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FERTIGATION METHODS EFFECTS ON WATER AND FERTILIZER UNIFORMITY IN DRIP IRRIGATION

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ABSTRACT

This investigation was carried out in order to:

(a). Compare between different fertigation methods with GR in line emitters under1.5bar operating pressure,

(b). Findout the best fertigation device with GR in line emitters and different lateral lengths in drip irrigation system; and

(c). Finally chose the best method and device for applied fertilizers and chemicals under certain operating condition.

Drip irrigation system including fertigation units represents in this research, The effect of fertigation devices under different lateral lengths on the distribution uniformity of water (D.U) and fertilization (F.D.U) were evaluated, in order to clarify the best fertigation devices and lateral lengths in the experimental farm. The results exhibit that the distribution uniformity DU using the hydraulic injection pump were 90 , 99 and 97% for lateral lengths of 20,40 and 50m respectively. However, DU's using the venturi device were 97, 92 and 99% for the same lateral lengths. However, using Pressure differential tank DU's were 97, 98 and 99% for the same lateral lengths. And using Electrical centrifugal pump DU's were 97 , 96 and 100 % for the same lateral lengths. The results of distribution uniformity of fertilization (F.D.U) with using the hydraulic injection pump were 96 , 98 and 99% for lateral lengths of 20 , 40 and 50m respectively. The F.D.U with using Electrical centrifugal pump were 97,98 and 96 % for lateral lengths of 20,40 and 50m respectively ,and the (F.D.U) with the venturi were 99 ,75 and 88% and with using Pressure differential tank were 86 , 88 and 96% for the lateral lengths of 20 , 40 and 50m respectively.

1. INTRODUTION

Chemigation , can be defined as the application of a chemical , bacterium,.. etc., via an irrigation system by injection the chemicals into the water flowing through the system.The use of modern irrigation methods become very important for saving,water and chemical as well as to optimize water fertilizer use efficiency.

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The term of chemigation began to be used in the **1970'S (Abdel-Aziz,1998).** Fertilizers were the first chemicals to be injected into modern irrigation systems **(Goldberg and Shamueli,1970) .** Chemigations currently used on a very limited basis and only for applying fertilizers in Egypt.The first reported application fertilizer through a trickle irrigation system was in 1982 by **Hegazi** then **El-Kobia et al.1986**.while the first reported injection of herbicides and fertilizers through both drip and sprinkler irrigation system by **El-Gindy,1988.** A Variety of agricultural chemicals can be applied via the micro-irrigation system, including pesticides, herbicides, fertilizer and growth regulators. However, care must be take that these chemicals don't react with naturally occurring dissolved solids such as calcium, or with each other, in such away as to result in precipitation or deposition. Precipitation of dissolved solids will cause clogging of emitters or orifices, and in some instances the addition of chemicals to adjust the PH or to otherwise prevent precipitation may be necessary. Agricultural chemicals are frequently injected into pressurized irrigation systems. Injection methods include the following:

(a) Positive displacement pump; and

(b) Pressure differential injectors, such as the venturi, some hydraulic pumps, and the by-pass tank.The application of the by-pass tank injector has been limited due to high energy requirements, difficulty in controlling injection rates.By-pass injection can be mproved by sing an electrical centrifugal pump to provide a simpleand economical way to inject chemicals into pressurized water line when the power source is neither available or out of use. often times, at least two injection dev ices are used, one with low and one with a moderate injection rate for chemigation **Bucks et al. (1980)** stated that drip irrigation is the frequent application of small. quantities of water directly on or below the soil surface usually as discrete drops, continuous drops, tiny streams, or miniature sprays, through emitters placed a long plastic pipelines. **El Gindy (1989)** stated that drip irrigation is a method for applying pipe constructed near the plants**. Strelkoff et al. (1999)** reported that modern surface irrigation methods and practices can achiev e significantly higher performance levels than existing methods and practices.**Gascho and Mashail (1991)** mentioned that fertigaton (ferti- irrigation) is the frequent application of appropriate amounts of fertilizers in irrigation water orthrough irrigation systems at a time when the crop needs it this definition includes surface irrigation methods and pressurized systems. **El – Gindy (1995)** reported that modern irrigation system with suitable chemigation technology, safe and efficient chemigation would provide significant benefits in improving crop productivity and cost effectiveness while minimizing environmental impact. **Sayed et al. (1999)** showed that the chemigation has several inherent advantages over conventional dry-blend fertilization or crop production on coarse textured soil such as lower fertilizer inputs, reduced nutrient leaching, flexibility in scheduling to meet crop demands and lowering the variable costs. They also stated that the irrigation method becomes a multifunction unit able to supply crops with necessary water and nutrients needed. **Lamm et al. (2001)** stated that mico-irrigation can potentially" spoon feed" nutrients to a crop accurately supplying the crop's nitrogen **(N)** needs throughout The season enhances crop yields and reduces the potential for groundwater contamination from nitrates.

2- MATERIALS AND METHODS.

General description of experimental area:

2.1.1. Location:

This research was carried out in the experimental farm of the Irrigation unit, Agriculture Engineering Department, Faculty of Agriculture. Cairo University.

2.1.2-Chemical analysis of irrigation water:

The water was supplied from a well. A sample of water had been collected and analyzed. The table (2-1) shows the chemical of water sample.

Table (2-1): chemical analysis of irrigation water

EC (ds/m)	pH	Cations dm/cm			Anions dm/cm			
		Ca^{+}	Mg^{++}	Na^{+}	K^{+}	cl^{-}	co_3^{--}	Hco_3^{-}
0.64	7.2	1.03	0.74	8.01	0.42	3.73	0.00	1.95

2.2 Treatments:

The main plot were assigned to surface drip irrigation system, while the sub- plots were four fertigation methods and sub-sub plots were working at 1.5 bar as a working pressure.

2.2.1.Main treatments:

The main treatments included four of fertigation methods as follows:

(a) Pressure differential tank (P.D.),
(b) Venturi (**V**),
(c) Hydraulic injection pump (hyd.P.),
(d) Electrical centrifugal pump (E.C.P)

2.2.2.Sub- treatments:

There were three different lateral lengths of 20, 40,50 m .

2.3 Irrigation system and its components:

The irrigation system consists of the following components:

A) The pump: a centrifugal pump with 3.8 kw (5 Hp), was used to give Water discharge of (15m^3/hr) and 20m pressure head.

B) The control unit: it consists of the following:

-Screen filter 250 mech,
-Valves to control pressure head and water flow,

-Pressure gauges 0.5 m head accuracy.

C) Fertigation unit: it consists of four different fertigation units as follows,

1 -Pressure differential tank:

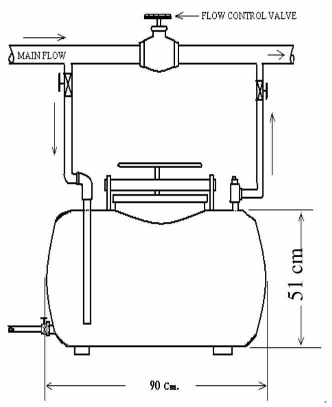


Fig. (2-1) Pressure differential tank

(Metwally,2001)

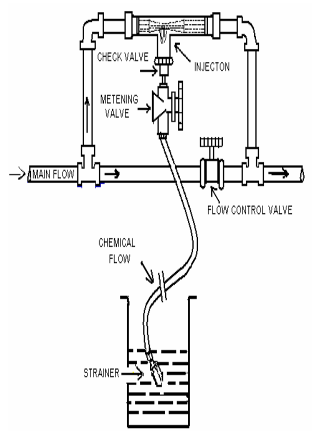


Fig.(2-2) Vanturi suction device.

(Alkeng and Schmidt, 1985) .

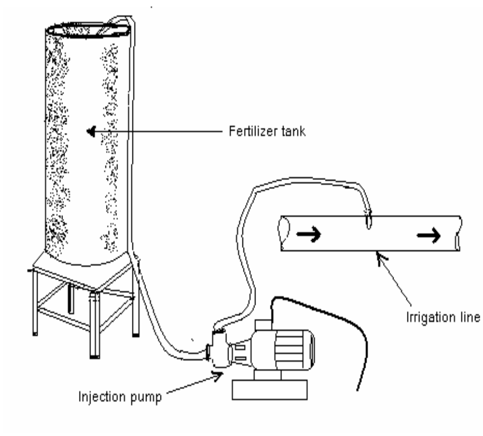
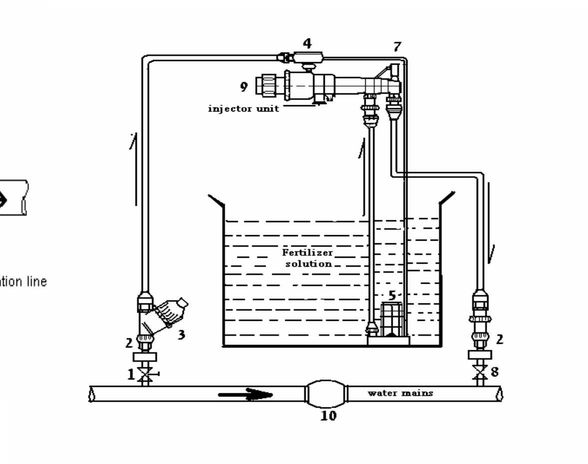


Fig (2-4) Electrical centrifugal pump.

. **(Lamm et al. (2001)**



Key to schematic diagram:

1- Drive water hand valve
2- Union coupl.
3- Filter.
4- Automatic cut-out.
5- Suction hea.
7-Air-release valve
8- Injection line hand valve.
9- Water exhaust.
10- Check valve (optional).

Fig.(2-3) Hydraulic injection pump. (**Lamm et al. (2001)**

1 -Pressure differential tank:

Fig . (2-1) Indicates the fertigation unit of pressure differential tank. It consists of tank (140lit) capacity and connected to the irrigation line by using hose 20 mm diameter through two control valves (one at inlet and the other at outlet).

2-Venturi:

Fig.(2-2) Indicates the fertigation unit of venturi. It consists of a cylindrical entrance section 2.5 cm diameter, cylindrical throat section 12.5 cm diameter and diffuser section 25mm diameter. The tank 140lit capacity connected to the venturi using hose 12.5mm diameter through control valve at absorption line. Venturi unit connected to the irrigation line by using 25mm through two control valves (one at inlet and the other at outlet).

3 - Hydraulic injection pump:

Fig.(2-3) Indicates the fertilizer and chemical injector needs no external power supply, since the linear hydraulic motor contained within the unit, is powered by the hydraulic pressure of the irrigation system. The unit is resistant to nearly all known chemicals used in agriculture and horticulture, the technical data of hydraulic injection pump is shown in **table (2-2)**

Table(2-2): The technical data of hydraulic injection pump.

Injection rate	10 to 320 lit/h
Working pressure	0.5 to 8 bar
Water consumption	3times the quantity of chemical injected.
Gross weight	5kg.
Materials	High grade engineering plastics. Parts in contact with chemicals are no corrosive to most chemicals. Seals-viton, nitrile rubber or polyurethane.

4 - Electrical centrifugal pump:

Fig.(2-4) Indicates a centrifugal pump with 0.37 kw (1/2 Hp), It gives a water discharge of (2m^3/hr) and 60m pressure head.

D) Pipe lines:

1- Main line:

Polyethylene pipe 90mm diameter was used and provided by control valve to ontrol the operating pressure.

2- Sub main line:

Polyethylene 90mm diameter was used and provided by 90 mm control valve to control the operating pressure.

3-Lateral lines:

Polyethylene laterals 16mm diameter and 20,40,and 50 lengths were used. Indicates one emitter were used in procedures:

- A laminear, Long path emitter type in-line with a discharge of 4 lit/h.

Each lateral line was connected to the sub main line through a ball valve.

Methods:

A) Pressure head losses:

The friction losses along the sub main and lateral were calculated according to Hazen and Williams' s equation. Who ever the pressure head losses during the fertigation along the laterals 1,6,12 were measured by pressure gauges in different (where L is the length of lateral line). An accurate pressure gauge $\frac{1}{3}L, \frac{2}{3}L$ points were at inlet, with range of 0-2 bar, and accuracy of 0.5 bar.

B) Injection rate:

To control and measure the injection rate during the fertigation two ways were used, a small flow meter and graduated reservoir and a stop watch.

2.4.Measurements and calculation :

A- Water distribution uniformity (DU):

The **DU** of the system was determined by using the American Society of Agricultural ASAE method 1985 as follows:

$$Du = \frac{qn}{qa} \times 100$$

Where:

Du water distribution uniformity%.

qn mean of lowest quarter of emitter flow rate, l/h.

qa mean emitter flow rate l/h.

B) Fertilizer concentration in stock solution:

The concentrated stock solution was calculated with the equation:

$$C = \frac{F * Df * n * 100}{a}$$

Where:

C mass of the fertilizer in gm in the stock solution, is controlled to be p.p.m. 1000

F Desired concentration of nutrient (g_m/m^3).

n Volume of the reservoir for the stock solution (m^3).

a the ratio of pure elements in the fertilizer.

Df Dilution Factor.

$$\text{Dilution Factor} = \frac{\text{flow rate of the irrigation system}}{\text{flow rate of the fertigation}}$$

C) Fertilizer distribution efficiency:

The fertilizer distribution efficiency of the system was determined by measuring the weight of the fertilizer (mg) in the total volume of water cached from the different emitter, during a 20 min from the start of fertigation operation.

The total water cached from emitter at the inlet, 1/3, 2/3 and the end of laterals, for laterals number 1,6,12 respectively. The fertilizer distribution efficiency was determined as follows:

$$F.D.U = \frac{W_{fm}}{W_{fa}}$$

Where:

F.D.U the fertilizer distribution efficiency %.

W_{fm} mean weight of fertilizer in water of the lowest 1/4 emitter (mg).

W_{fa} mean weight of fertilizer in water during chemigation (mg) .

2-5 :Experimental Procedures

This research was carried out in the experimental farm of the Irrigation unit, Agriculture Engineering Department, Faculty of Agriculture, Cairo University. .The source of the water was well. Head control unit consisted of valve, check valve, main filter, flow meter, pressure reduction valve, inlet and outlet of injector. The inlet and outlet of injector are designed to use the different Fertigation devices separately by connecting the injector in the same place, easily as shows in Fig (2-5).Four fertigation devices were used: hydraulically actuated pump (hyd.P), Electrical actuated pump (E.C.P), venturi and deferential pressure tank. The irrigation system was designed to use for measuring only.Three different areas with three different lateral lengths were prepared for this applied research. The areas were100 , 200, and 250 m^2 with lateral lengths of 20 ,40 and 50 m respectively with one type of emitter in line dripper. Each area (Block) had control valve with submain40m long consisting of 12 laterals.The diameres of submain were75mm for the lateral lengths of 20, 40, and 50m. The sub main was used to irrigate on two sides.The PE lateral with diameter of 16mm, had emitter spacing of 50cm and emitter rate was 4 l/h and spacing between lateral were 1m as shown in **Fig (2-5).**

3- RESULTS AND DISCUSSION

3-1 Pressure head losses along the lateral:

The main factor affecting on the operation of drip irrigation is the pressure head. The data indicated that once the fertigation starts by fertigator devices which depend on differential pressure, the head in drip irrigation is affected . Fig (3-1) shows the effect of fertigation method on the pressure head along different lateral lengths in line number 1. It is clear from the data that the minimum losses in pressure head were in lateral length of 20m.The data also showed that the pressure heads used under the venturi were 0.35,0.3,0.25, and 0.3 bar for the lateral lengths of 20m at the inlet, 1/3,2/3,and end of the lateral respectively.

However, the pressure heads under using the pressure differential tank were 0.3, 0.2, 0.1and 0.3 bar for the same lateral length and at the same point.

centrifugal pump However, the pressure heads under using the electrical

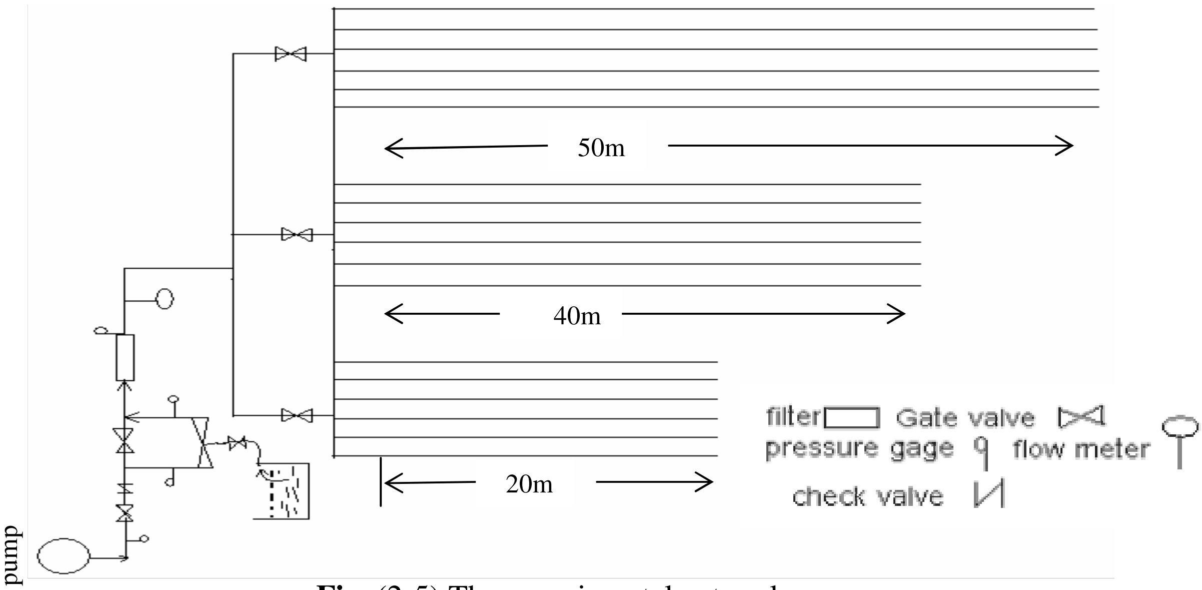


Fig. (2-5) The experimental network .

were 0.25, 0.1, 0.05 and 0.15 bar for the same lateral length and at the same point. The data also showed that the pressure head decreased as the lateral length increased. The maximum losses in the pressure head were in the lateral length of 50m. Fig (3 -1),(3-2) and (3-3) show the effect of fertigation methods on the pressure head along the lateral lengths for lines number 1, 6, and 12. It is clear from the figures that the losses in pressure head take the same trend as lateral; No.1. On the other hand, the data indicated that there is big relationship between the head losses along the lateral and the fertigation methods. The highest losses of head were under using of differential pressure tank, while the lowest losses in the head were under the hydraulic injection pump, this is due to that the operation of differential pressure tank and venturi depend mainly on the differential pressure between the inlet and outlet of fertigators.

The data in fig (3-4) shows the effect of fertigation method on the average of pressure head along the different lateral lengths for lines No.1,6, and 12. It is clear from the data that under using hydraulic injection pump the averages of the pressure head were1.6 ,1.4, and 1.2 bar for the lengths of 20, 40, 50m respectively. However, the averages of head under using of venturi were 1.4, 1.3, and 1.2 bar for lengths of 20, 40, and 50m respectively. Meanwhile the averages of head under using of differential pressure tank were 1.3 , 1.2 , and 0.9 bar for lateral lengths of 20, 40, and 50m respectively.

3-2 Fertilizer distribution uniformity:

The highest value of fertilizer uniformity coefficient was 100%for electrical centrifugal pump injection method at 15m of operating pressure head for GR drip line at 50m of lateral length. While, the lowest value was 71%for pressure differential tank at 10m operating pressure head .

The highest value of fertilizer uniformity coefficient was 100%for the hydraulic pump injection method at 15m of operating pressure head for GR drip line at 40m of lateral length. While, the lowest value was 78% for pressure differential tank at 20m operating pressure head .

Table(3 -1): The effect of fertigation methods on fertilizer uniformity %under operating pressure head, (15 m) and different lateral lengths in (GR drip line).

Fertigation methods. / lateral lengths, m.	Pressure differential tank	Hydraulic injection pump	Electrical centrifugal pump	Venturi
20	86	96	97	99
40	88	98	98	75
50	96	99	96	88
Mean values	90	98	97	87

Data in table (3-1) show that by increasing operating pressure head tended to increase fertilizer uniformity coefficient under different fertigation methods, this may be due to increase injection rate by increasing operating pressure head.

3 -3.Water distribution uniformity (DU) :

The distribution uniformity of water in the drip irrigation system is the most important factor in the evaluating the efficiency of the drip irrigation system.The DU depended mainly for pressure head in the network of drip irrigation.Table (3-2)represents the DU befor fertigation and under the fertigation methods for different lateral lengths. It is clear that the DU's befor operating of fertigation were100,99, and 97 %for the lateral lengths of 20, 40, and 50m repectivly. The data indicated also that the DU was affected by both of fertigator devices and lateral lengths. The DU values were90, 99, and 97 % under using of Hydraulic injection pump for lateral lengths of 20,40, and 50m respectively. However, the DU values under using of venturi were 97 ,92 ,and 99 % for the lateral lengths of 20, 40, and 50m respectively. Meanwhile, the DU values under using of pessure differential tank were97 , 98 , and 99% for lateral lengths of 20, 40, and 50m respectively.

Table (3-2): The distribution uniformity values (%) before and during fertigation Under different fertigation methods and lateral lengths.

lateral length	Before fertigation	During fertigation			
		D.A.tank	Hyd..P	E.C.P	Venturi
20m	100	97	90	97	97
40m	99	98	99	96	92
50m	97	99	97	100	99

Fertigation devices which depend on the differential pressure between the inlet and outlet are to be avoided as much as possible.
D.P tank can only be used with (PE tube of 16mm/50cm spacing between emitters of 4 lit/h) and lateral length of 40m or less.
It is better to use the Hyd. P to get high DU and F.D.U.

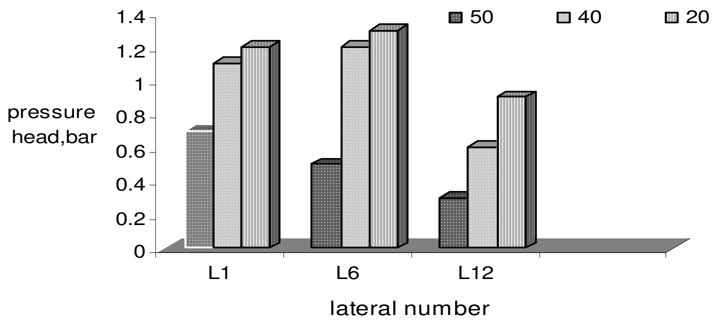


Fig (3-1) : Effect of Pressure differential tank on the average values of pressure head Along different GR lateral lengths and under different number.

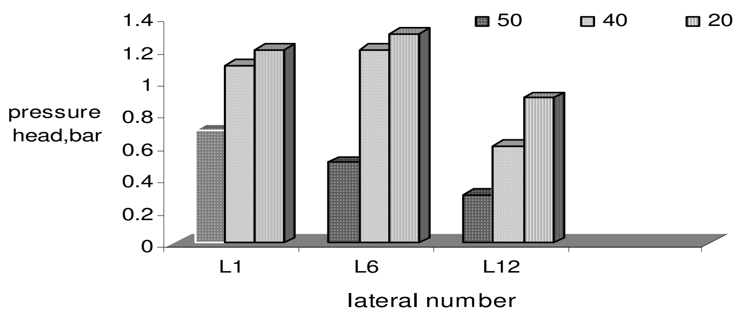


Fig (3-2) : Effect of hydraulically actuated pump on the average values of pressure head Along different GR lateral lengths and under different number.

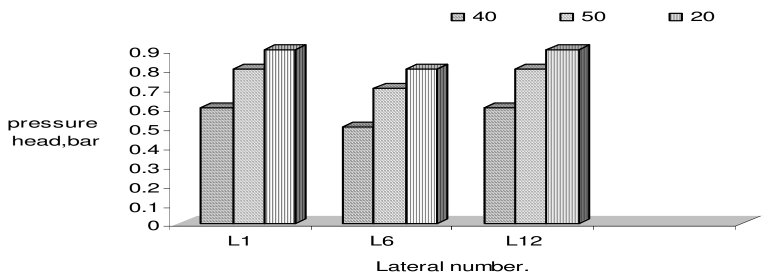


Fig (3-3) : Effect of Electrical centrifugal pump on the average values of pressure head Along different GR lateral lengths and under different number.

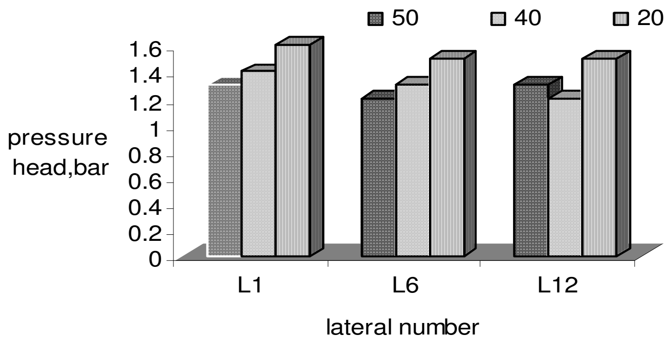


Fig (3-4) : Effect of Venturi on the average values of pressure head Along different GR lateral lengths and under different number.

3-4 .Fertilizer distribution uniformity (F.D.U):

Table (3-3) shows the fertilizer uniformity under fertigation methods for different lateral lengths. It is clear from the data that the best uniformity of fertilizer was under using Hyd. P. The F. D.U,s were 96,98, and 99% for lateral lengths of 20,40, and 50 m respectively. However, the F.D.U ,s under using the venturi were 99 , 88,and 75 % for the lateral lengths of 20, 40, and 50m respectively. Meanwhile, the F.D.U,s under using the D.P. tank were 86,88 and 96% for the lateral lengths of 20, 40, and 50m respectively. And, the F.D.U ,s under using the E.C.P were97,98 and 96% for the lateral lengths of20, 40, and 50 m respectively.

Table (3-3): The fertilizer uniformity (%) under fertigation methods for different Lateral lengths.

Lateral length	D.P.tank	Hyd. P	E.C.P	Venturi
20m	86	96	97	99
40m	88	98	98	88
50m	96	99	96	75

4 -5 .Fertilizer concentration along laterals:

One of the most important advantages of the drip irrigation system is the fertigation. with irr. water Generally the data indicated that the concentration of fertilizer was effected by both fertigation device and lateral length. Figures (3-7), (3-8), and (3-9) shows the effect of fertigation methods and lateral lengths on the fertilizer concentration in drip irrigation system. Although the concentration of fertilizer is the same in stock solution for the different fertigation methods, the data exhibit that there are differences in the values of fertilizer concentration under the fertigation method along the different lateral lengths. It is clear from the data that the concentrations under lateral lengths of 20m were 96, 99 , and 86 ds/m for the Hyd. P, Venturi and D.P.tank respectively. However, the concentrations under lateral length 40m were 98,88 and 88 ds/m for the same fertigation devices respectively. Meanwhile, the concentrations under lateral length 50m were 99,75and96ds/m for the same fertigation devices respectively. It is noticed from the results that the fertilizer concentrations decreased from one method of injection to another. The differential pressure tank caused most of these reduction followed by the venturi method. The reason for the reduction is due to deposition of some fertilizer in the tank and other system components. In the meantime, the experiment measurements were taken over 20 min. duration from the start of fertigation. After this duration some of the repositions was wasted during washing of the tank other exposed equipment.

4 – SUMMARY AND CONCLUSION

The head control unit of the drip irrigation had been modified to use the different fertigation devices easily in the same place. Four fertigation devices with three different lateral lengths were used in this research. The aim of this work was evaluate the effect of the different fertigation devices and lateral lengths on the uniformity of water and fertilizer.The results indicated that:

(a) The pressure head in the lateral was affected by the both of fertigation devices and lateral lengths .

(b) The average values of pressure head under using of Hyd.P were1.2, 1.5, and 1.3 bar for lateral lengths of 20,40, and 50m respectively. However, under using the Venturi were 1.5,1.3,and1.2bar for the same lateral lengths. Meanwhile, under using of D.P.tank were 0.97, 1.4 and 1.3 bar for the lateral lengths 20, 40, and 50m respectively. Meanwhile, under using of E.C.P were 1.2 , 1.3 and 1.5 bar for the same lateral lengths.

(c) The DU differs during the fertigation. The DU was 100, 99 and 97 % before fertigation for lateral lengths of 20, 40, and 50m respectively. Meanwhile, under using the hyd.P, DU became 90, 99 and 97% for the same lateral lengths. However, under using the venturi DU was 97,92 and 99% for the same lateral lengths. On the other hand, under using of D.P.tank it become 86,88 and 96% for the same lateral lengths. On the other hand, under using of E.C.P it become 97, 96 and 100 % for the same lateral lengths. Although the same fertilizer concentration was used in the injector stock solution the results exhibit different fertilizer concentrations for both the fertigation devices and lateral lengths.

(d) The F.D.U,s under using Hyd. P. were96, 98, and 99% for lateral lengths of 20, 40, and 50m respectively. However, under using the venturi were 99,75and 88% for the same lateral lengths. Meanwhile, under the use of D.P. tank were 86 ,88 and 96 %for the same lateral lengths respectively.

5- RECOMMENDATIONS

Fertigation devices which depend on the differential pressure between the inlet and outlet are to be avoided as much as possible. D.P tank can only be used with (PE tube of 16mm/50cm spacing between emitters of 4 l/h) and lateral length of 40m or less. It is better to use the Hyd. P to get high DU and F.D.U.

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الملخص العربى

"تأثير أجهزة الحقن على انتظامية المياه والأسمدة في الري بالتنقيط"

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اجريت هده الدراسة بوحدة الري بقسم الهندسة الزراعية - كلية الزراعة – جامعة القاهرة و تم استعمال أربع أجهزة تسميد هى حاقن الأسمدة (الفنشوري) والمضخة الهيدروليكية وخزان السماد العادي و المضخة الكهربائية. حيث تعتمد فكرة الفنشوري و المضخات على السحب أما خزان

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١ - استاذ ورئيس قسم الهندسة الزراعية – كلية الزراعة – جامعة القاهرة .
٢- مدرس الهندسة الزراعية - كلية الزراعة – جامعة القاهرة .
٣- معيدة بقسم الهندسة الزراعية - كلية الزراعة – جامعة الفاتح - ليبيا.

السماد العادي فيعتمد على فكرة الاضافة و السحب وتم تصميم شبكة الري بحيث تشمل على ثلاث مساحات مختلفة هى١٠٠ ، ٢٠٠ و ٢٥٠م٢ لثلاث أطوال من الخراطيم هم ٢٠، ٤٠، ٥٠ م بالترتيب. ولمعرفة تأثير الوسائل المذكورة للتسميد الكيماوي خلال شبكة الري بالتنقيط وتحقيق الغرض من القياس تم اتخاذ عدة مؤشرات يمكن من خلالها مقارنة النظم وعلاقتها بأطوال خطوط الري أهمها الضغط وتوزيعه على طول الخطوط ومعامل انتظامية توزيع المياه و السماد وتركيزه في الشبكة. و من أهم النتائج المتحصل عليها الأتي:

١- تباين تأثير طرق الحقن المختلفة على الضغط داخل شبكة التنقيط.وأظهرت النتائج تأثيرأطوال الخراطيم على توزيع الضغط حيث كان متوسط قيم الضغط للمضخة الهيدروليكية ٠,٩ ، ٠,٨ ، ٠,٧ جوي لثلاث أطوال من الخراطيم ٢٠،٤٠، ٥٠ بالترتيب.بينما كانت قيم الضغط عند أستخدام الفنشوري ٠,٩ ، ٠,٧ ، ٠,٥ جوي بالترتيب .بينما كانت قيم الضغط في أستخدام المضخة الكهربائية ٠,٨ ، ٠,٧ ، ٠,٦ جوي بالترتيب. أماحالة أستخدام خزان السماد وصلت قيم الضغط الى ٠,٧ ، ٠,٦ ، ٠,٥ جوي لنفس أطوال الخراطيم .

٢- تغير معامل انتظامية توزيع المياه خلال عمليات حقن الأسمدة فبعد ما كان ١٠٠ ، ٩٩ ، ٩٧ % لأطوال الخراطيم ٢٠،٤٠،٥٠م بالترتيب وبدون تسميد، أصبح مع استخدام خزان السماد ٩٧ ، ٩٨ ، ٩٩% لنفس أطوال الخراطيم . أما في حالة استخدام المضخة الهيدروليكية كانت القيم ٩٠ ، ٩٩ ،٩٧% لنفس الأطوال الثلاثة . بينما في حالة استخدام المضخة الكهربائية وصلت القيم ٩٧ ، ٩٦ ، ١٠٠% لنفس الأطوال الثلاثة. في حين باستخدام الفنشوري بلغت قيم معامل انتظامية التوزيع الى ٩٧، ٩٢ ، ٩٩% لنفس الأطوال على الترتيب.

٣- وصلت قيم معامل انتظامية توزيع السماد مع استخدام الفنشوري٩٩ ، ٨٨، ٧٥ % لأطوال الخراطيم ٢٠،٤٠،٥٠ م بالترتيب ، بينما كان معامل انتظامية التوزيع للسماد مع استخدام المضخة الهيدروليكية٩٦ ، ٩٨ ، ٩٩ % لنفس الأطوال الثلاثة السابقةعلى الترتيب . ووصلت قيم معامل انتظامية توزيع السماد باستخدام المضخة الكهربائية٩٧، ٩٨ ، ٩٦ % لنفس الأطوال الثلاثة. وانخفضت القيم عند استخدام خزان السماد حيث وصلت قيم معامل انتظامية توزيع السماد الى ٨٦،٨٨ ،٨٢% لنفس أطوال الخراطيم الثلاث بالترتيب.

وعلى ذلك يوصى البحث بالتالي :

أ. لا يفضل استخدام أجهزة التسميد التى تعتمد على فرق الضغط وبالخصوص التي تعتمد على نظرية الاضافة والسحب لسائل السماد المراد حقنه .

ب. ينصح باستخدام خزان السماد العادي فقط في حالة ما تكون أطوال الخراطيم ٤٠م فأقل للخرطوم ١٦مم ونقاط GR تصرفه ٤لتر/ساعة والمسافة بين النقاطات ٥٠سم .

ج. استخدام كل من السمادة الهيدروليكية والكهربائية لأطوال فرعيات ٤٠،٥٠م.

د. استخدام الفنشوري مع طول ٢٠،٤٠ متر .

هـ . يوصى البحث بضرورة استخدام السمادة الهيدروليكية مع أطوال الخراطيم ٥٠م فأكثر للحصول على أعلى أنتظامية للمياه و السماد.