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IMPACT OF BUBBLER DISCHARGE AND IRRIGATION WATER QUANTITY ON 1- HYDRAULIC PERFORMANCE EVALUATION AND MAIZE BIOMASS YIELD

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ABSTRACT: The aim of current research work was to study the effect of two bubbler irrigation discharges (BD) were: a) 8 LPH and b) 12 LPH, and different water quantity treatments from evapotranspiration (ET): 100%, 75%, 50% on uniformity coefficient (UC%), emission uniformity (EU%) and coefficient of variation (CV%), maize (*Zea mays-L.*, HF-10 Varity) grain and Hay yield. The experimental design was split in randomized complete block with three replicates. So, field experiment for one growing season (2014) was conducted in sandy soil at the Agricultural Research and Production Station of National Research Centre, El-Nubaria, Elbehira Governorate, Egypt. Irrigation water was added in order to compensate for ET of maize. The obtained results could be summarized as follow: Parameters under study could be ranked in following descending orders: 8 LPH>12 LPH and 100>75>50 for bubbler discharge treatments, except for CV%. Investigated bubbler discharge (8 and 12 LPH), increase operating pressure head, getting improvement in UC%, EU% and decreasing CV values. With respect to BD and ET% effect on UC, EU%, maize hay yield, and significant difference at the 1 % level between all mean values of bubblers and ET% treatments were obtained. The interaction effects of the investigated factors, the highest and lowest values of maize hay yield were recorded under 8 LPH X 100% and 12 LPH X 50% ET treatments. These attained results were attributed to the improvement in hydraulic parameters of UC%, EU% and CV Also the Irrigation treatments of 100 and 75% from ET were covered water requirements and also recorded convergent results in values which means that the quantity of water added (which is the difference between the 100-75% =25% ET). It's amount, in excess of the plant required under the current conditions of the experiment. So it can be recommended to using 75% for saving 25% from water requirements under bubbler irrigation system using 8 LPH bubbler.

Keywords: Bubbler, Irrigation, Discharge, Hydraulic, Uniformity, Maize, Grain, Hay.

1. INTRODUCTION

The irrigation water requirements of maize oscillate from 500 until 800 m3 for achievement of maximum production by a variety of medium maturity of seed [1 and 2]. On a coarse texture soil, maize production increased with a combination of deep tillage and the incorporation of hay deposits in mulch, together with a general increase in crop irrigation [3].Maize (*Zea mays L.)* is cultivated in areas lying between 58º north latitude and 40 º south latitude at sea level up to an altitude of 3,800 m. It is a crop which is irrigated worldwide. The main maize producing country being the USA [4].Other research scientists [5; 6] have made an extensive irrigation study in the cultivation of maize and they found that the irrigation is of the utmost importance, from the appearance of the first silk strands until the milky stage in the maturation of the kernels on the cob. They added that once the milky stage has occurred, the appearance of black layer development on 50 % of the maize kernels is a sign that the crop has fully ripened. The aforementioned criteria were used in the experimental plot for the total irrigation process.

Most research projects on this particular subject refer to the effect of irrigation on maize yield using sprinkler and/or furrow irrigation. In contrast, only a few studies have been made on maize cultivation under drip irrigation system [5], and [6] and they used the evaporation pan method to calculate the quantity of water needed for irrigation. From advantage of drip irrigation is that, there are many tools available for soil moisture measurement [7; 8] electronic programmers and electro hydraulic elements which give the possibility of complete automation of irrigation networks[9].

The application of fertilizers is usually broadcasting with low efficiency under surface irrigation methods, resulting in higher costs and environmental problems, [10], who stated that maize (*Zea MaysL.*) is one of the most important cereals, both for peoples and animals consumption, in Egypt and is grown for both grain and forage.

The aims of this work were to study the effect of two bubbler irrigation drippers discharges (BID) 8 and 12 LPH and different water quantity from evapotranspiration (ET): 100, 75, 50 % on maize

(*Zea mays L.*) vegetative growth, grain and Hay yield.

2. MATERIAL AND METHODS

Field experiment was carried out for only one growing season (2014) in sandy soil at the Agricultural Research Station of National Research Centre, El-Nubaria, El-Behira Governorate, Egypt, to study the effects of two bubbler (BD) differs in discharge (8 and 12 LPH) and different irrigation water quantity from evapotranspiration (ET): 100 , 75, 50 % on maize (Zea mays L., HF-10 Varity) vegetative growth, grain and hay yield. Vegetative growth and yield included: Leaf area, Leaf length, leaf number plant-1, plant height, grain yield, and Hay yield. Soil physical properties such as texture of experimental soil was determined after [11] and soil moisture retention after [12].Whereas soil chemical characteristics of soil paste saturation extract and irrigation water analysis were determined after [13] (Tables 1, 2; 3).

The experiment design was split in randomized complete block design with three replicates for only one growing season (2013). Source of irrigation water was a ground water. The total experimental area was one feddan (4200 m2). After soil preparation, maize grains (Zea mays L.), variety Giza-155 were seeded on the 3rd of May, 2013. Plants were irrigated every 3 days using examined BID. Irrigation process was carried out to compensate soil moisture by ETc of maize and salt leaching requirement was took place (Table 4). Details of the pressure and water supply control have been described by [14].

Irrigation networks include the following components: 1.Control head: It was located at the water source supply. It consists of centrifugal pump 3`` /3``, driven by electric engine (pump discharge of 80 m3/h and 40 m lift), sand media filter 48``(two tanks), screen filter 2`` (120 mesh), back flow prevention device, pressure regulator, pressure gauges, flow-meter, control valves and chemical injection, 2. Main line: PVC pipes of 75mm in (ID) Ø to convey the water from the source to the main control points in the field, 3. Sub-main lines: PVC pipes of 75mm in (ID) Ø were connected to the main line through a control unit consists of a 2`` ball valve and pressure gauges, 4. Manifold lines: PVC pipes of 50mm in (ID) Ø were connected to the sub main line through control valves 1.5``, 5. Lateral lines: PE tubes of 16 mm in (ID) Ø were connected to the manifolds through beginnings stalled on manifolds lines, 6. Emitters: These bubbler emitters built on PE tubes 18mm in (ID) Ø, emitter discharge of 8 and 12 lh-1 LPH at 1 atm. nominal operating pressure and 30 cm spacing in between. The components of bubbler irrigation system include, supply lines, control valves, supply and return manifolds, lateral lines, bubbler emitters, check valves and air relief valves/vacuum breakers.

Hydraulic and uniformity parameters:

The evaluations of water application uniformity were calculated with 2 methods using discharge and pressure measurement data. The following equations reported by[15] and [16]were used to compute statistical parameters and analyze uniformity of the subsurface trickle system. The method is simple and straightforward and is still widely used:

$$q_{var} = \frac{q_{max} - q_{min}}{q_{max}} \quad \text{……………..… (1)}$$

$$CV = \frac{S}{\bar{q}} \quad \text{………….……………….. (2)}$$

$$UC = \left[\frac{\frac{1}{n}\sum_{i-1}^{n} qi - \bar{q}}{\bar{q}} \right] \quad \text{……………… (3)}$$

Where:

qmax and qmin are maximum and minimum emitter discharge, respectively, CV = coefficient of variation.

andS are the mean and standard deviation, respectively, of discharge (q), and n is the number of emitters.

[17] reported statistical uniformity represented in the following equation:

$$UC = 1 - \frac{\overline{\Delta q}}{\bar{q}} \quad \text{……………….…... (4)}$$

Where:

UC = statistical uniformity coefficient (%), and Δq = manufacturing coefficient of variation.

The coefficient of variation in this calculation refers to the depth of water applied. This statistical uniformity coefficient describes the uniformity of wastewater distribution assuming a normal distribution of flow rates from the emitters.

The flow rate through the pipe put depends on pipe surface roughness and air layer resistance. The change of hydraulic friction coefficient values, depending on variations in Re number values. Hydraulic losses at plastic pipes might be calculated as losses at hydraulically smooth pipes, multiplied by correction coefficients that assess losses at pipe joints and air resistance.

Irrigation scheduling: Intervals of irrigation (I) in day were calculated using the following equations:

I = d / ETc ………….………………. (5)

Where: d = net water depth applied per each irrigation (mm), and ETc = crop evapotranspiration (mm/day).

d = AMD .ASW .Rd . P …………….. (6)

Where: AMD = allowable soil moisture depletion (%), ASW = available soil water, (mm water/m depth), Rd = effective root zone depth (m), or irrigation depth (m), and p = percentage of soil area wetted (%).

AW(v/v %) = ASW(w/w %) . B.D …. (7)

Where: B.D. = Soil bulk density (gm cm-3).

Irrigation Intervals used was 4 days under treatments of bubbler irrigation systems.

Table 1. Some physical properties of the soil.*

Depth, cm	Particle Size distribution, %				Texture class	θS % on weight basis			HC (cmh-1)	BD (g/cm³)
	C. Sand	F. Sand	Silt	Clay		FC	WP	AW		
0-15	8.4	77.6	8.5	5.5	Sandy	14.0	6.0	8.0	6.68	1.69
15-30	8.6	77.7	8.3	5.4	Sandy	14.0	6.0	8.0	6.84	1.69
30-45	8.5	77.5	8.8	5.2	Sandy	14.0	6.0	8.0	6.91	1.69
45-60	8.8	76.7	8.6	5.9	Sandy	14.0	6.0	8.0	6.17	1.67

* Particle Size Distribution after [11] and Moisture retention after [12], FC: Field Capacity, WP: Wilting Point, AW: Available Water, HC: Hydraulic conductivity y(cmh-1), and BD: Bulk density(g/cm3).

Table 2. Some chemical properties of the soil*.

Depth, Cm	pH 1:2.5	ECexpaste dSm-1	Soluble cations and anions (meq/L)							
			Ca++	Mg++	Na+	K+	CO3--	HCO3-	SO4--	Cl-
0-15	8.3	0.35	0.67	0.48	2.08	0.23	0	0.22	0.93	2.31
15-30	8.2	0.36	0.72	0.51	2.15	0.24	0	0.23	1.03	2.35
30-45	8.3	0.34	0.65	0.54	2.02	0.21	0	0.31	0.83	2.28
45-60	8.4	0.53	1.25	0.84	3.02	0.20	0	0.32	1.74	3.25

*Chemical properties after [13]

Table 3. Some chemical properties of the used irrigation water.

pH	EC dS/m	Soluble cations and anions meq/L								SAR
		Ca++	Mg++	Na+	K+	CO3--	HCO3-	SO4--	Cl--	
7.3	0.37	0.69	0.53	2.30	0.18	0.00	1.12	0.72	1.86	2.94

Table 4. Water requirements for transgenic maize grown at the experimental site.

Month	Apr	May	Jun	Jul	Aug	Sep
Epan (mm/day)	6.56	6.36	7.84	9.44	9.28	7.23
Kp	-- 0.71 ---					
Kc	1.05	1.08	1.15	1.17	1.22	1.25
Kr	0.45	0.90	0.95	1.00	1.00	1.00
ETo (mm/day)	4.66	4.52	5.57	6.70	6.59	5.13
ETc (mm/day)	2.20	4.39	6.08	7.84	8.04	6.41
Ks	---100% (1.00)--------------------------------------					
Eu	--90% (1.11)---------------------------------------					
Lr	--10%--					
Growth stage	Planting(Establishment)	Vegetative	Flowering		Ribbing yield Harvesting	
Length of growth stage	2-21 Ap.	21 Ap-1 Jun	2 Jun-5 Jul		6 Jul-5 Aug.	
IRg. season (days)	19	42	34		31	
IRg (mm/month)	51.5	227.2	209.7	57.9	257.5	88.0
IRn (mm/month)	41.8	184.4	170.2	47.0	209.0	64.1

2.1 Measuring the seasonal evapotranspiration (ET):

The (ET) was computed using the Class Pan evaporation method for estimating (ETo) on daily basis was taken from nearest meteorological station as showing in Table 4.

The modified pan evaporation equation to be used:

ETo= KpEp……………………… (8)

where: ETo = reference evapotranspiration [mm day-1],

Kp= pan coefficient of 0.76 for Class A pan placed in short green cropped and medium wind area. Ep= daily pan evaporation (mm day-1), Seasonal average is (7.5 mm day-1), [18].

The reference evapotranspiration (ETo) is then multiplied by a crop coefficient Kc at particular growth stage to determine crop consumptive use at that particular stage of maize growth.

ETc= EToKc…………..……………..…. (9)

The reduction factor (Kr) was calculated using Eq. 6.

Kr = GC + ½ (1 - GC)………………….. (10)

Where: GC = ground cover percentage.

Irrigation efficiency (Ea) calculated by

Ea =Ks Eu ………….…………….…..... (11)

Where: Ea = Irrigation efficiency, Eu = emission uniformity (%) and Ks = reduction factor of soil wetted.

The distance between rows was 0.7 m and 0.25 m among plants in same row. Each row was irrigated by a single straight lateral line in the closed circuits and traditional drip irrigation plots. The total experimental area was 4200 m2. This area divided in to tow parts for each of the dripper discharge of BIS, plot areas of bubbler drippers discharges were 2100 m2, the plot area 2100 m2 divided to three sub-plots each water quantity treatments from (ET) 100, 75 and 50% = 700 m2. Irrigation season of maize was ended 15 days before harvest. Maize yield was harvested on September 15 with total growth period 110 days. Plants' density was 40000 plants per feddan according to Ministry of Agricultural in Egypt. Fertilization program had been done according to the recommended doses throughout the growing season (2013) for maize crop under the investigated irrigation systems using fertigation technique. Fertilizers NPK, minor nutrients, weed and pest control applications followed recommendations of transgenic maize yield in El-Nobaria, Egypt.

2.2 Measurements of maize biomass yield:

The measured yield components included total grain weight Kg/fed and hay yield (Kg/fed).Grain yield was determined by hand harvesting the 8 m sections of three adjacent center rows in each plot on 2014 and was adjusted to 15.5% water content. In all treatments plots, the grain yields of individual rows were determined in order to evaluate the yield uniformity among the rows.

Treatments mean were compared using the technique of analysis of variance (ANOVA) and the least significant difference (LSD) between systems at 1 %, [19].

3. RESULTS AND DISCUSSION

3.1 Hydraulic parameter performance evaluation:

Table (5) showed the main one of bubbler irrigation dripper discharge (BD), sub-main one of the evapotranspiration percentage (ET %) and different operating pressure head on Measures Uniformity coefficient (UC %),Emission uniformity (EU%) and Coefficient of variation (CV%).

Table (5) illustrated the effect of different BD and ET % on measures UC and EU %. Data could be ranked in the following descending orders: 8 LPH > 12 LBH for D treatments and 100 > 75 > 50 % from Etc for irrigation treatments. Concerning to the values of UC and EU %, the attained results indicated that there were significantly among mean values of both BD and ET % treatments. According to the effect of interaction between both investigated factors, the highest and lowest values of UC and EU% were recorded at 8 LPH and 100 ET % treatments. Also, data noticed that under all BD treatments, all the highest values were observed at 100 ET % treatments.

Regarding to hydraulic parameters (UC and EU%, differences were significant at 5 % level among all mean values of BD and ET % treatments. The maximum and minimum values of plant height were found in the interactions of BD by PLH and ET % treatments as follows: 8 X 100 and 12X50, respectively. While CV % data could be ranked in the following ascending orders: 8<12 and 100 < 75 < 50 for BD by LPH and ET % treatments. Concerning the measures CV %, results showed significant differences among mean values of both main effect (B) and sub-main effect (ET %). According to the interaction effect between both investigated factors, the highest and lowest values CV% were recorded at 8 LPH and 100 % ET. Also, data noticed that under all the two examined BD, the highest values were observed at 50 %ET. For hydraulic parameter CV%, differences were significant at 5 % level among all mean values of BD and ET % treatments. The effects of interaction between two studied factors were significant at the 5 % level. The maximum and minimum values of plant height were found in the interactions between BD and ET % at 8 X 50 % and 12 X 100 %, respectively. We can notice that with two cases of bubbler discharge, whenever increase-operating pressure head, getting improving in UC% and EU % and decreasing the CV %.

Table (6) showed the effect of bubbler irrigation dripper discharge and the water quantity from ET % on grain yield (Kg/fed) and Hay yield (Kg/fed).

Table 5. Effect of discharge of bubbler and water quantity on hydraulic performance evaluation measures for different emission devices, and operating pressure head

BD	ET (%)	Operating pressure head(m)	Hydraulic performance evaluation		
			Uniformity coefficient (%)	Emission uniformity (%)	Coefficient of variation (%)
8 LPH	100	10	96.15a	93.37a	0.92a
	75	7.5	95.75b	92.43b	1.36b
	50	5	94.47c	90.41c	2.76c
12 LPH	100	10	94.98a	91.07a	2.17a
	75	7.5	94.46b	90.83b	2.65b
	50	5	93.85c	90.19c	3.47c
LSD0.5			0.21	0.18	0.34
BD	8		95.46a	92.07a	1.68a
	12		49.43 b	90.70b	2.76b
LSD0.5			3.45	1.25	0.22
ET (%)	100		95.57a	92.22a	1.55a
	75		95.11b	91.63b	2.01b
	50		94.16c	90.30c	3.12c
LSD0.5			0.26	0.36	0.78

BD: bubbler irrigation drippers discharges, LPH: liter per hour, ET %: evapotranspiration treatments,

Table 6. Effect of bubbler discharge and water quantity on maize biomass yield.

BD	ET (%)	Yield (Kg/fed)	
		Grain	Hay
8 LPH	100	5532a	4827a
	75	5527ba	4823ba
	50	5070d	4295e
12 LPH	100	5478c	4553c
	75	4668e	4365d
	50	4436f	3925f
BD X ET (%)	$LSD_{0.05}$	12	14
BD	8LPH	5376a	4648a
	12LPH	4861 b	4281b
	$LSD_{0.05}$	88	76
ET (%)	100	5505a	4690a
	75	5098b	4594b
	50	4753c	4110c
	$LSD_{0.01}$	68	56

3.2 BD: bubbler irrigation drippers discharges, LPH: liter per hour, (ET%): evapotranspiration treatments.

Under drip irrigation likely results in greater partitioning of water to transpiration and less to soil evaporation due to water supply is limited, which would result in slightly less water stress. At greater irrigation requirement (IR), the greater concentration of drip irrigation delivered water and nutrients in the root zone may result in poor aeration or nutrient leaching, which may limit yields [20; 21]. [22] Investigated the deficit irrigation for soybeans using surface drip at Curtis and solid set sprinklers at North Platte, They used a greater range of IR than at Colby, but relative performance drip and sprinkler could not be compared because these were at different in both locations and years.

Data in Table (6) indicate the effect of BD and ET % as studied factors on maize grain yield (Kg/fed), both of them could be ranked in the following ascending orders: 8 > 12 LBH and 100 > 75 > 50 %, respectively. In respect to the main effect (BD) on grain yield, one can notice that the differences in grain yield were significant among BD treatments at the 5 % level. The highest and lowest grain yield values were obtained at 8 LPH and TDIS, respectively. According to grain yield, the effect of ET % treatments, there is significant differences at the 5 % level between 100, 75; 50 %, whenever the highest and lowest values were achieved using 100 and 50 % from ET, respectively.

Concerning the effect of BD versus ET % on grain yield, there were significant differences at the 5 % level, except at the following interaction: 8 LPH under 100 and 75% from ET. The maximum and minimum values of grain yield were obtained in 8 LPH X 100 and 12 LPH X 50 in same sequence, respectively. [23, 24, 25; 26] found that a range of seasonal irrigations applied relative to meeting the full irrigation requirement. Grain yield vs. seasonal irrigation were grouped for years having average or greater rainfall or significant drought for simulated low-pressure precision applicators and drip irrigation, where yield and seasonal irrigations were averaged for each group of years under experiment. For average to wet years, grain yield with drip irrigation was slightly greater than simulated low-pressure precision applicators, but vice versa for drought years. In average to wet years, differences in grain yields were primarily due to kernel weight, but in drought years, this was due to the number of kernels per ear [23] for actual yield component data).

Hay yield (HY):

Table (7) indicated the effect of both BD and ET % on maize Hay yield (kg/fed). We can notice that the change in maize hay yield took the same trend of vegetative growth parameters and thus took the trend of grain yield too. Concerning the positive effect of BD and ET % on maize hay yield, they could be ranked in following descending orders: 8LPH > 12 LPH and 100 > 75 >50 % from ET. With respect to BD and ET % effect on maize hay yield, one can notice significant difference at the 1 % level between all means values of BD and ET %. According to the interaction effect of the two investigated factors, the highest and lowest values of maize hay yield recorded under 8 LPH X 100 and 12 LPH X 50 % from ET.

We can notice that maize grain and hay yield took the same trend of other vegetative growth parameters, and this finding could be attributed to the close correlation between vegetative growth from side and grain and hay yield from the other one and also due to positive relations between increasing of growth parameters and increasing maize grain and hay yield.

4. CONCLUSION

It could be conclude that increase-operating pressure head to get improving in uniformity coefficient % and emission uniformity % and decreasing the coefficient of variation %. The improvement of the studied vegetative growth and yield parameters of maize plants under both of 8, 12 LPH and 100, 75 ET % resulted by improving both water and fertilizers distribution uniformity in the sandy soil. Maize grain and hay yield took the same trend of other vegetative growth parameters, and this finding could be attributed to the close correlation between vegetative growth from side and grain and hay yield from the other one and also due to positive relations between increasing of growth parameters and increasing maize grain and hay yield. Irrigation water quantity at 100 and 75 % ET were covered water requirements and also recorded convergent results in values, which excess of the plant required under the current conditions of the experiment. So it can be recommend to using 75% for saving 25% from water requirements under bubbler irrigation system using discharge of 8LPH.

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