EFFECT OF DRIPPERS GEOMETRICS MAP ON HYDRAULIC PERFORMANCE OF DRIPPERS

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Abstract

The influence of dripper geometric map on hydraulic properties of the dripper gets wide application in drippers performance. Three types of drip geometric map (vertical-horizontal, and in-out), and three angles of water entrance to the drip base (45°.,90° and 180°) two drip water path length, use 20 to 25 mm and 25 to 30 mm were used. The following results are obtained:-

1- For the effect of dripper geometric map shape on drip hydraulic properties the vertical and horizontal ones were more efficient than the in-out one.

2-The water angle 180° was more efficient than others in dripper's performance compared with the other degrees (45° and 90°).

3- The effect of path length on dripper performance. As the path length decreased to 20 mm the dripper performance increased (EU %) also CV achieved highest degree in CV classification (Excellent) according to ASAE. Also, path length between 25 to 30 mm recorded the lower hydraulic performance of drippers.

The recommendations of this research are: use a geometric map of drippers, either vertical or horizontal, with the angle of water entrance through the base of drippers (180 °) with the length of the path of drippers not exceeding 25 mm.

Keywords: - drippers geometric map, hydraulic performance.

INTRODUCTION

Drip irrigation is one of the most effective methods among all water-saving irrigation technologies. The dripper is the main component of the drip irrigation system and its structure has an important impact on the irrigation uniformity, anti-clogging capacity and life-span of the system. The dentate structure has a significant effect on the flow process.

Ozekici and Sneed (1991) reported that the research on hydraulic properties of tortuous dentate flow paths has indicated that the majority of energy dissipation occurs at the dentate places. But because of narrow flow path and complex boundary of drip emitters, it is difficult to conduct quantitative measurement on the inner movement and energy dissipation process**.** Also, the following conclusions are obtained:

1) To the non-compensatory drip emitter, the minimum flow index is 0.5 for completely turbulent flow;

2) Both discharge coefficient and flow index of the labyrinth emitter are positively correlation with the wetted perimeter. The bigger the wetted perimeter is, the higher the sensitivity of the emitter discharge to the pressure is.

3) With equivalent labyrinth path cross section area an emitter with a square shaped cross section performs better than one with a rectangle section.

As one of the current most effective water-saving irrigation technologies, drip irrigation plays a more and more important role in the development of modern agriculture. The emitter is the main component of the drip irrigation system and its structure has an important impact on the irrigation uniformity, anti-clogging capacity and life-span of the system Glaad and Klous (1974). The width of the flow path of an emitter is only about 0.6–1.3 mm and it is easily clogged by the pollutants in water. Currently, the most widely used emitter is the tortuous dentate emitter, which belongs to the category of long path emitters Wei *et al.* (2006a).

Adin and Sacks (1991) carried out farmland experiments to study the clogging problem of emitters in sewage irrigation system, their results showed that the clogging was closely related to the channel structure and suggested channel design should consider: shortening and widening the flow path; rounding the straight edges on the protruding teeth and so on. Wu *et al.* (2004) carried out an investigation on the subsurface drip irrigation system and they thought emitter clogging caused by the attached granules and proposed to optimize the channel structure to solve this problem. Wei *et al.* (2008) adopted the numerical simulation and experiments, three types of emitters, including eddy drip-arrows, pre-depositing drippers and round-flow drip-tapes were evaluated by them, the results showed that the eddy drip-arrows have the best anti-clogging performance among three emitters. Wei *et al.* (2006a and b) and Zhang *et al.* (2007) conducted three-dimensional (3D) numerical simulations on the curve of flow rate versus pressure heads through labyrinth-channel emitters.

All researchers used k and x to evaluate an emitter’s hydraulic performance. Moreover, the values of k and x are usually regressed from the experimental curve of flow rates and pressure heads. Therefore, it is not easy to choose the optimal structure from a group of emitters with the same shape but different dimensions on the basis of the two variables, especially at the design stage of emitters.

The aim of this investigation was to study the effect of drip geometric map shape on drippers hydraulic performance.

MATERIALS AND METHODS

Laboratory experiments were conducted at the National Irrigation Laboratory of Agricultural Engineering Research Institute (AEnRI), Dokki.Giza. Laboratory tests were carried out for the six types of drippers used. According to geometric map shape.

The dripper geometric map shapes were, A- Vertical drip geometric map B- Horizontal drip geometric map, and In out drip geometric map, added to that the water angle intrance in drip base and water path length. All measurements were done according to ISo (1991) for evaluating dripper flow rates by using drip irrigation test facility which consisted of: water tank, multi-stage pumping unit, pressure regulator, air compressor, filtration unit, temperature regulator and , Lines of pipes, Six tested drippers were evaluated after measuring flow rates via operating pressure which started from 0.5 bar to 1.5 bar. The other hydraulics properties were calculated such as (EU, CV, q_{var}).

In addition, for all drip Types, the measuring of drip geometric map, water path length and finally water angle intrance were done using calibrated instrument and Auto Cade program.

The following Fig . (1), clearly appears the drip geometric map drawing as pelt drawing.

Friction losses measurements: all drip pressure drop were measuring used pressure drop apparatus which consists of digital flow meter from 0 to 20 m3/h also it's consists of digital pressure gauge which measuring the pressure drop in samples under test in mbar.

Water inter angle: the angle of water path in the drip base was measuring according to the drip base with the column water path in the drip tube.

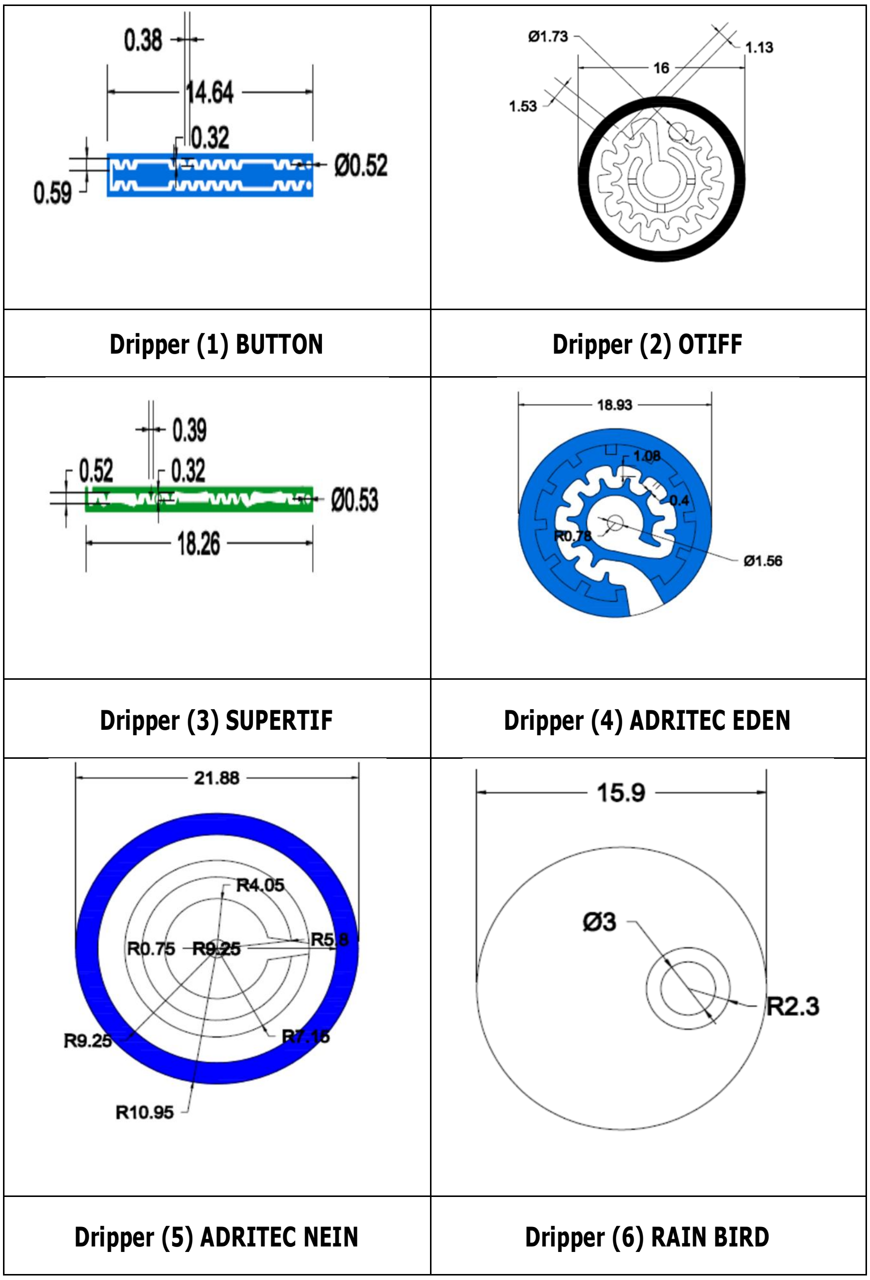

Fig. 1. As pelt drip geometric map shape for variable drippers
(all drip measurement in (mm)).

Methods of calculation

- Pressure - flow relationships:

The emitter discharge is usually characterized by the relationship between discharge, pressure and an emitter discharge exponent. The equation for emitter flow that has been used by many researchers (Keller and Karmeli, 1974) can be expressed as:

$$q = kp^x$$

Where:

q = emitter flow rate, l/h,

k = constant of proportionality that characterizes each emitter.

p = operating pressure, bar, and

x = emitter discharge exponent that characterizes the flow regime.

The pressure influence on emitter discharge variation can be presented in two ways, either directly as the average of emitter discharge or as a percentage of discharge change that occurs at the actual operating pressure at 25 ^{0}C according to AENRI and MSAE, 2002 as follows:

$$q_{var} = \frac{q_{max} - q_{min}}{q_{max}} * 100$$

Where:

q_{var} = the emitter flow variation, (%);

q_{max} = maximum emitter flow, (l/h), and

q_{min} = minimum emitter flow, (l/h).

In general criteria for $q_{var.}$ values are; 10-20 % acceptable; greater than 20%, not acceptable according to ASAE (1996a).

-Emission uniformity (Eu):

Emission uniformity is used to indicate performance for emitters. Values were calculated according to the following equation (Keller and Karmeli, 1974).

$$Eu = \left({}^{q_n}/{q_a}\right)100$$

Where:

Eu = emission uniformity, %,

q_n = average of the lowest 1/4 of the emitter flow rate, l/h, and

q_a = average of all emitter flow rate, l/h.

-Emitter manufacture's coefficient of variations:

The manufacture's coefficient of variation "CV" indicates the unit to unit variation in flow rate for a given emitter. The emitter manufacture's coefficient was calculated by measuring the discharge from a sample of the new emitters according to AENRI and MSAE, 2002 as follows:

$$CV = {}^{s}/{q_a}$$

Where:

CV = manufacturer's coefficient of emitter variation;

q_a = average flow rate (l/h), and

s = standard deviation of emitter discharges rates at a reference pressure head.

RESULTS AND DISCUSSION

The effect of pressure on drip flow rates are presented in Fig (2). Table (1) contains the influence of the following (drip geometric map shape, water path length, and water base angle) on drip hydraulic characteristics. It was very clear that, there were a close relationship between operating pressure and drip flow rates for all tested drippers, as operating pressure increased also flow rates increased.

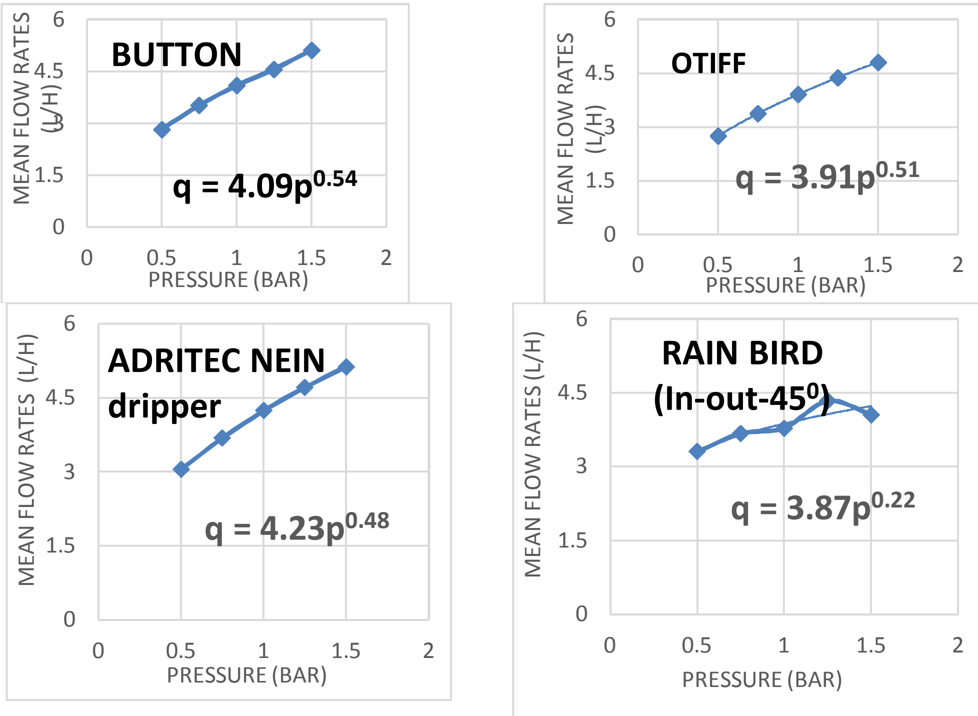

Fig. 2. Performance curves of different drip geometric map shapes and different water base angles.

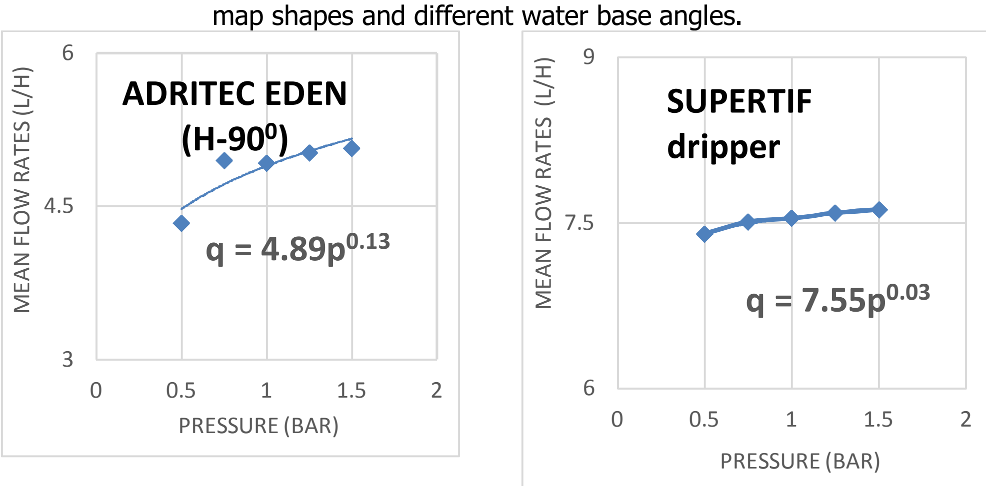

Fig. 2. Performance curves of different drip geometric map shapes and different water base angles.

All dripper are tested under five pressure levels 0.5 to 1.5 bar .All drippers hydraulic characteristics ranged from acceptable to margin till unacceptable from all data recorded in Table (1). The first dripper had the following specification (the efficient one in all measuring item), q= 4. 07 L/h., Cv = 1.26 %., EU= 98.25., q_{var} = 3.89%., drip exponent 0.54., path length 24.52mm., fully turbulent flow ., 180° water path angle., vertical drip geometric map shape and hf =82.1 mbar. The second one had q= 3.91 L/h., Cv = 4.8 %., EU= 96.0 ., q_{var} = 9.15%., drip exponent 0.51 ., path length 21.39 mm., fully turbulent flow ., 180° water path angle., horizontal drip geometric map shape and hf = 75.15 mbar. From data presented before it was very clear that the drip geometric map shape, path length, water path angle were affected in dripper performance (EU, CV, q_{var}).

The research results concluded that:-

1-No different appeared in drip performance in drip geometric map shape (vertical or horizontal).

2- Water path angle was the effective parameter the highest one in drip performance was angle 180° in compare with 90° and 45°.

3- The path length also affected drip performance; the best measuring was obtained from the length 20-25 mm from water intrance through drip base to the outer in drip part in the other hand it may be noticed that as path increased hydraulic parameters of drip such as (EU, CV, q_{var}) decreased.

Table 1. Collected all dripper measurements and calculations for the six drippers.

Dripper	BUTTON	OTIFF	SUPERTIF	ADRITEC EDEN	ADRITEC NEIN	RAIN BIRD
Flow rate (l/h)	4.07	3.91	7.54	4.92	4.24	3.78
h_f (m)	0.13 m	0.14 m	0.14 m	0.13 m	0.14 m	0.13 m
Manufacture's coefficient of variation CV (%) at (1 bar)	1.26	4.80	4.19	7.79	9.98	13.85
Emission uniformity (Eu %)	98.25	96.0	94.44	91.04	89.49	83.62
Emitter flow variation (q_{var} %)	3.89	9.15	11.52	22.46	30.84	40.26
Emitter discharge exponent (x)	0.54	0.51	0.03	0.13	0.48	0.22
Flow regime	Fully turbulent	Fully turbulent	pressure compensating	pressure compensating	Fully turbulent	pressure compensating
Path length (mm)	24.52	21.39	23.59	29	31.51	28
Inner diameter (mm)	3.37	3.4	3.4	3.6	3.4	4.4
Outer diameter (mm)	3.7	3	4.2	3.6	5.4	4.6
Water inter angle	180^0	180^0	180^0	90^0	180^0	45^0
Drip map shape	Vertical	Horizontal	Vertical	Horizontal	Vertical	In out

CONCLUSIONS

Determining the factors that affected the efficiency of the hydraulic drippers was the main objective of this research. The effect of the dripper geometric map on drip performance was studied. The following conclusion were obtained: using vertical or horizontal drip geometric map shapes with 180° of inner water in drip base added to that path length 20 – 25 mm was the most efficient in all dripper hydraulic properties.

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تأثير خريطة المنقطات الهندسية على الأداء الهيدروليكى للمنقطات

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دراسة تأثير خريطة المنقطات الهندسية على الاداء الهيدروليكى للنقاطات وذلك من خلال استخدام ٦ أنواع مختلفه من النقاطات الخارجية ذات خرائط مختلفة (عمودية – افقية – داخل خارج) وكذلك بزوايا دخول ماء لمسار النقاط مختلفة (٤٥° –٩٠° –١٨٠°) وذات طول مسار داخلى يتراوح من (٢٥–٢٠) مم و(٣٠–٢٥) مم.

نتائج البحث تتلخص فى الاتى:

١– تأثير شكل خريطة المنقطات الهندسية على خصائص النقاط الهيدروليكية ،أظهر البحث انه لا يوجد تأثير لشكل خريطة النقاط سواء الرأسى أو الافقى على الاداء الهيدروليكى للنقطات فى حين ان النقاطات ذات الخريطه داخل خارج (بدون مسار) كان الاداء الهيدروليكى لها غير جيد مقارنتا بذات المسار الافقى والراسى.

٢– زاوية دخول مسار الماء (١٨٠°) كانت أكثر فاعلية فى تحسين أداء النقاط بالمقارنة بالزوايا الاخرى (٤٥°–٩٠°) و يرجع ذلك لزيادة مساحة دخول الماء الى مسار النقاط .

٣– تأثير طول مسار دخول الماء على أداء النقاط ، أظهرت النتائج أنه كلما قل طول مسار دخول الماء فى حدود (٢٥–٢٠) مم كلما زاد ذلك من كفاءة اداء النقاط مقارنتا بالنقاطات ذات المسار الطويل.

نتائج البحث توصى بى: أستخدام خريطة نقاط سواء الرأسية أو الافقية مع زاوية دخول الماء مع قاعدة النقاط (١٨٠°) مع طول مسار نقاط لايتعدى ٢٥ ملليمتر يكون لة تأثير ايجابى على تحسين الاداء الهيدروليكى للنقاط.