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Effect of Irrigation Period and Organic Fertilization (TOP_{10}) on Growth, Production and Water Use by Maize Crop

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Abstract: *Field experiment was carried out during autumn season of 2012 at the experimental farm, Crop Research Station, beyond to Research Office of Agricultural, Abu-Ghraib/ Baghdad - Iraq. The layout of the experiment was split plot in Randomize Complete Blok Design with three replications. The objective was to study the effect of irrigation intervals and organic fertilizer levels on some growth characteristics, yield and water use efficiency of maize (synthetic cultivar 5018).The irrigation intervals (irrigation every 4 days, 7 days and 10 days) were in main plots while organic fertilizer Top_{10} levels (0, 3 g L^{-1} and 5 g L^{-1}) foliar application after 40 and 60 days from planting were in sub plots. Results showed that irrigation every 4 days and the level 5 g L^{-1} of fertilizer Top_{10} gave highest plant height (180 cm), number of leaves (16 leaves. $plant^{-1}$), ear height (21 cm), and number of rows.ear^{1} (16.6 rows.ear^{-1}) and grain yield (9.375 ton.ha^{-1}). Irrigation every 4, 7 and 10 days + 5 g L^{-1} of Top_{10} organic fertilizer gave the highest values in WUE about 19.7, 17.9 and 17.2 kg ha^{-1}mm increasing about 25.47, 36.64 and 39.83% respectively. From these results the conclusion was irrigation every 10 days, with application organic fertilizer (Top_{10}) in 5g L^{-1} could be recommender for maize in semi arid regions similar to that in Iraq where the research was conducted.*

I. Introduction

Corn is one of the cultivated crops for grain and fodder with tremendous yield potential grown round the year under irrigated condition. In many parts of the world, maize is the most important food stuff and particular, provides the daily bread for the indigenous population of rural area. Corn has become a widely grown feed particularly as a second crop after wheat or barley. The corn production in Iraq is about 1066800 ton ha^{-1} of grain corn from 1809200 ha (**Ministry of Agriculture, 2012**).

Common irrigation methods used for corn production in region are wild flooding, furrow and sprinkler irrigation. In general, the farmers over irrigate, resulting in high water losses and low irrigation efficient, thus creating drainage and salinity problems (**Yazar et al., 2002**). Climate and water availability are major determining factors in corn production (**Morgan et al., 2003**). For normal growth and development of corn, its high and stable yields and high quality it is necessary to maintain optimum soil moisture throughout the growing season. Only optimum condition permit the plants to use water according to their needs, i.e., to the level of potential evapotranspiration (ETP). Effect of irrigation on corn yield performance depends on weather condition in the year of growing, primarily on the amounts and distribution of rainfall. Application of organic fertilizers is one of important practical measures to improve soil fertility. Adequate nutrition is the ecosystem response to the addition of artificial or natural substances, in addition to providing necessary nutrient for crops and improving soil physic-chemical properties, organic fertilizer is able enhance soil microbial activity of soil, such as improving activity of soil enzymes and increasing soil microbial biomass (**Sun et al., 2003**). Water supply plays a significant role in the utilization of fertilizers active substances especially that of nitrogen. Due to the changing precipitation, the effect of fertilization strongly varies on an annual basis. The correlation of irrigation and fertilization has been investigated by many researchers. The irrigation and fertilizer research indicated that irrigation improves the efficiency of fertilization and there is a strong correlation between fertilizer utilization and the water supply of a plant (**Sun et al., 2003, Ati et al., 2013**). The objective of this research was (i) to predict maize yield under different irrigation period (ii) to predict maize yield under different levels of organic fertilizer (Top_{10}).

II. Material And Methods

Field experiments on maize was carried out at Crop Research Station in Abu-Ghraib Baghdad , Iraq 2012 during autumn season (July to November) Baghdad, Iraq (33°22'N, 44°24'E; altitude, 34.1 m). Some soil characteristics (Table 1) were determined as follows: soil particle size distribution by pipette method, soil bulk density was determined by the core method. Soil reaction (pH) and electrical conductivity (EC) were determined at the same soil water suspension 1:1 (W:V) by pH-meter and electrical conductivity-bridge, respectively. Organic matter was determined by method of Walkley and Black, these methods as mentioned in Refs **(Black, 1965 and Page et al., 1982).**

Table 1: Physic-chemical properties of the soil

Soil depth (cm)	BD g. cm^{-3}	F.C %	W.P %	AW %	Particle size distribution (gm/kg) clay	Silt	sand	Texture	EC $dS.m^{-1}$	pH	OM %
0-30	1.41	32.0	15.2	16.8	370	490	140	SiCL	3.61	7.5	1.32
30-60	1.44	34.5	14.1	18.4	420	470	110	SiC	3.22	7.4	1.12

The experimental treatments were split plot arranged in Randomize Complete Block Design with three replicates. The main plots were assigned to irrigation intervals, whereas (synthetic cv. Maize 5018) organic fertilizer was assigned to the sub plots. Plots area was 3×5 m^2. Grains of corn were sown at a rate of 62500 plants. ha^{-1}, with recommended dose of fertilizer compound (N. P) (27-27) with rate 400 kg. ha^{-1}, Recommended rate of nitrogen 400 kg ha^{-1} (46% N) was applied as a form of urea in two split equal doses (at 6 leaves stage, and after 30 days from first applied). Sowing was done on July 15th. Harvest was done on November 20th. The treatments were:

1. Irrigation treatment as follows:

a. Irrigation every 4 days.
b. Irrigation every 7 days.
c. Irrigation every 10 days.

2. Fertilizers with Top $_{10}$ (soluble foliar fertilizers, high efficiency, and fast absorption from the leaves) composed from (15% Nitrogen –N-, 16% Phosphorus –P_2O_5-, 22% Potassium –K_2O) adding with three rates:

a. 0.00 g L^{-1} (control)
b. 3 g L^{-1} (added with two times with same amount after 40 and 60 days from planting).
c. 5 g L^{-1} (added with two times with same amount after 40 and 60 days from planting).

The amounts of applied irrigation water (m^3/ha) correspond to each interval. Irrigation was applied according to the irrigation intervals. Irrigation system was surface flow irrigation through line pipe provided with meter gages for measuring water applied. Irrigation were scheduled when soil water content in the root zone was depleted by the crop to specific fraction of available water (irrigation was imposed at 60% depletion of available water). All other agricultural practices were carried out as recommended. Actual evapotranspiration was estimated by the soil sampling method and calculated according to the **Heerman (1985):**

$ETa = R + I – D \pm \Delta W$

Where:

ETa= the evapotranspiration (mm) R = the rainfall (mm)
I = the depth of irrigation (mm) D = the depth of drainage (mm)
ΔW = the change of soil water storage in the measured soil depth

Since the amount of irrigation water was only sufficient to bring the water deficit to field capacity, deep percolation was ignored. Water use efficiency was calculated according to the following equation:

$$(WUE_c) = \frac{\text{Yield (Kg ha}^{-1}\text{)}}{ET_a \text{ (mm)}}$$

At harvest time, two central rows in each plot were harvested to determining grain yield and then; grain yield per hectare was calculated. Sub sample of 10 plants was taken from each plot to measuring plant height in cm, No. of row/ear, leaves No, ear height and 50% masculine flowering. Analysis of variance (ANOVA) was conducted to evaluate the effects of the treatments on the yield and water use efficiency. Least significant differences method (L.S.D) was used to differentiate means at the 0.05 level **(SAS, 2010).**

III. Result And Discussion

The results of Table 2 indicate significant differences of each period irrigation and fertilization Top 10 spray in each of the plant height, number of leaves. $plant^{-1}$, ear height and number of row. ear^{-1}. The irrigation frequency 4 days and the level 5 g L^{-1} of fertilizer Top 10 gave the best parameters 180 cm, 16 leaves. $plant^{-1}$, 21 cm and 16.6 row ear^{-1}, respectively. These results may be due the all parameters of growth components increased with decreasing period irrigation and increase levels of fertilizers. This can be due to the role of water stress decrease water potential of leaves, reduces photosynthesis as a result of reduction of open stomata also working on reducing the production plant pigments such as chlorophyll, which reduces the carbohydrates produced, and corresponds this result with **Cavero et al. (2000)** who have found that the stress moisture reduces

the breadth and elongation leaves of maize because of the low rates of radiation optical intercepted by leaf area. The plant water relations and photosynthetic rates of grain maize were improved by fertilizers Top_{10} and it has been concluded that application of Nitrogen- Potassium- Phosphor fertilizer could be considered a significant factor in overcoming soil moisture stress. In other hand the 50% masculine flowering decrease with decrease period of irrigation and increasing level of fertilizers Top_{10}, this due that the masculine flowering period very sensitive to water stress for low representation outputs of carbon-allocated to growth and form ear.

The values of all the plant growth parameters were significant among the various period irrigation treatments; this means that increasing the amount of water applied (period irrigation 4 days) increased the all plant parameters, This is due to a decline in moisture tension posed to plants, and the abundance water and increase the ability nutrients, which increases with increasing rates of organic fertilization.

Results showed that organic fertilizers have a significant effect ($P<0.05$) on all the plant growth parameters (Table 2), this due that trugor of young leaf cell was depended on their K^+ content, and in the low concentration of nutrient, growth rate, cell size and water content of tissue were reduced (**Mengel and Arneke, 1982**).

Table 2: Effect of different irrigation intervals and organic fertilizer on plant height, leaves number, ear height, number of rows ear^{-1} and 50% masculine flowering

a. Plant height

Treatment	4 days	7 days	10 days	Mean
Control	165.3	157.3	151.6	158.1
3 g L^{-1}	170.2	161.6	155.1	162.3
5 g L^{-1}	180.0	166.7	160.2	168.9
Mean	171.8	161.8	155.6	163.9
LSD (0.05)	Irrigation interval = 3.9			
	Fertilizers = 3.9			
	Interaction = 7.3			

b. Number of leaves Plant^{-1}

Treatment	4 days	7 days	10 days	Mean
Control	14	14	12	13.3
3 g L^{-1}	15	15	12	14.0
5 g L^{-1}	16	15	14	15.0
Mean	15	14.6	12.6	14.1
LSD (0.05)	Irrigation interval = 0.4			
	Fertilizers = 0.4			
	Interaction = 1.7			

c. Ear height

Treatment	4 days	7 days	10 days	Mean
Control	18.6	17.6	16.3	17.5
3 g L^{-1}	19.3	18.6	18.0	18.6
5 g L^{-1}	21.0	19.8	19.0	19.9
Mean	19.6	18.6	17.7	18.6
LSD (0.05)	Irrigation interval = 0.7			
	Fertilizers = 0.7			
	Interaction = 2.2			

d. Number of rows ear^{-1}

Treatment	4 days	7 days	10 days	Mean
Control	15	15	15	15.0
3 g L^{-1}	16	16.3	15.3	15.9
5 g L^{-1}	16.6	16.3	16	16.3
Mean	15.9	15.9	15.4	15.7
LSD (0.05)	Irrigation interval = 0.2			
	Fertilizers = 0.2			
	Interaction = 1.1			

e. 50% masculine flowering

Treatment	4 days	7 days	10 days	Mean
Control	61	63	65	63
3 g L^{-1}	55	58	61	58
5 g L^{-1}	51	54	57	54
Mean	55.6	58.3	61	58.3
LSD (0.05)	Irrigation interval = 2.6			
	Fertilizers = 2.6			
	Interaction = 5.5			

Data in Table (3) shows that value of water consumptive use (ET_a) as affected by period irrigation and organic fertilizer levels, the values varies from 494, 512, 529 mm for irrigation period every 4, 7 and 10 days, respectively. Therefore, the values of water consumptive use were decreased by increasing water stress (increase period irrigation). The reason for this was existing water content in the soil before the beginning irrigation and the climatically parameters.

Results from Table (3) showed that organic fertilizer had significant effect ($p<0.05$) on the value of water consumptive use (ET_a) varies from 535, 509, 490 mm for control, 3 g. L^{-1} and 5 g L^{-1} applied foliar organic fertilizer. Water shortage is usually accompanied by reducing accumulation of aerial organs and the production of photosynthesis which seemed to be due to reduced absorption of nutrients and the production and transfer of processed substances. Results of data on crop water use efficiency (WUE_c) for all treatments are presented in Table 3 indicated the importance of organic fertilizers for good yield and better utilization of water, this can be attributed to the role of macro and micronutrients in improving crop resistance to water stress and other stresses (**Rahimizadeh et al., 2007**).

Table 3: Seasonal water consumption (ET_a) (mm), grain corn yield (ton ha^{-1}) and crop water use efficiency (WUE_C) at different irrigation period and organic fertilizers

Irrigation Treatment		Evapotranspiration (ETa) (mm)	Grain yield (t. ha^{-1})	WUEc (kg. ha^{-1}.mm)
Irrigation Treatment				
4 days		494	8.687	17.6
7 days		512	7.916	15.5
10 days		529	6.999	13.2
LSD			0.985	
Organic fertilizer levels				
Control		535	6.812	12.7
3 g. L^{-1}		509	8.062	15.8
5 g. L^{-1}		490	8.729	17.8
LSD			0.985	
Irrigation Treatment × Organic fertilizer levels				
4 days	Control	516	8.125	15.7
	3 g. L^{-1}	491	8.562	17.4
	5 g. L^{-1}	475	9.375	19.7
7 days	Control	534	7.000	13.1
	3 g. L^{-1}	512	8.000	15.6
	5 g. L^{-1}	490	8.750	17.9
10 days	Control	555	6.812	12.3
	3 g. L^{-1}	525	8.062	15.4
	5 g. L^{-1}	507	8.729	17.2
LSD			2.320	

The crop water use efficiency (WUE_c) of all the treatment ranges from 12.3 to 19.7 kg ha^{-1} mm. It can also be deduced from the results of the percentage difference in water use efficiency compared between irrigation treatments, also in organic fertilizer levels. Water use efficiency in the irrigation period based on organic fertilizers was significant ($p<0.05$) (Table 3). In the 4, 7 and 10 days irrigation period + 5 g L^{-1} gave the highest values in WUEc recorded 19.7, 17.9 and 17.2 7 kg ha^{-1} mm, respectively increasing about 25.47, 36.64 and 39.83% respectively.. From these results it could be concluded there is decline in crop water use efficiency with increasing soil moisture stress. Those increases in crop water use efficiency were mainly due to increase of available water resulted in an increase of total grain yield more than the increase of actual water consumptive use. Data in Table (3) show that total yield significantly decreased as water stress increased (irrigation period). The highest yield of maize was obtained by irrigation period 4 days (8.687 ton ha^{-1}). It is obvious that frequent irrigation (short time between irrigations) produced maximum values of total yield of maize. Also, data in Table (3) show that the percentages of increase in grain yields were more in organic fertilizers application compared with control treatment. This in due that increase water deficit resulted in decrease in crop yield. Crop roots take up nutrients and the water from upper parts of the soil under the condition of low water stress or non-stress.

In conclusion, based on the results obtained from this research, an irrigation time interval of 7 and 10 days, with application organic fertilizer (Top $_{10}$) + 5 g L^{-1}, could be recommended for maize in semi arid regions similar to that in Iraq where the research was conducted.

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