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PERFORMANCE OF AUTOMATIC CONTROL DIFFERENT LOCALIZED IRRIGATION SYSTEMS AND LATERAL LENGTHS FOR: 1- EMITTERS CLOGGING AND MAIZE (*ZEA MAYS L.*) GROWTH AND YIELD

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ABSTRACT: Many parts of the world including Egypt currently suffer from water scarcity. For this reason optimization of the available water has become a necessity not only from the point of limited water resources, but also relative to the growing demand for food. Field experiments were conducted at Experimental Farm of National Research Center, El-Nubaria, El-Buhaira Governorate, Western Delta, Egypt to study the effect of automatic control of the localized irrigation system(LIS) as a modified system on emitter's clogging and maize parameters in new reclaimed lands by using the following treatments: a) Bubbler irrigation systems (B); b) Low head drip irrigation system (LHD), and c) Mini-sprinkler irrigation system (MS) through different lateral lengths (40, 50; 60m). Plants were irrigated every 4 days to compensate ETc and salt leaching requirement took place. The obtained data showed that emitter's clogging percentage could be ranked in the ascending orders: LHD<B<MS for LIS and 40<50<60 for lateral lengths used. The highest emitter's clogging % was 14.25 % recorded under MS and the 10.68 % was recorded at B irrigation system. Emitter's clogging percent of lateral lengths treatments recorded 6.34, 12.27; 18.86 % under 40, 50; 60 m, respectively. Vegetative growth and yield parameters (leaf area, plant height, leaf length, number of leaf plant-1, grain and straw yield) LIS and lateral lengths used could be ranked in the following ascending order: MS<LHD<B and 60<50<40 m for lateral length, respectively. LIS and different lateral lengths, were recommend for planting maize under the treatment LHD X lateral length at 40 m that found to be suitable for high production of grain and straw yield and using either B or MS according to their availability.

Key Words: Automatic, irrigation, localized, lateral, Emitter, Clogging, Maize.

1. INTRODUCTION

The use of localized irrigation system (LIS) is increased progressively not only under limited of irrigation water but also in coarse textured soils. The main device on a localized irrigation system is emitter, which is used to dissipate pressure and flow rate of water at a constant rate at several points along a lateral and variation in flow rate should take place with minor changes in pressure across the lateral. [1] Reported that clogging of some drippers reduces the total flow in the lateral line and caused higher discharge from non-clogged drippers. The properties of emitters that play a vital role in designing a LIS are flow rate variations due to manufacturing tolerance, closeness of flow-pressure relationship to design specifications, drippers flow exponent, operating pressure range, pressure loss in laterals due to insertions of drippers and stability of the flow-pressure relationship over a long period of time. Emitters are classified according to their incorporation in the lateral, flow rate, form of pressure dissipation, and construction [2].

Emitter clogging may be due to physical, chemical and biological factors [3]. Two or more of these reasons may occur at the same time [4].

Also, [5] reported that clogging may be due their extreme small passages of water and low flow rate. Whereas, [6] found clogging at the end of the laterals than at the beginning that caused by pressure head loss. [7] found that normal fertilizers generally tend to clog the emitter.

Maize (*Zea Mays L.*) is considered one of the main crops in Egypt, ranked third in importance to wheat and rice. The irrigation water requirements of maize oscillate between 500 and 800 mm for achievement of maximum production by a variety of medium maturity of seed [8 and 9] who had made an extensive irrigation study in the cultivation of maize, found the same conclusion i.e. 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. The aforementioned criteria were used in the experimental plot for the total irrigation process.

Farmers are forced to adopt improved irrigation managements in order to optimize water use, including the adoption of deficit irrigation and enhancing irrigation performance, thus leading to higher water productivities. The pathway to achieve an efficient irrigation water use imposes the need to systematically optimize the soil and water management practices and the irrigation equipment [10]. Proper scheduling of both sprinkler and drip irrigation is critical for efficient water management in crop production, particularly under conditions of water scarcity [11]. Regarding to the drip irrigation method, not only some savings in water usage occurs, but also the yield increases [12], and the on-farm irrigation efficiency can reach 90% when a properly designed and managed drip irrigation system is used. [13] stated that maize is one of the most important cereals, both for people and animals consumption, in Egypt and is grown for both grain and forage. The questions often arise, "What is the minimum irrigation capacity for irrigated transgenic maize? And what is the suitable irrigation system for irrigating maize?. These are very hard questions to answer because they greatly depend on the weather, yield goal, soil type, area conditions and the economic conditions necessary for profitability.

The aim of the work presented in this paper is studying the effect of automation controller of localized irrigation systems used: bubbler, low head drip and mini-sprinkler irrigation system under different lateral lengths (40, 50 and 60m as a control) on emitter's clogging and maize plant parameters.

2. MATERIAL AND METHODS

Field experiment was carried out in the growing season (2014) in sandy loam soil at the Experimental Farm of National Research Centre, El-Nobaria, El-Behaira Governorate, Egypt. Three localized irrigation systems (LIS) of: a) bubbler (B); b) low head drip (LHD), and c) mini-sprinkler (MS) as a control were put in main plots and three irrigation lateral lengths were set up at 40, 50 and60 m in submain plot and each plot was triplicated (Figs. 1 a and b)

Some soil physical, chemical characteristics such as EC 2.37 dS-1(in extracted soil paste), soil pH (8.10) and CaCO3 (5.7 %) and water properties of the studied soil, irrigation water characterized by 0.36 dSm-1, 7.6 pH and sodium adsorption ratio 2.51, are carried out after [14] and moisture retention at field capacity (9.5) and wilting point (3.6) after [15] and available water by subtracting (5.9% on weight basis). Soils of the experimental site was sandy loam in texture.

Fertilizers added according to the recommended doses as follows: 100 kg/fed superphosphate (15.5 % P2O5) and 30 kg ammonium sulphate (21 % N) during soil preparation. Ammonium nitrate (33 %N) at 100 kg in two equal doses after 28 and 45 from planting. Potassium sulphate (50% K2O) at 50 kg/fed 60 days from planting. Weed and pest control applications were carried out following recommendations.

Maize *(Zea mays L.)*, Giza-155, was cultivated on April, 2, 2013. The distance between rows was 0.7 m and 0.25 m between plants in same row. Each row was irrigated by a single straight lateral line in the closed circuits and traditional drip irrigation plots. Plants densities were 40,000 plants per fed (4200 m2) according to (ISU), Northeast Research and Demonstration Farm. Fig. (2) shows that the total experimental area was 1878 m2. Under each of the tested localized irrigation systems, plot areas of Lateral lines lengths were 168, 210 and 252 m^2 under treatments 40, 50 and 60 m lateral lengths, respectively. Irrigation season of transgenic maize ended 11 days before harvest that carried out on September 15, 2013.

Components of yield measured include plant height (cm), leaf length (cm), leaf area (cm2), number of leaves plant, total grain weight Kg/fed and straw yield (Kg/fed). Plant measurements and observations were started 21 days after planting till harvest date. All plant samples were dried at 65oC. Grain yield was determined by hand harvesting the 8m sections of three adjacent center rows in each plot on 2013 and was adjusted to 12.5% water content. In all treatments, the grain yields of individual rows were determined in order to evaluate the yield uniformity among the rows. Details of the pressure and water supply control have been described by [16]. Uniformity test has been carried out in order to modify lack of pressure head at the end of lateral lines in the MS. Irrigation networks was illustrate in Fig. (3). The emitters used of LHD(GR) built in PE tubes 18mm in (ID) Ø, emitter discharge of 8 lh-1, and operating pressure 0.4 bar. Emitters of BIS were PE, 10 lh-1at 0.4bar and MS were PE, 12 lh-1at 0.4barby pump operating pressure and 30 cm among.

Emitters Clogging:

The emitter is considered laminar-flow-type (Re < 2000) [11]. To estimate the emitter flow rate cans and a stopwatch were used. Ten emitters from each lateral had been chosen to be evaluated by calculating their clogging ratio at the beginning and at the end of the growing season for two seasons. Three emitters were selected at the beginning, middle and end of the lateral were tested for flow rate. Clogging ratio was calculated after [17] using the following equations:

$$E = (qu/ qn)100 \qquad (1)$$

$$CR = (1-E)\ 100 \qquad (2)$$

where: E = the emitter discharge efficiency (%) qu = emitter discharge, at the end of the growing season (L/h) qn = emitter discharge, at the beginning of the growing season (L/h) CR = the emitter clogging ratio (%).

Measuring the Seasonal evapotranspiration (ET):

The (ET) was computed using the Class Pan Evaporation method for estimating (ETo) on daily basis was taken in site from installed station in the NRC farm as showing in Table (1).

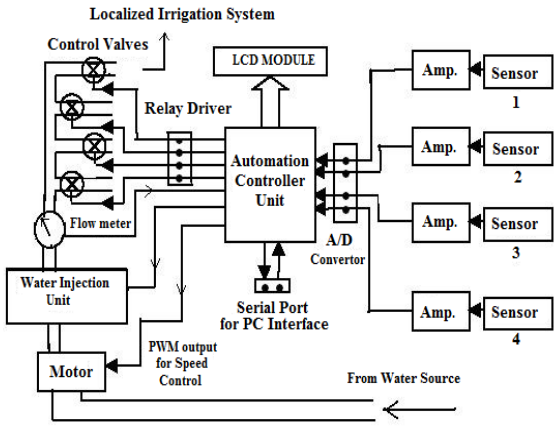

Fig. 1a. Controller unit

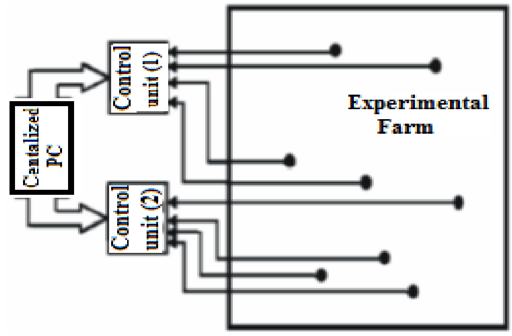

Fig. 1b. Application to field

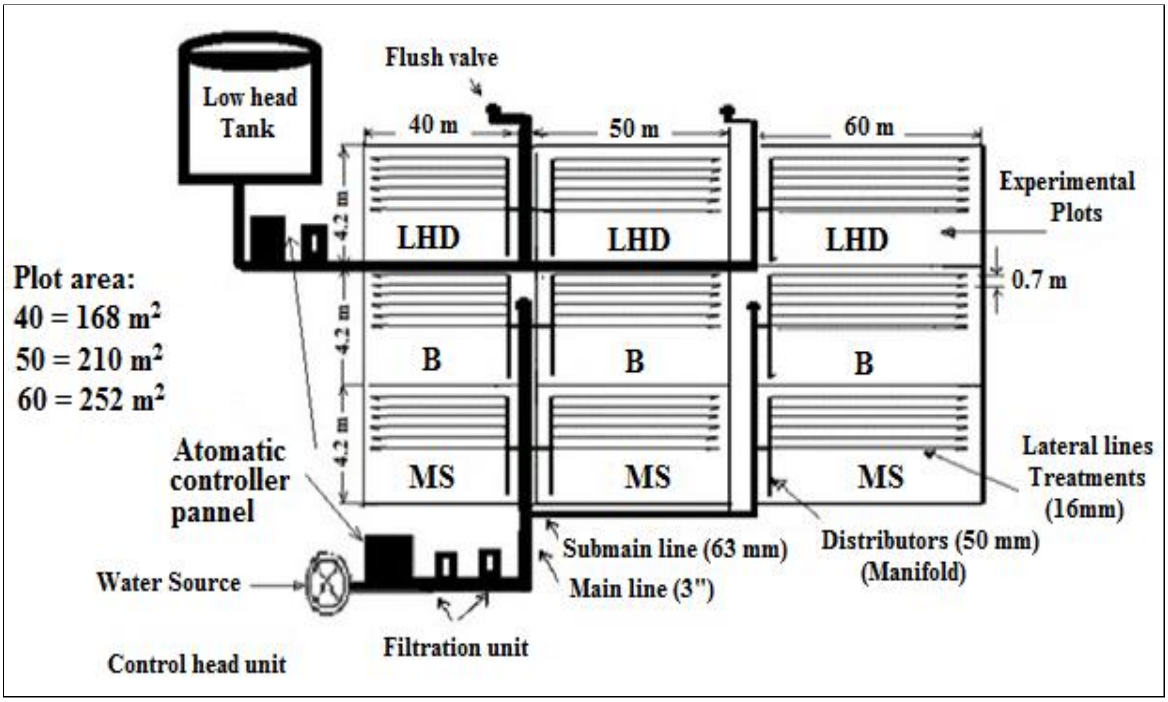

Fig. 2. Layout of Localized irrigation system plots (LHD, B and MS); treatments of(L1=40m;L2=50m and L3=60 m). scale 1:2000

Table 1. 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	0.9	0.95	1	1	1
ETo (mm/day)	4.66	4.52	5.57	6.7	6.59	5.13

ETc (mm/day)	2.2	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.		
Number of Days (Irri. season)	19	42	34	31		
IRg (mm/month)	51.5	227.2	209.7	57.9	257.5	88
IRn (mm/month)	41.8	184.4	170.2	47	209	64.1

The modified pan evaporation equation to be used:

ETo= KpEp…….…….. (6)

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]. [17].

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…..…... (7)

The reduction factor (Kr) was calculated using Eq. 8.

Kr = GC + ½ (1 - GC)……… (8)

Where: GC = ground cover percentage.

Irrigation efficiency (Ea) calculated by

Ea =Ks Eu…………… (9)

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

The investigated main factors and treatments mean were compared using the technique of analysis of variance (ANOVA) and the least significant difference (LSD) between systems at 1 %,[18].

3. RESULTS AND DISCUSSION

3.1 Emitters Clogging.

Different emitters of localized irrigation tubing systems vary among manufacturers. Most emitters use mechanisms that provide a tortuous pathway for the water to pass before being emitted into the soil. Generally, emitter discharge increases with system pressure. However, some types of emitters may be pressure compensating so that water discharge does not change much with variations in pressure[19]

Regarding to the emitters clogging %, data notice that the increase clogging was very close to the amount of water passing through lateral from side and to the correlated irrigation system with operation pressure. Also, data revealed that increased lateral length associated with decrease in pressure, so, increase clogging is expected. The recorded values of the clogging relative to the LIS and lateral length were 8.53, 10.68, 14.25 and 3.34, 12.27; 18.68, respectively.

Table 2. Main effect of automation localized irrigation systems and lateral lengths on emitters clogging %.

Main factors and treatments	% Emitter Clogging
LHD	8.53a
B	10.68a
MS	14.25b
L1 40	6.34a
L2 50	12.27a
L3 60	18.86c

Data in Table (2) and Fig (3) indicated to emitter's clogging % of main factors and treatment of different automation localized irrigation systems and lateral line lengths, the best and/or lowest percent recorded 8.53 % with low head drip irrigation system (LHD) while the highest percent of emitter's clogging was 14.25 % recorded under mini-sprinkler irrigation systems (MS), and the percent 10.68 % was recorded bubbler irrigation system. Emitter's clogging percent of lateral lengths treatments recorded 6.34, 12.27; 18.86 % under 40, 50; 60 m, respectively. There are no significant differences between all main factors and treatments exception between MS and 60 m with all percentage values.

Table 3. Interaction between automation localized irrigation systems and lateral lines lengths on %of emitters clogging.

localized irrigation systems	Lateral length (m)		
	40	50	60
low head drip	7.43a	10.40b	13.67c
Bubbler	8.51a	11.48b	14.77c
Mini-sprinkler	10.30b	13.26c	16.56c

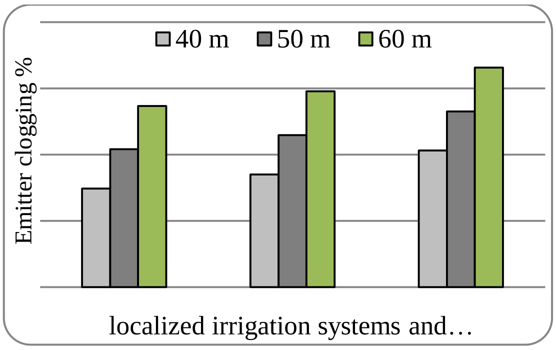

Fig. 3. Effect of automation irrigation systems and lateral lines lengths on emitter clogging%.(LHD: low head drip irrigation system, B: bubbler, MS: mini-sprinkler).

Data in Table (3) showed the interaction between main factor of different automation localized irrigation systems and treatments of lateral lengths. The highest interaction of emitters clogging 7.43 % achieved in case of LHD and lateral length 40 m, while the highest interaction of emitter clogging(16.56 %) was achieved with MS and 50 m in same sequence. the abovementioned results was in a harmony with those obtained by [20, 21; 22]

3.2 Maize vegetative growth.

Table (4) shows localized irrigation systems (LIS) and the lateral length on some vegetative growth and yield parameters of maize. Measured parameters were: leaf area (cm2), plant height (cm), leaf length (cm), number of leaves plant-1, grain yield and straw yield (ton/fed). The obtained data indicated that the effect of LIS and lateral length could be ranked in the following descending orders: LHD > B > MS and 40>50>60 m, respectively. Differences within values of both LIS lateral length treatments were significant at the 5 % level except that between LHD and B.

The effect of interaction between two studied factors were significant at the 5 % level except in the following interactions: LHD X 60 m, B X 50 m, B X 60 and MS X 60. The maximum and minimum values of plant height were attained in the interactions of lateral length and LIS as follow: 40 X LHD and 60 m X MS, respectively. The data on hand agreed with [23],who published an extensive review of drip irrigation system research covering both agronomic and horticultural crops as well as design and management considerations. [24] reviewed some of the historical, present and anticipated future uses of drip irrigation system, concluding that research and manufacturing advances have allowed a greater using drip irrigation system for a larger array of lower-value, commodity-type crops. Drip irrigation system has not been used extensively in the Great Plains (central USA) for field corn (Zea mays) production because of high initial costs and because of the uncertainty about drip irrigation system life. However, with increasing concerns about water conservation and water quality protection, irrigators are looking for more efficient irrigation systems.

However, [23] observed a similar value for subsurface drip irrigated corn. [24], in their synthesis on indicators of crop water status, demonstrated that soil water status assessed through criteria like soil water content, volume of water supply, humidity, or soil water potential constitute an imperfect parameter to characterize real plant water status, and it leads consequently to variability in water use efficiency. [25] added that there is no consistent relationship between plant production and water use efficiency. It may therefore be further concluded that for conditions where high water use efficiency is an advantage because it is a marker for low water use, selection for the preferred plant type can be done by directly selecting for small plant size, small leaf area, or reduced growth duration.

Table 4. Effect of localized irrigation systems and lateral lengths on maize plants growth and yield.

Localized irrigation system	Lateral length (m)	Growth and Yield Characteristics at Harvest(average)					
		Leaf area (cm^2)	Plant height (cm)	Leaf length (cm)	No. of leaves per plant	Yield (ton/fed)	
						Grain	Straw
LHD	50	495.1a	195.5a	70.1a	16.3a	4.8a	5.8a
	75	492.7c	194.1cb	68.3d	15.7b	4.6b	5.5cb
	100	488.3e	193.4d	67.4e	15.0ef	4.3ed	5.2e
B	50	494.1b	194.4b	69.8b	15.7cb	4.5cb	5.7ba
	75	486.2f	193.3ed	67.4fe	15.0fg	4.3fe	5.5dc
	100	473.3h	192.7h	66.2g	14.4h	4.1g	5.1f
MS	50	492.2d	193.1f	69.1c	15.3d	4.4dc	4.9g
	75	484.5f	192.9gh	66.2h	15.0g	3.8h	4.5h
	100	469.2i	191.2i	65.9i	14.0i	3.5i	4.2i
interaction	LSD 0.05	1.6	1.1	0.6	0.4	0.2	0.3
Localized irrigation system	LHD	492.0a	194.3a	68.6a	15.7a	4.6a	5.5a
	B	484.5b	193.5b	67.8b	15.0b	4.3b	5.4ba
	MS	482.0cb	192.4c	67.1c	14.8cb	3.9c	4.5c
	LSD 0.05	1.3	0.8	0.5	0.3	0.2	0.2
Lateral length	50	493.8a	194.3a	69.7a	15.8a	4.6a	5.5a
	75	487.8b	193.4b	67.3b	15.2b	4.2b	5.2b
	100	476.9c	192.4c	66.5c	14.7c	4.0cb	4.8c
	LSD 0.05	1.9	0.9	0.7	0.5	0.3	0.3

LHD: low head drip, B: Bubbler, MS: mini-sprinkler, fed (4200 m^2)

3.3 Maize grain yield (GY).

Regarding to the effect of of LIS and plant height on maize GY (ton/fed), it could be ranked in the following ascending orders: MSIS < BIS < LHDIS and 60 < 50 <40 m, respectively. In respect to the studied main effect of LIS on GY, one can notice that, the differences in GY were significant among all investigated LIS at the 5 % level. The highest and lowest GY were obtained in LHD and MS, respectively. While there is significant differences at the 5 % level between GY of lateral length 40 m and both of 50 and 60 m, but the differences between 50 and 60 m lateral length isnon-significant whenever highest and lowest values were achieved at 40 and 60 m, respectively. Concerning to the GY as affected by LIS X lateral length, there were significant differences at the 5 % level, except at the following interactions: LHD X 60, B X 40, B X 50 and MS X 40 m. The maximum and minimum values of GY were obtained in LHD X 40 m and MS X 60 m, respectively. This finding agreed with obtained by [26].

We can notice that maize GY 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 yield from the other one. These data supported by [27],who compared the relative efficiencies of trickle, sprinkler, and furrow irrigation for maize production in Texas and found that irrigation water-use efficiencies (i.e., the ratio of crop yield increase to irrigation applied) of 0.0140, 0.0119, and 0.0115 Mg ha-1 mm-1 with the three respective systems. In a limited study in Italy, [28] reported that yield increases of up to 35% with subsurface drip irrigation as compared with sprinkler irrigation for maize. [29] evaluated subsurface drip irrigation for corn production in the southeastern Coastal Plain of the USA. They found that subsurface drip irrigation required less irrigation water than surface drip irrigation did.

3.4 Maize Straw yield (SY).

Results notice that the change in SY took the same trend of vegetative growth parameters and thus took the trend of GY also due to previous reasons mentioned before (Table 4). Concerning the positive effect of (LIS and lateral length) on SY, they could be ranked in following descending orders: LHD>B>MS and 40>50>60 m lateral length. In respect to the effect of LIS and lateral length on the SY, one can notice significant difference at the 5 % level between all means values of LIS and lateral length except LHD and B.

Although, high frequency is generally touted as a major advantage of micro irrigation, this is not the general case for maize in this region. [30] reported that irrigation frequency (continuous or pulsed irrigation) did not affect micro irrigate maize yields on loamy sands in the Atlantic Coastal Plain, whereas [29] reviewed several surface drip studies and concluded that some crops respond to high frequency on some soils and some do not. Some published articles indicates that decreasing lateral lines of surface or subsurface drip irrigation systems may be beneficial under deficit irrigation conditions where a slow, seasonal mining of the soil water is occurring or in cases where frequent fertigation is practiced.

4. CONCLUSION

It could be concluded that: Emitter's clogging % increased with increasing needed operating pressure and increasing lateral length. Emitter's clogging % could be managed through using low head pressure system and decreasing lateral line. Growth and yield parameters (leaf area (cm2), plant height (cm), leaf length (cm), number of leaves plant-1, grain and straw yield (Kg fed-1), LIS and LLL used could be ranked in the following ascending orders: MS < B < LHD and 60<50<40 m, respectively for all studied parameters. The highest values of leaf area (cm2), plant height (cm), leaf length (cm), number of leaves plant-1; grain and straw yield (Kg fed-1) could be seen in the interactions: LHDX 40 m ; MS X 60 m, respectively. Under automatic control different localized irrigation systems and different lateral lines lengths, we recommend planting maize under the treatment (LHDIS X 40 m) which was found to be suitable for high production of GY and SY and using either BIS or MSIS according to their availability.

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