

DESIGNING TRICKLE IRRIGATION SYSTEM WITH PRESSURE COMPENSATING EMITTERS

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Received: Oct. 4 , 2020

Accepted: Nov. 29 , 2020

ABSTRACT: The objective of this study was to design the trickle irrigation system by compensating emitters (Katif) and The experimental work was carried out in the experimental farm of faculty of Agriculture, Menoufia university during 2018. A field experiment was conducted for 50 m and 75 m of lateral length with outer diameter 16mm and ϕ 13.6mm inner diameter under discharges of (2,4 and 8 L/h) and spacing between emitters 0.5 m. Several points were taken 2 m apart into considerations, such as emitter characteristic friction losses, manufacturing variation, discharge and hydraulic variation. Emitters were tested at 50 ,100 ,150 and 200 kpa to determine the pressure –discharge relationship and the uniformity parameters.

The found results showed that the exponent values for the compensating emitters under study ranged from 0.06 to 0.2. The measured coefficients of manufacturing variation values for compensating emitters were in the excellent class. As such the variation of discharge through these laterals is restricted by limiting their number to have emission uniformity, EU, greater than 90%.

Key words: Trickle irrigation; compensating emitter (Katif); laterals length; emission uniformity; pressure discharge relationship.

INTRODUCTION

Trickle irrigation system is a system that has been used for long in various parts of the world under different climatic conditions, crop types as well as soil types. It is a type of irrigation that slowly applies small amount of water to part of the plant root zone (McConnell, 2003). It is consider the newest of all methods of irrigation systems in water application. It described as the frequent slow application of water to soil through mechanical devices called emitters, or applicators located at selected points along the water delivery lines. (Jensen, 1993).

Khairy et al., (2016) showed that mobile drip irrigation system have the best results because the efficiency of surface drip irrigation 95% and the results showed the classification of all used drip tubes were fully pressure compensating .

Trickle irrigation system, to suit the condition of a particular site, is specially designed in order to achieve high efficiencies in its performance and economy. (Jack & David, 1974)

Early research in drip irrigation design was conducted mostly for a single lateral line (Wu,1992).

Design the trickle irrigation system by compensating emitter can apply water to plants at very low flow rates. This ensures more efficient watering, reducing the risk of over watering or under watering and saving energy by using low pressure and we can use it in designing trickle irrigation system.

The objective of this paper is to design the trickle irrigation system using the pressure compensating emitters (Katif).

MATERIALS AND METHODS

The experiments were carried out in Department of Agricultural Engineering laboratory and farm of faculty of Agriculture Menoufia university, during 2018 .

Compensating emitters (katif) with three different flow rates :2,4 and 8L/h at emitters spacing of 0.5m .

Emitters were tested at 50,100 , 150 and 200kPa to determine manufacture coefficient of variation CV_m , X and k values using equation 1 and 2. Emitters were connected with the energy of lateral line and measure all variation in the emitter discharge as a result of manufacture's variations and hydraulic variations.

Katif described with flow- regulated self - flushing emitter and prevents water run- off along the drip line .

In this study, there were two drip lines 50m and 75m (Fig.1), long which are made of Poly Ethylene (PE).

The outer diameter of the lateral line was 16mm with ϕ 13.6 mm inner diameter and the irrigation line was installed on ground with

Manufacturing coefficient of variation was calculated using equation (1) and its classification are shown in Table (1) for (Bralt et al ., 1987)

$$cv_m = \frac{s}{q} \quad (1)$$

Where ,

CV_m = Manufacturing coefficient of variation

S= sample standard deviation

q= Average emission rate of sample

Head- discharge relationship

The head discharge relationships for emitters were expressed by the formula (karmeli, 1977and Wu and Gitlin, 1977)

$$q = KH^x \quad (2)$$

Where ,

q = Discharge rate of emitters , L/h.

K = Discharge Coefficient

H = Pressure Head , m.

X = Emitter flow exponent

The value of X varies from 0 to 1 for wide range of emitters. If X approaches zero, the drippers are classified as fully pressure compensating and it is, however difficult to achieve in the manufacturing process.

Trickle irrigation is a type of irrigation that slowly at applies small amount of water to part of the plant root zone (McConnell, 2003).

It is consider the newest of all methods of water application. It described as the frequent slow application of water to soil through mechanical devices called emitters, or applicators located at selected points along the water delivery lines (Jensen, 1993).

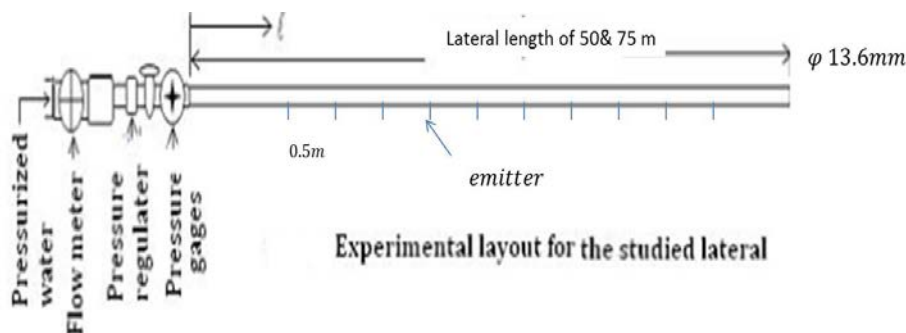


Fig. (1): Experimental lay out for the studied lateral.

Designing trickle irrigation system with pressure compensating emitters

Table (1): Illustrate the classification of manufacturer's coefficient of variations .

Emitter type	C _v range	Classification
Point source	<0.05	Excellent
	0.05- 0.07	Average
	0.07 – 0.11	Marginal
	0.11 – 0.15	Poor
	>0.15	Unacceptable
Line source	<0.10	Good
	0.10 – 0.20	Average
	>0.20	Marginal to unacceptable

RESULTS AND DISCUSSION

Pressure-Discharge Relationship:

Results show that the predicted exponential equations for this studied emitters are as follow :

$q = 1.9923 * p^{0.211}$ for the katif emitter of 2 l/h (3)

$q = 3.6063 * p^{0.177}$ for the katif emitter of 4 l/h (4)

$q = 8.3969 * p^{0.067}$ for the katif emitter of 8 l/h (5)

Where,

q: the discharge of emitter in (l/h).

P: pressure in (bar).

It can be noticed that the emitter discharge exponent values (x-values) varied between 0.067 to 0.211.

Discharge along the lateral line:

Fig. (2) showed the relationship between the discharge and the ratio of lateral length. Results showed that, the discharge measured was closed to the discharge calculated along lateral length of 50 m at operating pressure of one bar.

Friction losses:

The friction losses in lateral length 50 and 75 m for different discharges of 2,4 and 8 l/h are shown in Fig. (3). that the friction losses in different discharges 2, 4 and 8 l/h at lateral length 75m are bigger than the friction losses in 50 m .

It can be noticed that, the lateral length effect on the friction losses.

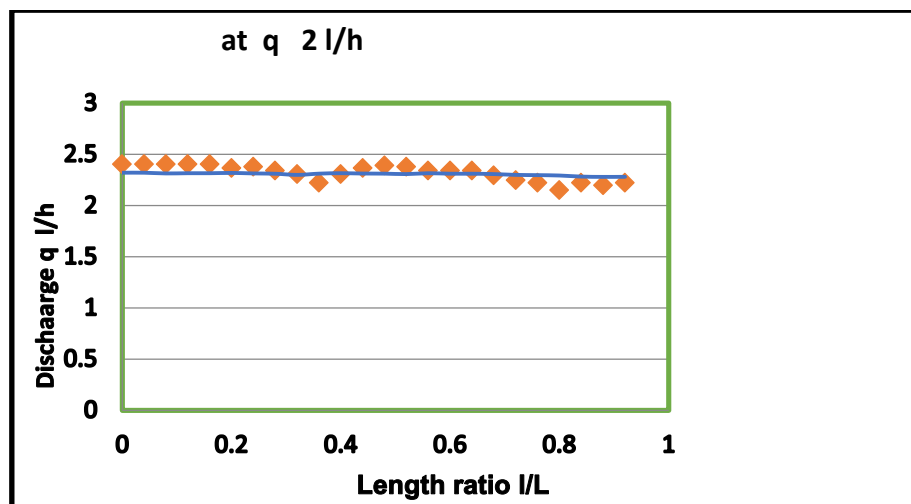


Fig. (2). Discharge along lateral for Katif compensating emitter 2 L/ h for 50 m lateral long under pressure of one bar .

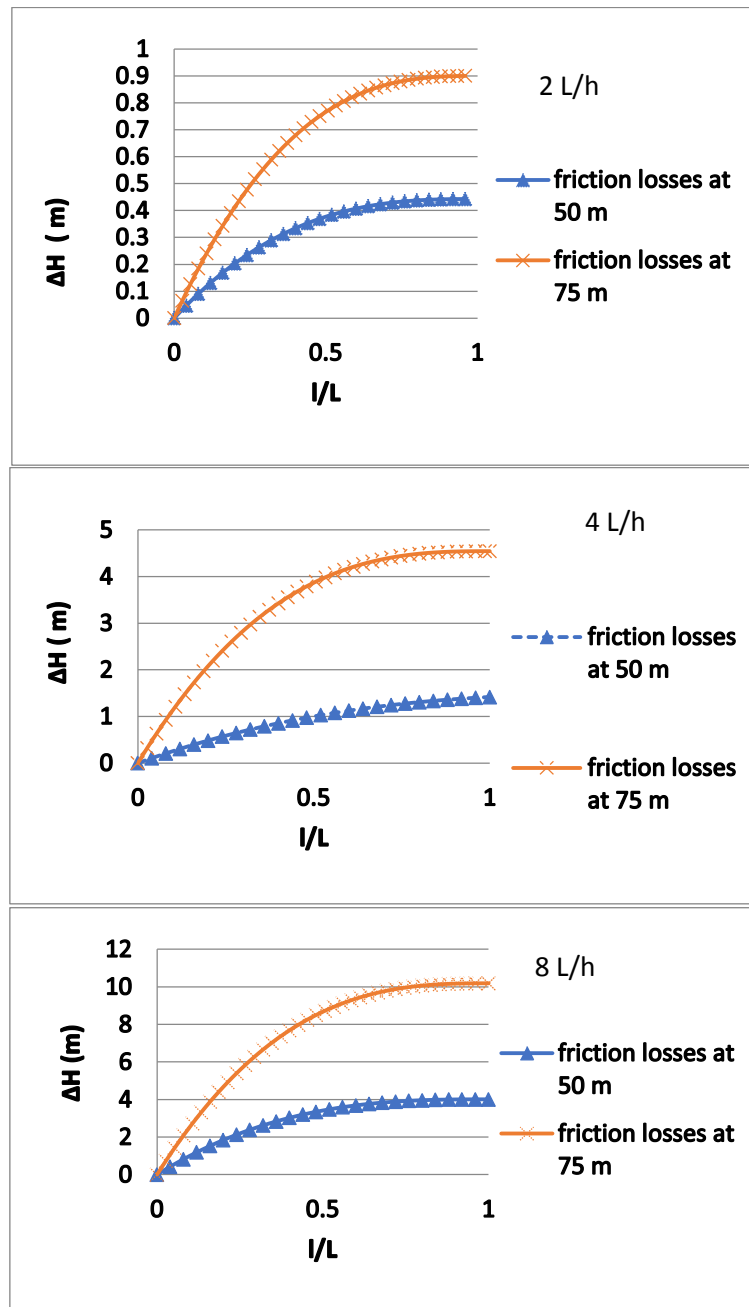


Fig. (3): Shows the friction losses versus length ratio under 2,4 and 8 l/h and 0.5m Katif compensating emitters spacing.

Emission uniformity (EU)%:

The best results of the emission uniformity, as shown in Fig. (4), were found under 8 L/h which was about 97%. The results are taken four times along laterals.

Data in Tables (2) and (3) show the studied design parameters, such as the friction losses, (ΔH), coefficient of variations (CV), the emission uniformity, (EU), the discharge measured along lateral ($Q_{measured}$), the discharge determined along lateral ($Q_{determined}$), q variation and coefficient of uniformity (CU).

Designing trickle irrigation system with pressure compensating emitters

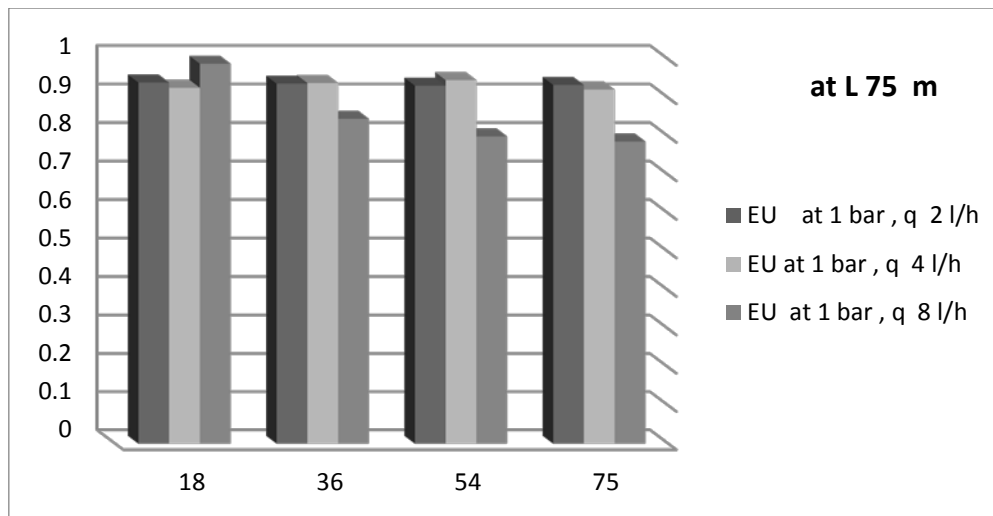


Fig. (4): Show the emission uniformity in pressure one bar at lateral length 75 m

Table (2): Design parameters for φ 13.6mm and 2m spacing discharges 2.4 and 81/h and 50m lateral length.

Design parameters	1 bar			1.5 bar		
	q 2 l/h	q 4 l/h	q 8 l/h	q 2 l/h	q 4 l/h	q 8 l/h
ΔH	0.44291	0.70	2.22	0.44284	1.19	2.5
CV	3.36924	4	5.09	2.11683	5.8	6.42
EU	95.7	94	93.5	95.08	93.7	93
$Q_{measured}$	231.65	408.8	815.3	233	423.7	823.4
$Q_{determined}$	230.73	455.4	820.5	234.15	465.8	830
CU	97.4	96.8	95	96	96.18	95.17
q_{var}	1.99	3.22	8.12	2.19	3.33	8.22

Table (3): Design parameters for φ 13.6mm and 2m spacing under discharges of 2.4 and 81/h and 75m lateral length.

Design parameters	1 bar			1.5 bar		
	q 2 l/h	q 8 l/h	q 4 l/h	q 2 l/h	q 4 l/h	q 8 l/h
ΔH	0.442911	2.89	.986	0.442848	1.23	3.7
CV	3.369242	7.2	6.17	2.116838	5.22	8.42
EU	95.7	91.5	92.2	95.08	93.6	90
$Q_{measured}$	231.65	810.3	598	233	0.644	813.4
$Q_{determined}$	230.73	820.5	455.4	234.15	465.8	830
CU	96.9	93.1	91.6	96.1	96.1	95
q_{var}	1.99	8.12	3.4	2.19	3.5	8.22

Table (2) showed that the results along lateral 50 m for three emitters discharge 2,4 and 8 l/h. The friction losses were equal to 0.442 at pressure 1 and 1.5 bar for emitter discharge of 2 l/h, equal to .71 and 1.19 at pressure 1 and 1.5 bar for emitter discharge of 4 l/h and equal to 2.22 and 2.5 at pressure 1 and 1.5 bar for emitter discharge of 8 l/h.

The coefficient of variation were equal to 3.36% and 2.11% for emitter discharge of 2 l/h at pressure 1 and 1.5 bar , equal to 4 % and 5.8% at pressure 1 and 1.5 bar for emitter discharge of 4 l/h and equal to 5.09% and 6.42% at pressure 1 and 1.5 bar for emitter discharge of 8 l/h.

The emission uniformity (EU) were equal to 95.7 % and 95% for emitter discharge of 2 l/h at pressure 1 and 1.5 bar , equal to 94 % and 93.7% for emitter discharge of 4 l/h at pressure 1 and 1.5 bar and equal to 93.5 % and 93 % for emitter discharge of 8 l/h at pressure 1 and 1.5 bar .

The discharge (measured) showed in this table 4 for three emitter 2,4 and 8 l/h at pressure 1 bar equal to 231.3 ,408.8 and 815.3 for three emitter and equal to 233 , 423.7 and 823 at pressure 1.5 bar .

The discharge (determined) showed in this table 2 for three emitter 2,4 and 8 l/h at pressure 1 bar equal to 230.73 ,455.4 and 820.5 for three emitter and equal to 234.15 , 465.8 and 830 at pressure 1.5 bar .

The coefficient of uniformity (CU)% were equal to 97.4 % and 96% for emitter discharge of 2 l/h at pressure 1 and 1.5 bar , equal to 96 % and 96.17% for emitter discharge of 4 l/h at pressure 1 and 1.5 bar and equal to 95 % and 95.17 % for emitter 8 l/h at pressure 1 and 1.5 bar .

The q variation for emitter 2 l/h at pressure 1 and 1.5 bar equal to 1.99 and 2.19 , for emitter 4 l/h equal to 3.22 and

3.33 and for emitter 8 l/h equal to 8.12 and 8.22 .

Table (3) showed that the results along lateral 75 m for three emitters 2,4 and 8 l/h . the friction losses were equal to 0.442 at pressure 1 and 1.5 bar for emitter discharge of 2 l/h, equal to .98 and 1.23 at pressure 1 and 1.5 bar for emitter discharge of 4 l/h and equal to 2.89 and 3.7 at pressure 1 and 1.5 bar for emitter discharge of 8 l/h.

The coefficient of variation were equal to 3.36% and 2.11% for emitter discharge of 2 l/h at pressure 1 and 1.5 bar, equal to 7.2 % and 8.42% at pressure 1 and 1.5 bar for emitter discharge of 4 l/h and equal to 5.09% and 6.42% at pressure 1 and 1.5 bar for emitter discharge of 8 l/h.

The emission uniformity (EU)% were equal to 95.7 % and 95.08% for emitter discharge of 2 l/h at pressure 1 and 1.5 bar, equal to 92.2 % and 93.6% for emitter 4 l/h at pressure 1 and 1.5 bar and equal to 91.5 % and 90 % for emitter discharge of 8 l/h at pressure 1 and 1.5 bar.

The discharge (Q_{measured}) showed in this Table (3) for three emitter discharge of 2,4 and 8 l/h at pressure 1 bar equal to 231.6 ,598 and 810.3 for three emitter and equal to 233 , 644 and 813.4 at pressure 1.5 bar .

The discharge ($Q_{\text{determined}}$) showed in this Table (3) for three emitter discharge of 2,4 and 8 l/h at pressure 1 bar equal to 230.73 ,455.4 and 820.5 for three emitter and equal to 234.15 , 465.8 and 830 at pressure 1.5 bar for emitter discharge 2,4 and 8 L/h, respectively.

The coefficient of uniformity (CU) were equal to 96.9% and 96% for emitter 2 l/h at pressure 1 and 1.5 bar , equal to 91.6 % and 96.17% for emitter 4 l/h at pressure 1 and 1.5 bar and equal to 93 % and 95 % for emitter 8 l/h at pressure 1 and 1.5 bar .

Designing trickle irrigation system with pressure compensating emitters

The variation discharge (q_{var}) for emitter discharge of 2 l/h at pressure 1 and 1.5 bar equal to 1.99 and 2.19, for emitter discharge of 4 l/h equal to 3.4 and 3.5 and for emitter discharge of 8 l/h equal to 8.12 and 8.22.

CONCLUSION

The purpose of this study provide water and energy by designing two trickle irrigation systems with compensating emitters (Katif) which have constant discharge with different pressure on zero slope fields based on manufacturing and hydraulic variations. The experiments were carried out in Department of Agricultural Engineering Laboratory and Collage Farm of Faculty of Agriculture, Menoufia University during 2018.

The experiments were designed based on flow variation of total allowable head loss for lateral by sitting a pressure regulator at the beginning of each lateral. Also, based on the emission uniformity that dependent on the coefficient of variation of lateral.

A manufacturing coefficient of variation was calculated based on laboratory test by testing three emitters 2, 4 and 8 l/h at inlet pressure of 1 and 1.5 bar. A total, CV_t was determined in turn of calculating system uniformity. A field experiment was conducted for 50 m and 75 m of lateral length at zero slope for $\phi 13.6$ mm inner diameter and 16 mm outer diameter. In addition, spacing between emitters (2 m) with compensating emitters (Katif) under

three different emitter flow rates under inlet pressures of 1 and 1.5 bar.

Friction loss was measured along lateral line and compared to the calculated one. The coefficient of variation of emitter flow rate was found for 50 m and 75 m of drip lateral line on zero slope.

REFERENCES

- Bralts, V.F., D.M. Edwards and I.P. Wu (1987). Drip irrigation design and evaluation based on the statistical uniformity concept *Advances in Agronomy*, 4: 67-117.
- Jensen (1993). "significance of energy losses due to emitter connections in trickle irrigation lines j.irrig.and drainage Div, 119 (5).
- Kahiry, M.F., A . El-mesery, F.E. Zabady and M. H. Fayed (2016). Design and evaluation of mobile drip irrigation system. *Miser of journal agriculture engineering* (33) .
- Keller, J. and D. Karmeli (1974). Trickle irrigation design parameters *Trans. ASAE*, 17(4): 678–684.
- McConnell, T. (2003). "Trickle irrigation for home gardens extension farm management special list, Kenny. <http://www.irrigation/r/edu>.
- Wu, I.P. and H.M. Gitlin (1983). Drip irrigation aplication efficiency and schedules. *Trans. ASAE*, 28: 92-99.
- Wu, I.P. (1992). Energy gradient line approach for direct hydraulic calculation in drip irrigation design. *Irrig. sci.* 13: 21-29.

تصميم شبكات ري بالتنقيط ذي النقاطات المعوضة للضغط

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الملخص العربي

الهدف من هذه الدراسة هو تصميم نظام ري بالتنقيط ذي النقاطات المعوضة للضغط حيث نفذت هذه التجارب الحقلية لطول خط ري بالتنقيط عند 50 و75 متر حيث القطر الداخلي لخط الري بالتنقيط 13.6 مم والقطر الخارجي 16 مم باستخدام نقاطات ذات تصرفات مختلف 2 و4 و8 لتر/ساعة والمسافة بين النقاطات 0.5 متر . والعديد من النقاطات اخذت في الاعتبار مثل خصائص النقاطات وفواقد الاحتكاك وعوامل التصنيع والتصرف والاختلافات الهيدروليكية. والدراسة تمت مقارنتها عند خط 50 و75 من حيث فواقد الاحتكاك والتصرف وطول الخط . والبيانات الابتدائية اوضحت الانتظامية ومعامل التوزيع ومعامل الاختلاف حيث تم تجميع هذه البيانات من مزرعة كلية الزراعة جامعة المنوفية .

ومعاملات الاختلاف التصنيعي المقاسة اوضحت التغير في التصرف للنقاطات ووضحت هذه القيم لكل من معامل الاختلاف التصنيعي CV_m ومعدلات التصرف وتمت مقارنتها مع نتائج اختبار النقاطات للتأثير للنقاطات المعوضة للضغط عند الضغوط المختلف عند 1 و1.5 بار علي الأداء الهيدروليكي لنظام الري بالتنقيط . تم استنتاج اس العلاقة للمنقطات المعوضة للضغط عن طريق معادلة منحني الاداء للنقاطات وتتراوح بين 0.06 الي 0.2 . وقيم معامل الاختلاف للنقاطات المعوضة للضغط المقاسة اعطت نتائج ممتازة والاختلاف في معدلات التصرف علي طول الخط اعطت انتظامية توزيع اكبر من 90 % مما يدل علي كفاءة المنقطات المعوضة للضغط من النوع Katif . الكلمات الاسترشادية: الري بالتنقيط، نقاطات المعوضة للضغط، خطوط الري الفرعية، انتظامية التوزيع، العلاقة بين الضغط والتصرف .

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Designing trickle irrigation system with pressure compensating emitters
