). That confirmed by biological yield (37.15 t. ha^{-1}) as in (table 4). where the supply of the plants with water and nutrients which they are two factors from the three natural resources factors of growth (water, nutrients and light) they showed the role of mulching in increase soil water holding capacity-using soil mulching decrease evaporation from soil surface causing vegetative growth improvement of plants (5).

Mulching soil surface led to change thermal system and moisture of soil, which caused change the environmental factors of plant that led to increase germination percentage and grain yield (3). Mulching also effect on soil microorganisms activities that play role in nutrient transformation affects specially nitrogen through maintained, soil moisture and improve their aeriation (6). Mulching was very active to protect soil moisture and prevent rising of sells through capillary (27).

Biological yield and grain yield were not influenced with moisture conservator (M2) in comparison with control (table 4). This due to that moisture conservator had no effect on many growth characters, which had not effect when we used it alone, this may be due to a little quantity which used in the study or do not put the granules moisture conservator in the correct soil depth but when used it with wheat stubble it had additive effect.

Conclusion

The study evaluated the effect of different irrigation methods on growth, yield and matter production of corn under middle region of Iraq during 2016.

Drip irrigation method (D) gave the same corn yield compared to the surface (S) and furrow irrigation methods (F) in spite of the applied water with drip was less than surface and furrow by (49.31% and 49.35%) respectively. Most of growth parameters were not affected by drip irrigation compared to surface and furrow while the most water saving was obtained in the drip irrigation compared with surface and furrow. Drip irrigation system was found very efficient irrigation method.

In this study, also we concluded that mulched soil surface with wheat stubble improved growth and grain yield of maize. This might be due to proper moisture availability.

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نمو وحاصل الذرة الصفراء تحت طرائق الري وبعض المعالجات الفيزيائية

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المستخلص

نفذت تجربة حقلية لدراسة تأثير طرق الري والمعالجات الفيزيائية على النمو وحاصل محصول الذرة الصفراء في منطقة الكرامة في قضاء الكوت / محافظة واسط. استخدم تصميم القطاعات الكاملة المعشاة بترتيب الالواح المنشقة بثلاث مكررات، وتضمنت التجربة ثلاثة طرائق للري، السطح (S)، المروز (F) والتنقيط (D)، في حين أن ثلاثة معالجات فيزيائية بالإضافة إلى معاملة المقارنة، M0: بدون تغطية، M1: تغطية مع تبن الحنطة (15 طن. هكتار$^{-1}$)، M2: حبيبات البوليمر المدفونة مع التربة وM3: التغطية مع تبن الحنطة + حبيبات البوليمر المدفونة مع التربة. أظهرت نتائج الدراسة عدم وجود تأثير معنوي لطرائق الري على ارتفاع النبات وقطر الساق والمساحة الورقية ودليل المساحة الورقية وعدد الصفوف في العرنوص وعدد الحبوب في الصف وعدد الحبوب في العرنوص وحاصل الحبوب والحاصل البايلوجي ودليل الحصاد باستثناء وزن الحبوب كان له تأثير كبير، ووجد أعلى وزن للحبوب في الري بالمروز (193.5 غم).

في حين أن المعالجات الفيزيائية أثرت معنويا على ارتفاع النبات وقطر الساق والمساحة الورقية ودليل المساحة الورقية وعدد الصفوف في العرنوص وعدد الحبوب في العرنوص وحاصل الحبوب والحاصل البايلوجي، أعلى ارتفاع للنبات كان (164.8 سم)، المساحة الورقية (670.9 سم2)، دليل المساحة الورقية (5.57)، عدد الصفوف في العرنوص (16.58)، عدد الحبوب في العرنوص (760.6)، حاصل الحبوب (13.99 طن. هكتار$^{-1}$) والحاصل البيولوجي (37.15 طن. هكتار$^{-1}$) في معاملة M1. أما فيما يتعلق بأعلى قطر ساق فقد بلغ (33.32 ملم) في M3، غير أن عدد الحبوب في الصف ودليل الحصاد لم يتأثر بشكل كبير بالمعالجات الفيزيائية. أما بالنسبة للتداخلات فكانت غير معنوية لجميع الصفات المدروسة.

الكلمات المفتاحية: طرائق الري، المعالجات الفيزيائية، نمو وحاصل الذرة الصفراء.

بحث مستل من رسالة ماجستير للباحث الثاني.