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ENGINEERING MANAGEMENT OF SURFACE DRIP IRRIGATION SYSTEMS

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ABSTRACT

Recently maintenance operation is considered one of the main axes of engineering management of pressurized irrigation systems. There for the aim of this research work was to select the most suitable maintenance programs to improve drip irrigation systems laterals performance, and decrease the damages caused by emitter clogging as a result of bad maintenance applications. The physical maintenance programs included lateral end flushing with two different operation times"5, 10 minutes at the end of each irrigation", at four interval times "weekly, Bi-weekly, monthly, and at the end of each season". The flushing 5minutes was applied once continuous, and the other intermitted.

The systems performance was evaluated through three parameters: discharge, clogging, and pressure through seven evaluation criteria mentioned in the research.

The results showed that bi-weekly flushing for 5 min. continuously (MS_1P_12) proved to be the best flushing with fresh water program which decreases clogged emitters 44.21 % to be closer to the standard (control) with 4.85 %. Also partially clogged emitters decreased by 46.7 %, Emission uniformity(EU%) increased 19.4 %, and distribution uniformity(DU%) 13.9 % more than the control treatment. (MS_1P_12) was followed by the weekly flushing for 10 min. continuously. (MS_3P_11) as it raised (DU%) with 12.3 % and gave the highest value of pressure uniformity (UP%) that reaches 93.14%.

Keywords: drip irrigation system, performance, maintenance, flushing, clogging ratio ,distribution uniformity.

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INTRODUCTION

Drip irrigation fine performance deserve a wide branch in the scientific researches, for its importance in the agricultural future in Egypt. By the year 2005, 88547.6 feddans were greenhouses cultivations which produce 799.81 thousand tones/ year ***(S.I.A.S. 2006)***. The vegetables cultivations under greenhouses are important economically, fine drip irrigation will raise the total exports of vegetables that reached 1841.05 thousand tones / the year 2004, with a value of 651.29 million U.S. dollars, This exports of vegetables equal almost half the total agricultural and food exports in Egypt which is 1241.66 million U.S. dollars/the year 2004.***(A.A.S.Y.B. 2005).***Determining the exact cause of emitter clogging can be complex because the various agents in the water can interact with each other, aggravating the clogging problem. Moreover, considering the dynamic nature of many water quality parameters there is no way to predict if a clogging problem will develop in the long run ***(Ravina et al. 1992).***

Where farmers tend to complement or replace drip systems for peaches by sprinkler irrigation, showed that the main constraints were maintenance problems, and the control of filtration and rate of flow***(Revol et al. 1995)***.Filtration systems do not normally remove clay and silt particles, algae and bacteria because they are too small for typical economical filtration. These particles may travel through the filters as individual particles, burthen flocculate or become attached to organic residues and eventually become large enough to clog emitters ***(Nakayama et al. 2007).(Babagallo and Buttafuoco 1998)*** mentioned that pipe flushing at the end of the irrigation season and increasing water pressure did not fully clear clogged emitters.Preventive maintenance of the pumping system is essential during the irrigation season ***(Phocaides 2001)***.The long-term operation of the irrigation installation depends upon simple maintenance carried out by the farmer. The periodic servicing of pumping plants and the repair of special devices (filters, injector, etc.) is carried out by trained maintenance and repair personnel***(Phocaides 2001)***.

(Vieira et al. 2004) used phosphoric acid, sodium hypochlorite, and a commercial product and mechanical treatment for cleaning drippers in which the clogging was due to the presence of high iron content in water and concluded that . The mechanical treatment is a good alternative to recover the drip irrigation systems.

The irrigation system should be designed so that it can be flushed properly. To be effective, flushing must be done often enough and at an appropriate velocity to dislodge and transport the accumulated sediments ***(Nakayama et al. 2007)***. A minimum flushing velocity of 0.3 m/s is recommended for microirrigation systems ***(ASAE 1996)***. Flushing velocity of 0.5-0.6 m/s may be needed when larger particle sizes need to be removed, like when coarser filters are used ***(Hills and Brenes 2001,Nakayama et al. 2007 Cited by Puig-Bargu□s et al.2010)***. Drip irrigation system in China, which has been operational for 8 years. Some suggestions to solve the problem of clogging are described, including enhanced filtration, timely flushing and improving the route of water in the emitter ***(Wu et al., 2004)***.

There is not ageneral agreement on what is the best flushing frequency. Several researchers have studied different flushing frequencies: daily with stored treated effluents ***(Ravina et al. 1997)***, twice per week ***(Tajrishy et al. 1994)*** and once per week ***(Tajrishy et al. 1994, Hills et al. 2000)*** fortnightly and monthly with stored groundwater ***(Hills et al. 2000)***. However, in many areas only one flushing is carried out at the beginning and/or at the ending of irrigation season ***(Puig-Bargu□s et al.2010).***Emitter clogging was greater when no dripline flushing was carried out. However, no significant difference was observed between flushing intervals carried out at a velocity of 0.6 m/s ***(Puig-Bargu□s et al. 2010)***.

Filtering and flushing drip lines are simple and useful methods to prevent emitter clogging. Also flushing can clear the inorganic and organic materials precipitated in emitter orifices and on the inside –wall of drip hoses out of the system. Chemical clogging can be controlled with acid injection which can lower the PH value of irrigation water and thus prevent chemical precipitation ***(Ravina et al. 1992 and Dehghaisani et al. 2005)***. Emitter clogging was greater when no dripline flushing was carried out. However, no significant difference were observed between flushing intervals carried out at a velocity of 0.6 m/s ***(Puig-Bargu□s et al. 2010)***.Drip irrigation systems must have good and consistent filtration, water treatment, flushing and maintenance plans to ensure long economic life ***(Lamm and Camp 2007).*** We also recommend that an air/vacuum relief valve be used for drip irrigation to avoid ingestion of soil particles due to back siphoning. Flushing at a flushing velocity of 0.6 m/s was adequate when it was performed monthly or only at the end of the irrigation season ***(Puig-Bargu□s et al. 2010)***.

The aim of this study was to select the most suitable maintenance program for surface drip irrigation system laterals performance through twelve programs and subprograms.

MATERIALS AND METHODS

Field work was carried out in the central greenhouses of the Ministry of Agriculture, at Dokki.Flushing with water programs were tested in three 6 years old net work, triple greenhouses, shown at fig.1.

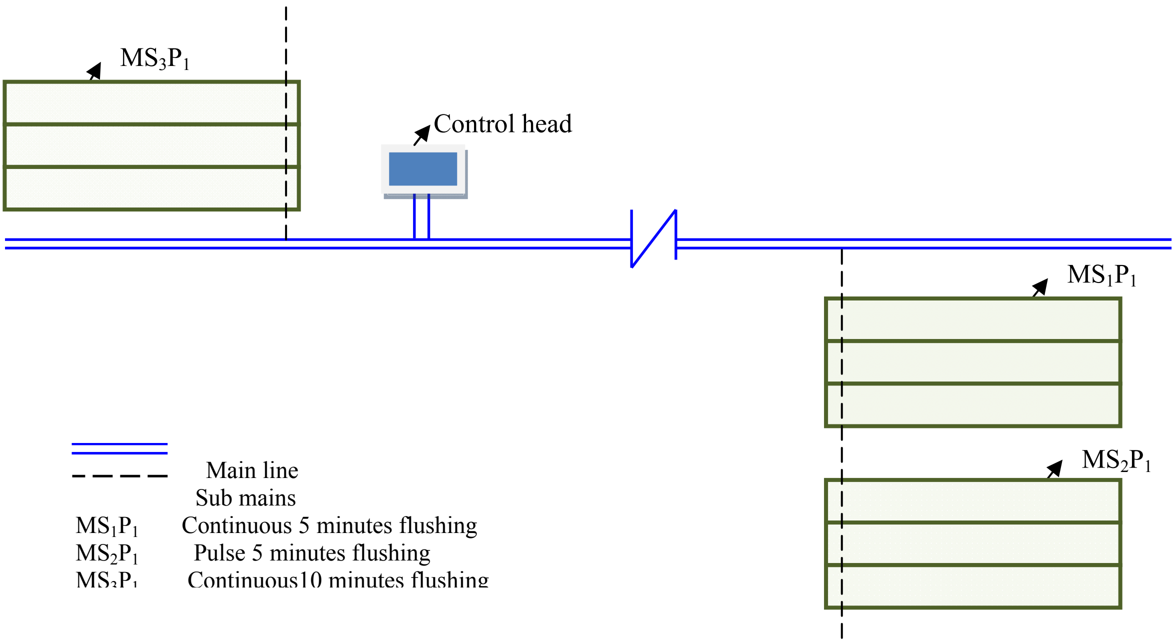


Fig.1:Flushing with water programs location.

MATERIALS:

Flushing with water programs were tested in 6 years old network, triple greenhouses in the central greenhouses of the Ministry of Agriculture at Dokki, the layout of which is shown at fig.1., Each greenhouse has the same dimensions 24m width×60m length, and covered by polyethylene plastic at a height of 10 m.

Studied drip system components consists of: Control head located at the source of the water supply which was a well of 60-80 m^3/hr, consists of 3″/2″ screen filter 120 mesh/inch, Pressure gauge, valves before and after the filter, The fertigation unit which is a venturimeter. Main lines made of P.V.C. pipes, 110 mm dia. Manifold also P.V.C. pipes, 90 mm dia. , Sub main lines made of P.V.C., 75 mm dia., Laterals made of 16 mm Polyvinyl-ethylene (PE) hoses, and distributors which are built in emitters, 4 l/hr, 0.5m spacing.

1. Water and Soil irrigation analysis:

Soil samples were collected from the investigated area, analyzed in the soil science central laboratory, Fac. of Agric., Cairo university. The properties of the irrigation water and the soil are shown in tables 1, 2.

Table.1.Water chemical analysis

	PH	EC Ds/m	Cations (meq/l)				Anions (meq/l)		
			Ca^+	Mg^+	Na^+	K^+	HCo_3^-	cl^-	$So_4^=$
Irrigation water	7.68	0.52	0.1	1.3	2.7	0.2	2.0	2.2	1.0
Leaching water*	7.85	0.50	1.2	1.6	2.0	0.2	2.2	2.5	0.3

* Leaching water was taken from the laterals end in the beginning of the system operating before the search treatments.

Table.2. Soil chemical and mechanical analysis

PH	EC	Cations (meq/l)				Anions (meq/l)		
		Ca^+	Mg^+	Na^+	K^+	HCo_3^-	cl^-	$So_4^=$
7.65	6.2	27.5	14.0	16.66	3.8	3.0	21	38

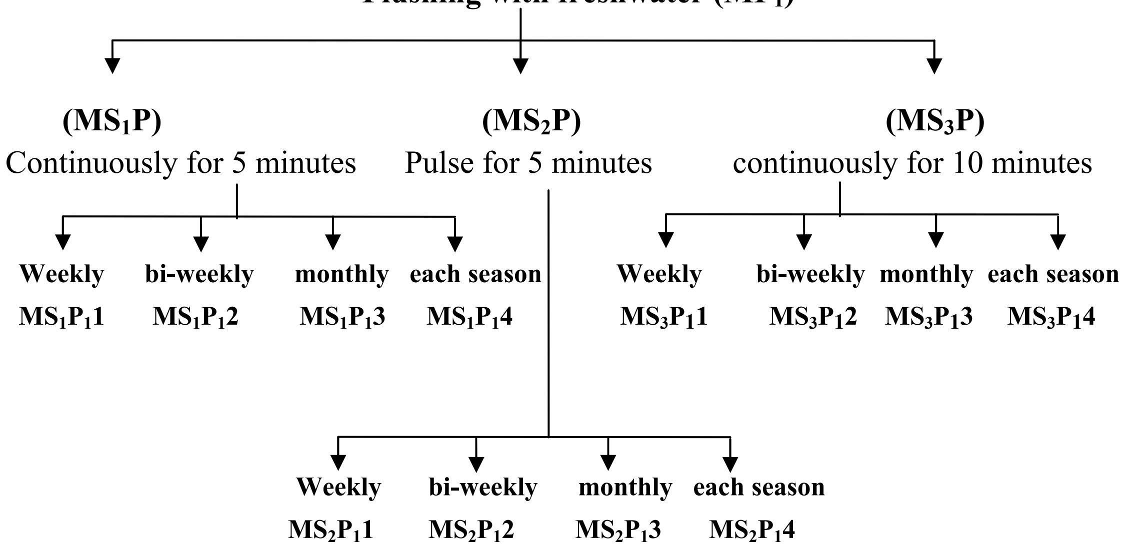
Soil texture	C. sand	F. sand	Silt	Clay
Sandy Loam	5.69	60.37	16.80	16.78

Methods:

<u>Maintenance procedure:</u> Maintenance programs steps are mainly for cleaning clogged and partially clogged emitters, repairing any damage, changing the lost components and control unit. According to ***(Halvey et al. 1973)*** individual cleaning for tricklers, and using pressurized water have many draw bakes as mentioned in the literature review, and flushing the net proved to be the suitable method for cleaning clogged emitters.

<u>Flushing procedure:</u> The studied maintenance program (MP_1) of drip lines flushing concentrate in twelve cases covering three sub main programs as illustrated in the following sciliton.Maintenance program2 (MP_2) is a new net work studied to compare the tested maintenance program with it, as a standard performance was

Flushing with freshwater (MP_1)



Measurements and calculations:

Four lines in each block and four stations on each line were selected for measuring the required parameters (Q, P) to evaluate the performance of such maintenance program using the Merriam and Keller (1978) method, modified by Vermeiren and Jobling (1986). The measured discharges and pressures at each station on each selected line which were used in evaluating criteria were mean of at least ten times of measures.

a. Discharge evaluation criteria:

1. Emission uniformity:

$$E = \left(Q_{lq} / Q \right) * 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

E: emission uniformity percentage (%).

Q_{lq}: is the mean of lowest one fourth of emitter discharge observations (l/h), and

Q: is the average of emitters flow rate (l/h).***(Keller and Bliesner 1990)***

Emission uniformity is not a parameter of efficiency, but it is not possible to have high efficiency when emission uniformity is low ***(Burt et al. 1997, Cited by Capra and Scicolone 2007)***.

2. Distribution uniformity along laterals:

$$DU = \left(Q_m / Q_n \right) * 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

DU: Distribution uniformity along laterals %.

Q_m : Average of measured discharge(l/hr).

Q_n : nominal discharge (l/hr).

3. Percentage of the initial flow rate:

$$q_{po} = \left(\frac{q}{q_o} \right) * 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

q_{po}: is the percentage of the initial flow rate

q : is the emitter flow rate, taken as the final reading average (l/h).

q_o : is the initial emitter flow rate, taken as the first reading average (l/h).***(Duran-Ros . et al. 2009)***

b. Clogging evaluation criteria:

1. Partial clogging ratio:

The degree of emitter clogging was estimated by using the following equation:

$$CRp = \left(1 - \left(Q_{avg} - Q_d\right)\right) * 100 \qquad \ldots\ldots. (4)$$

Where:

CRp: The emitter partial clogging ratio, (%),

Q_{avg} : The average flow rate for each used emitter (l/h)

Q_d: The design flow rate for each new emitter (l/h).***(Sultan 2001)***

2. Complete clogging ratio:

Complete clogging ratio (CR_c%) is computed as the percentage of the wholly clogged of the whole number of emitters.

$$CRc = \left(\frac{N_C}{N_T} \right) * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where:

CR_c: Complete clogging ratio (%),

N_c: The number of totally clogged emitters.

N_T: The total number of emitters.

The emitter plugging is an indirect measure for assessing the effectiveness of a filtration system. In addition its degree can be used as a measure of the effectiveness of preventive practices such as chemical water treatment. ***(ASAE Standard1996)***

3. Emitter flow variation:

The emitter flow variation can be calculated by comparing the maximum and minimum emitter flow rates according to the following equation:

$$Q_{var.} = [Q_{max.} - (Q_{min.}/Q_{max.})] \times 100 \quad \ldots\ldots (6)$$

Where:

$\mathbf{Q_{var.}}$: percent of discharge variation along the lateral line,

$\mathbf{Q_{max.}}$: maximum discharge, and

$\mathbf{Q_{min.}}$: minimum discharge with same units.***(Wu and Giltin 1983, Cited by Hezarjaribi et al. 2008)***

c. Pressure evaluation criteria:

1. Pressure uniformity (U_P%):

$$U_p = \left(\frac{P_{25}}{\overline{P}} \right) * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Where:

U_P : is the pressure uniformity.

P_{25}: is the average pressure of 25% of the emitters with the lowest pressure (kPa).

$\overline{P}$: is the average pressure of all the tested emitters (kPa).***(Bliesner 1976; sited by Duran-Ros et al. 2009)***

2. Pressure variation along laterals (ΔH%):

$$\Delta H = \left(\frac{\Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4}{N_L} \right) * 100 \quad .... (8)$$

Where:

ΔH: Pressure variation along laterals (%).

ΔH_1, ΔH_2, ΔH_3, and ΔH_4: Pressure difference between laterals inlet and end, for the four selected laterals, respectively.

Statistical analysis:

The data resulted from this research work were analyzed using SAS, 2008 statistical analysis program. The used type of statistical analysis was one way analysis of variance using Duncan's multiple range test.

RESULTS AND DISCUSSION

Chemical analysis of the irrigation water and the lateral flushing water showed a slight increment of 0.2 meg/l for Hco_3 and ca^{++}, and 0.3 meg/l for Cl^- and mg^{++}. On the other hand the physical analysis of the soil showed that the texture of the soil is sandy loam. By correlating both the chemical and physical analyses results , the problem of clogging is more likely to be physical rather than chemical in that specific location . Thus flushing of drip lines with water treatments were applied as a proper maintenance program.

The results of the studied maintenance programs were compared with a standard new network attitude, and the control of each program apart.Tables1,2 present the new net work results ,and the MP_1 control treatment data and calculations.

Table.3. A standard new network

Line Position	1		2		3		4	
	H_{bar}	$Q_{l/hr}$	H_{bar}	$Q_{l/hr}$	H_{bar}	$Q_{l/hr}$	H_{bar}	$Q_{l/hr}$
Inlet	1	4	0.8	3.5	0.8	3.6	1	3.913
First 1/3	1	4	0.7	3.458	0.9	4	0.9	3.717
Second2/3	1	4	0.8	3.558	0.9	4	0.8	3.496
End	0.9	4	1	4	1	4	0.85	3.683
$Q_{average}$		4		3.629		3.9		3.702
ΔH	0.1		0.2		0.2		0.15	

Although the net work was new, the discharge readings vary, but they were suitable to operate the system efficiently, that could be due to manufacturer variation. According to ***(Hezarjaribi et al. 2008)*** In the manufacturing processes there will be variations in passage size, shape, and final finish. The flow rate in trickle irrigation emitters is small; therefore any variation can cause large variation in relative flow rates.

The variations resulting from manufacturing process are generally assumed to be one of the significant parameters related to uniformity and efficiency of the system.Calculations confirms that. E%, DU%, and $Q_{var.}$% values were in the optimum range. This result was due to the age of the net which did not allow sediment to occur yet.

On the other hand, the measured pressure values were not equal to nominal values. For example ΔH along the lateral=16.3 while it must be in the range 10-15%.

Table.4.Water control treatment

Line	1		2		3		4	
Position	H_{bar}	$Q_{l/hr}$	H_{bar}	$Q_{l/hr}$	H_{bar}	$Q_{l/hr}$	H_{bar}	$Q_{l/hr}$
Inlet	0.6	2.85	0.7	3.13	0.65	2.5	0.7	3
First 1/3	0.6	2.8	0.7	3	0.5	2	0.6	2.8
Second2/3	0.6	2.333	0.6	2.5	0.5	1.9	0.6	2.45
End	0.5	2	0.5	1.95	0.55	1.95	0.5	1.5
$Q_{average}$		2.496		2.645		2.088		2.438
ΔH	0.1		0.2		0.1		0.2	

Table 2 shows the attitude of the water program network without maintenance. The measured data vary a lot from the optimum values. This variation in the readings may due to non regularity of the maintenance operations for this net work before. For example the calculated E%, and DU% values differs with 64.34, and 18.9% respectively less than the optimum values measured in the new network. While CR_c % and CR_P% are more with 39.36 and 66.4%.

Table.5.Maintenance programs evaluation

	DU%	EU%	q_{po} %	CR_P %	CR_c %	$Q_{var.}$ %	UP %	ΔH_b	O.V.C
MS_1P_1	77.4	77.43	97.1	32.99	17.69	3.12	88.07	0.18	5.48
MS_1P_1	90.5	65.91	80.0	31.19	2.96	3.27	92.19	0.11	8.53
MS_1P_1	83.67	43.01	80.58	56.99	12.64	1.37	90.11	0.18	3.63
MS_1P_1	81.72	38.97	49.8	42.48	67.57	2.20	90	0.14	2.00
MS_2P_1	85.36	24.27	82.83	43.32	2.88	2.42	91.39	0.14	5.05
MS_2P_1	85.3	79.29	68.02	45.79	3.15	2.31	85.07	0.19	6.16
MS_2P_1	84.2	56.98	69.57	58.02	43.96	2.51	88.45	0.14	2.52
MS_2P_1	81.0	57.96	69.12	65.65	23.21	1.42	90.04	0.11	2.96
MS_3P_1	88.94	36.27	91.7	45.83	6.033	2.68	93.14	0.11	4.93
MS_3P_1	77.29	53.72	91.46	56.44	2.95	2.60	85.58	0.15	4.39
MS_3P_1	82.43	42.08	96.87	55.85	5.85	2.94	81.96	0.18	4.04
MS_3P_1	81.12	44.15	83.36	51.36	25.43	2.02	92	0.09	3.18
Water co	76.6	46.47	68.04	77.95	47.17	1.98	87.22	0.15	1.87
MP_2	95.5	88.61	82.24	11.64	7.81	3.41	81.2	0.16	15.19

The eight evaluation criteria mentioned previously were calculated for each program. Following discussion will concentrate on the most convenient criteria as followed:

1- Effect of maintenance programs on discharge criteria:

a. Distribution uniformity:

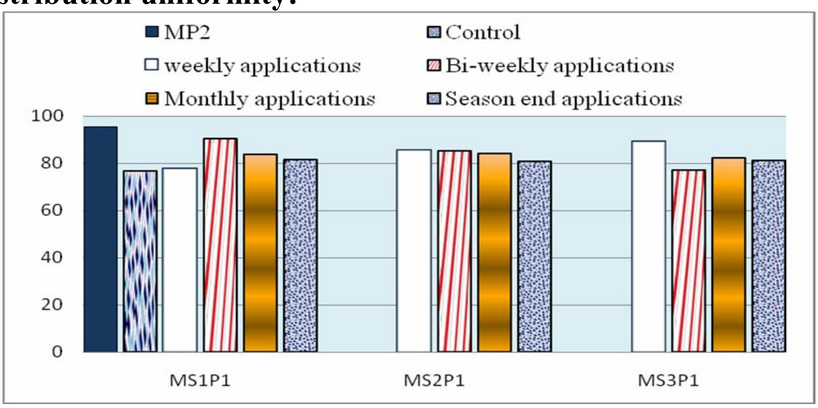


Fig.2.Effect of flushing programs on Distribution uniformity discharge criteria.

Distribution uniformity increased, the highest value of DU% was after 21 times of lateral weekly flushing for 5 minutes, which shows that ordinary maintenance of flushing laterals a time each season end isn't enough.

On the other hand, weekly application of continuous 10 min. flushing (MS_3P_11) followed by weekly application of pulse flushing sub program (MS_2P_11) were the best applications that improve DU% Value to be closer to the standard with 12.34%, and 8.699% more than the control, after the two programs respectively. But this increment is not significant statistically, so the weekly continuous flushing for 5 minutes (MS_1P_11) that is finally recommended.

The criteria DU% also is encouraging using the bi-weekly application of continuous flushing for 10 minutes(MS_3P_12) as a proper maintenance program because it is the only among the three submain programs that achieved the lowest improvement mathematically 0.69%, but shows a statistical significant difference towards MP_2, at accuracy of both 0.01and 0.05.

DU% almost has almost equal values for MS_1P_14, MS_2P_14, and MS_3P_14 which are less than MP_2 with 13.78, 14.49, and 14.38% respectively. That indicates that this treatment is not enough to clean sediments or raise lateral performance.

b. Emission uniformity:

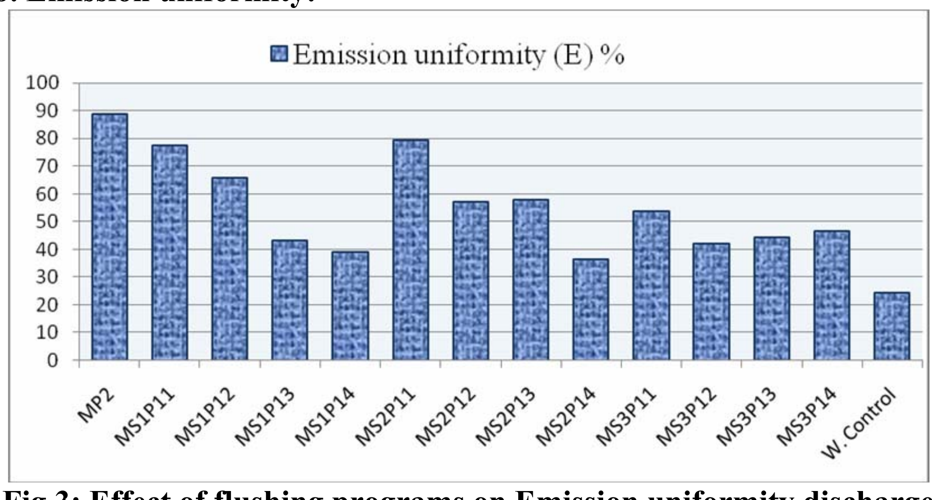


Fig.3: Effect of flushing programs on Emission uniformity discharge criteria.

Emission uniformity after the weekly application of continuous flushing for 5 minutes program (MS_1P_11) was highly significant at accuracy of 0.01, and 0.05,
It is clear that, MS_1P_11 shows the highest increment for E%, as the gap between control treatment and the standard new net work (MP_2) was 14.2% .Then after MS_1P_11 application the gap decreases to 11.177%.E% for the monthly application of continuous flushing for 5 minutes program (MS_1P_13) is less than the 10 minutes flushing at the same application (MS_3P_13) with 1.13% only, both monthly applications differs than the standard new net work (MP_2) with 45.587%.So these applications were not recommended.
Although E% for MS_3P_14 was the highest, but it is far from the optimum with 42.129%, which reflects no effect on improving the network performance sufficiently. Finally discharge criteria referred to the programs MS_1P_11, and MS_3P_12 as the best weekly treatments.

2- Effect of maintenance programs on clogging criteria:

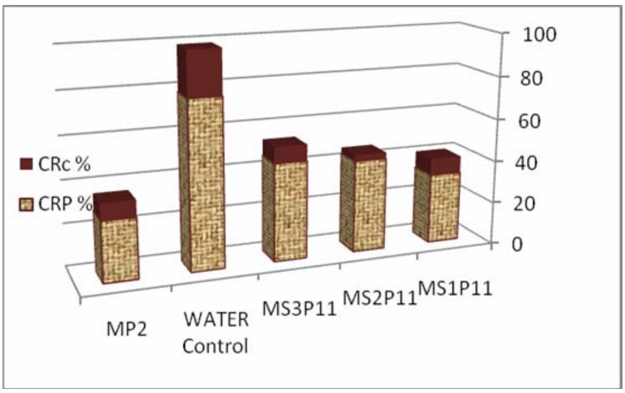


Fig.4.Clogging ratios in weekly water flushing programs.

All applications except weekly application didn't show a significant difference for clogging ratios. The results of weekly application presented at fig. 4 showed that complete clogging decreased by both using pulse maintenance in (MS_2P_11), and more time of continuous maintenance in (MS_3P_11).For example the weekly application of pulse flushing (MS_2P_11) is highly significant higher than MP_2 with 15% for partial clogging. Also (MS_1P_12) results into the greatest decrease in CR_C% with 5% closer to (MP_2).

The high values of complete clogging after (MS_1P_11), and partial clogging after (MS_3P_11) may be attributed to the increment of precipitations of non soluble salts, which showed that 5 minutes flushing is not enough time in this case to remove precipitations totally from the lateral.

3. Effect of maintenance programs on pressure criteria:

a. Pressure variation:

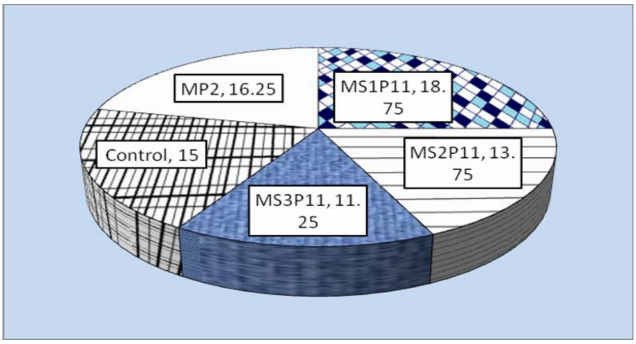


Fig.5. Effect of weekly water flushing programs pressure variation.

After (MS_1P_11) application Δh raises 3.75% more than the control as shown in fig.5., that may due to sediments slow movement through the lateral, which increase the clogging and so the pressure variation. On the other hand both using pulse maintenance in (MS_2P_11), and more time of continuous maintenance in (MS_3P_11) decrease Δh 1.25% and 3.75% respectively.

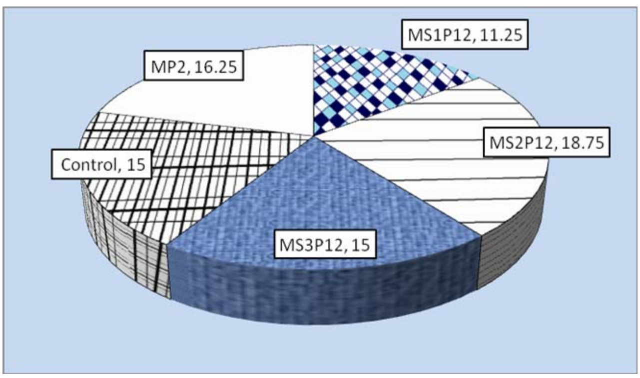


Fig.6.Effect of bi-weekly water flushing programs on pressure variation.

Δp became lower in each time of end flushing, until the precipitations stuck with the lateral walls began to solute. It became higher, then low and high alternatively, but ends with reasonable difference close to10%. Fig.6. pointed out that, every two weeks application programs are all simi similar to each other, results are lower than the weekly treatments with 5%, 8%, for (MS_1P_12) and (MS_2P_12), but (MS_3P_12) gives the same result, so two weeks application for this programs is not recommended.

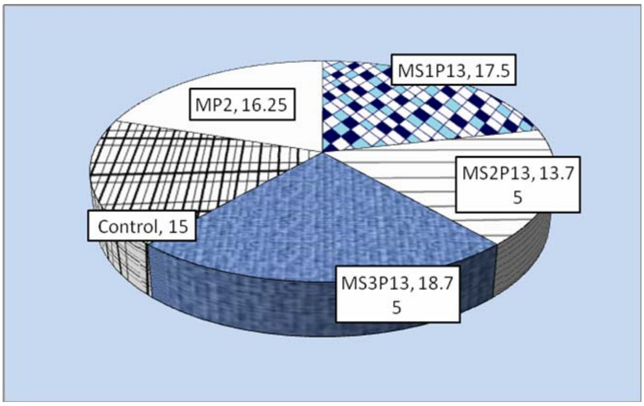


Fig.7. Effect of monthly water flushing programs on pressure variation.

Monthly application of (MS_1P_13) and (MS_3P_13) results don't differ than control significantly, added to that, their values were higher than the control so they were excluded.Commenting on the pressure variation for the sub programs of MP_1 when applied monthly, (MS_2P_13) reduce Δh 1.25%.

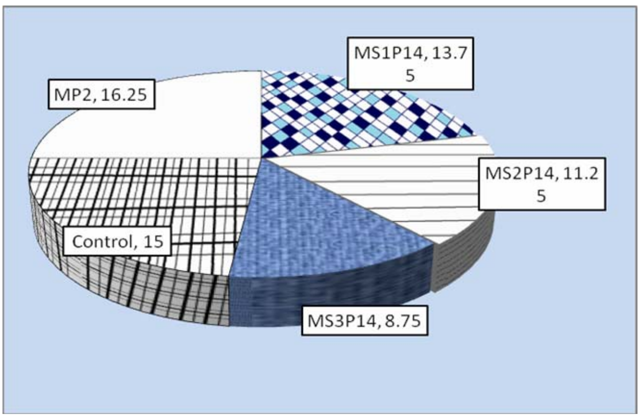


Fig.8. Effect of season end water flushing programs on pressure variation.

Season end application (MS_1P_14) does not differ than the monthly application (MS_1P_13).The reduction of Δh achieved by the monthly and season end applications is non significant in improving the network performance.

b. Pressure uniformity:

All the programs increase the pressure uniformity, but MS_3P_11 was the best, as it achieved the most improvement 11.92% more than MP_2.It is clear that (MS_1P_12) is the best biweekly application as it is 10.9% more than MP_2.Sub programs of (MSP_14) are all excluded, because The values of pressure uniformity (U_P%) were not significantly different in the three sub programs.

4.Relationship between maintenance systems and precipitations:

We can conclude that bi-weekly end flushing for 5 minutes continuously (MS_1P_12) does not make difference, sediments accumulated again then become lower again ended with higher quantity of sedimentation than the first accumulation.

While weekly application of the same program (MS_1P_11) shows an ideal curve for reducing accumulated sediments in the laterals by time applying a long-term continuous maintenance as the best way for improving the network performance.

CONCLUSIONS

From this investigation the following conclusion can be made:

1- The maintenance programs for surface drip irrigation through continuous flushing for 5 minutes (MS_1P_1) every week and every two weeks were closer in terms of the performance parameters (E %, CR_p %).

2- Following the program of continuous flushing for 5 minutes every two weeks (MS_1P_12) has an advantage over the program of continuous flushing for 5 minutes every week (MS_1P_11) by increasing the values of distribution uniformity for both discharge and pressure (UP, DU%) to 13.09 and 4.12% respectively and decreasing the percentage of partial clogging (CR_P%) and total clogging (CR_c%) by 46.85 % and 44.8% compared to the control.

3- According to the mentioned evaluation parameters it could be advised to follow the following flushing programs arranged according to priority as following: 5 minutes continuously each two weeks (MS_1P_12) - 5 minutes continuously weekly (MS_1P_11) - 10 minutes continuously weekly (MS_3P_11) - 5 minutes intermittently weekly (MS_2P_11).

4- Flushing for 5 minutes each two weeks (MS_1P_12) was the closest program to the standard performance of the new network as it achieved distribution uniformity for both discharge and pressure 90% and 92.19% respectively, also ΔH along laterals equals 11.2%.

5- The highest value of DU% was achieved after 21 times of lateral weekly flushing for 5 minutes, which shows that ordinary maintenance of flushing laterals a time each season end isn't enough.

6- Generally, when the periods of flushing become longer, the performance of the network deteriorate significantly. In such case the technical evaluation parameters decrease than the acceptable limits and the percentages of complete and partial clogging ratios increase. As the average values of some parameters were DU = 84.3% , E = 47%, CRc =55% , and CRp =29.78% when maintenance was applied each month and each season end.

7- On the contrary when periods between flushing are shorter, a significant improvement in the network performance was noticed and lower values for emitters clogging percentages were achieved. But this improvement is accompanied with increasing the number of labor.hour required for maintenance process, and so the cost and quantity of lost water from lateral ends.

8- Finally this study showed that the wrong maintenance application by cultivators for surface drip irrigation systems, by flushing them every long period of time to minimize the cost and quantity of lost water, leads to decrease the systems performance significantly besides the increment of emitters clogging percentages according to evaluation parameters.

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الملخـــــص العــــربى

الادارة الهندسية لنظم الرى بالتنقيط السطحى

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انتشرت نظم الرى الحديث في الأراضى الجديدة بمصر على نطاق واسع مع الألفية الثالثة واتجهت الأبحاث حديثا لدراسة ادارة هذة النظم. وتعتبر صيانة شبكات الرى أحد المحاور الرئيسية للادارة الهندسية لنظم الرى الضغطى خاصة الرى بالتنقيط.

لذلك هدفت الدراسة الى اختبار 12برنامج صيانة مقترحة لغسيل شبكة ري بالتنقيط السطحى بالماء لتحديد أنسبها مع وضع أولويات لباقى البرامج للتوصية باتباع أى منها طبقا لظروف كل منطقة وموقع.

طبقت برامج الغسيل لمدة5 دقائق مستمرة، 5 دقائق متقطعة، 10 دقائق مستمرة خلال أربع فترات مختلفة أسبوعيا، كل أسبوعين، شهريا، فى نهاية كل موسم.تم استخدام مجموعة من المعايير الهندسية للحكم على أداء شبكات الرى مثل كفاءة انتظام توزيع المياة (DU)،

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وانتظامية انبعاث المياة من المنقطات (E) ،انتظامية توزيع الضغط على خطوط التنقيط (UP) ،بالاضافة الى قياس نسب الانسداد الكلى(CR_C%) والجزئى (CR_P%) .ولقد طبقت معايير التقييم على شبكة رى بالتنقيط جديدة لاتخاذها كمستوى لمقارنة البرامج المختبرة على شبكات الرى بالتنقيط القديمة (عمر 6 سنوات) محل الدراسة.

وقد أوضحت نتائج الدراسة ما يلى:

1- يعتبر برنامج صيانة شبكات الرى بالتنقيط السطحى بالغسيل لمدة 5دقائق مستمرة (MS_1P_1) كل أسبوع و كل أسبوعين متقاربة فى معايير الأداء (E, CR_P %).

2- تميز اتباع برنامج الغسيل لمدة 5دقائق بصفة مستمرة كل أسبوعين(MS_1P_12) عن برنامج الغسيل لمدة خمس دقائق بصفة مستمرة كل أسبوع (MS_1P_11) بزيادة قيم انتظامية التوزيع لكل من التصرف و الضغط (UP, DU%)بمقدار 13,09 % و 12 ,4% على التوالى ونقص نسبة الانسداد الجزئى (% CR_P)والكلى(% CR_C) بمقدار كبير 46,85 % و 44,8 % عن الكنترول.

3- طبقا لمعايير التقييم المذكورة يمكن التوصية بأربعة أولويات لاتباع الغسيل على النحو التالى: 5 دقائق مستمرة كل أسبوعين (MS_1P_12) - 5 دقائق مستمرة كل أسبوع (MS_1P_11) - 10 دقائق مستمرة كل أسبوع (MS_3P_11) - 5 دقائق متقطعة كل أسبوع (MS_2P_11).

4- اتضح أن الغسيل 5 دقائق مستمرة كل أسبوعين (MS_1P_12) أقرب البرامج المطبقة فى تقييمها مع نتائج المعايير المقرره للشبكة الجديدة حيث حققت انتظامية توزيع للتصرفات والضغوط (DU = 90% و UP = 92,19%) و كان أيضا فرق الضغط على طول الخط (ΔP = 11,2%).

5- اتباع برامج الصيانة بالغسيل للشبكات شهريا أو فى نهاية الموسم أعطى قيم متدنية لمعايير التقييم خاصة (E%) حيث وصلت الى القيم 38,9% و 42,08% بعد تطبيق الغسيل 5دقائق مستمرة فى نهاية كل موسم (MS_1P_14) و 10دقائق مستمرة شهريا (MS_1P_13) على التوالى.

6- أظهرت قيم معايير التقييم للبرامج المختبرة تميز برنامج الغسيل لمدة دقائق مستمرة كل أسبوعين(MS_1P_12) بعد تكرار الصيانة عدة مرات مما يؤكد أهمية اتباع الصيانة المستمرة و ارتباطها بتحسين أداء الشبكات.

7- بصفه عامه فإن زياده فترات اجراء الصيانه بالغسيل ادت الى تدهور فى اداء الشبكه حيث نقصت قيمه معايير التقييم عن الحدود المقبوله وزادت نسب الانسداد الجزئى والكلى لنقاطات حيث كانت فى المتوسط DU = 84.3% ، E = 47% ، CRc =55% ، و29.78% =CRp عند اجراء الصيانه كل شهر او فى نهايه الموسم.

8- اتضح ان نقص فترات اجراء الصيانه بالغسيل بعد تكرارها بإنتظام يؤدى الى تحسن فى اداء شبكه الرى بالتنقيط السطحى مع نقص نسب الانسداد الجزئى والكلى للنقطات بينما كان ذلك على حساب زياده عدد عامل.ساعه المطلوب للصيانه وبالتبعيه التكلفه اللازمه مع زياده حجم الماء المفقود فى الغسيل فى نهايه الخطوط.

9- أوضحت الدراسة الى أن التطبيق الخاطئ للمزارعين فى صيانة شبكات الرى بالتنقيط و غسيلها على فترات طويلة بدعوى تقليل نفقات الصيانة وكمية الماء المفقود، يؤثر بفاعلية فى أداء النظام و زيادة نسب انسداد النقاطات تبعا لمعايير التقييم