DESIGN AND EVALUATION OF SAND-FILLED DRIPPER

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ABSTRACT

The sand-filled dripper is a new invention. In fact, the sand dripper is a micro tube(Poly ethylene), its length ranges from 5 to20cm and its diameter is 5 or 11 mm which is filledofuniform grain size sand (homogenous) (1,0.8, and0.63 mm), it is closed from its ends by screen pieces with negligible flow resistance.The aim of this study is determining the characteristics of sand dripper and their effects with effective heads "H" on discharge "q".These characteristics are length "L", diameter "D" and diameter of sand particles which fill ofthe tube. The dimensional analysis is used in this study, the results show that:$\boldsymbol{q = Cg^{0.5}d^{2}D^{0.5}(H/L)(R^{2} = 94\%)}$*(where: q is in L/h, g is in m/s*^{2}*, H is in m, d is in cm, D is cm and C is a constant equal to 1.45 and 5.52 for typesof 5 and 11 mmrespectively).Thesand dripper type 11was notsuitable for use with the lateral lines of 16 or 18 cm. However, sand dripper type5issuitable for use as traditional emitter. The sand dripper type 5 which has 10 cm length and 0.8 mm sand diameter gave CV equal to 0.07 at effective head 12m.*

INTRODUCTION

Trickle irrigation is based on the fundamental concepts of irrigation only the root zone of the crop and maintaining the water content of the root zone at near optimum levels. There are several problems associated with trickle irrigation.The most revere problem is the clogging of emitters. Point and line-source emitters generally have smaller passages for discharging water and are more prone to physical, chemical, and biologically induced clogging than are bubblers or micro sprinklers. There are many types and designs of point-source emitters available commercially; **(James 1988).** Point-source emitters can be classified as long path, orifice, or pressure compensating emitters.

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The classification depends on the exponent in this equation: $q = k.p^x$ Where:"q" is emitter discharge (volume/time), "p": is operation pressure (force/area), and "k" and "x" are constants for specified emitters. When "x" approaches '1' the emitter is considered a long-path or laminar-flow type emitter. An orifice-type point-source emitter has a x of about 0.5, while x for a pressure compensating emitter is positive and nearly zero. Also "x" = $Log(q_1/q_2)/Log(H_1/H_2)$ where: q_1 is emitter discharge at effective head (H_1) and q_2 is discharge at effective head (H_2), also "k" can be determined from "x" **(Al-Amoud 1997)** and **(Keller and Karmeli 1975)**. **Awady (1975)** made and described a tricklerof plastic tube of 1.3 mm I.D. and 3, 4, 6, and 40 cm lengths. The discharge rates of trickler tube were different with length from about 68 to 22 ml/min.

The objectives of this study are to design and evaluate a new trickler (sand-filled dripper types 5 and 11 mm-d) and the determination of its characteristics of and effects with different effective heads on discharges.

MATERIAL AND METHODS

The main objective of this research was evaluating a sand dripper for use in trickle irrigation. The sand dripper consists of micro tube which is full by graduated sand, screenpieces at each end of themicro tube, and barbed end, (Fig.1). In order to determine the relation between sand dripper discharge and different variables as length, diameter,size of sand particles and effective head. The sand was graduated by dry sieving.

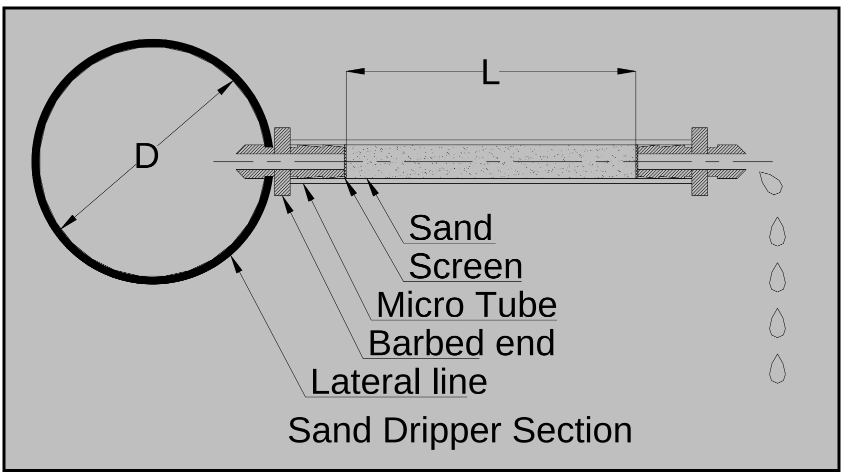

Fig. (1): Typical installation of sand dripper.

Methods

The discharge from sand dripper depends on: (1) characteristics of sand dripper such as length "L", diameter "D", and sand size which fill it, (2) effective head "H" on sand dripper.

The dimensional analysis given here will serve to guide arranging the various factors in dimensionless groups. Discharge of sand dripper depends on these variables which were collected in the following equation:

$$q = f(H, L, D, d, g) \ldots\ldots\ldots\ldots (1)$$

Where:

q: sand dripper discharge (volume/t),
g: gravitational acceleration(length/t$^{2)}$,
H: effective head (length),
D: sand dripper diameter (length),
L: sand dripper length (length), and
d: diameter of sand granules which fill dripper (length).

Others factors representing state of flowsuch as Reynolds No. (the flow regime is laminar) are assumed constants for all treatments, and thus omitted from the analysis as long as results are confirmed.By mean of simple dimensional analysis, the variables can be arranged into dimensionless analysis groups. A possible form will be,

$$\pi_1 = k(\pi_2, \pi_3, \pi_4) \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\frac{q}{g^{0.5} . D^{2.5}} = k\left(\frac{H}{L}, \frac{D}{d}, \frac{L}{D}\right) \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In order to determine the “k - function” the laboratory experiments were done.
Minitab program - regression analysis (non linearmulti regression) was used. The input data applied to regression analysis were in Ln (Natural logarithm)form;therefore, the coefficient output becomes exponential.

The laboratory experiments were located at the Irrigation Laboratory of the Agricultural Engineering Department, Faculty of Agriculture, Al-

Azhar University, Nasr City. The aim of the laboratory experiments was to determine the sand dripper discharge “q”.

Determination of sand dripper discharge:

To determine the sand dripper discharge “q” at different characteristics of sand dripper, the different sand dripper lengths “L” of 5,10,15, and 20 cm anddifferent sand diameters(which of sand) “d” of 1,0.8 and 0.63 mm were used. The effective head “H” was changed at each case from 3, 6, 9 and 12 m. The water was collected from sand dripper by measuring in cylinder and the time was determined by stop watch. The sand dripper internal diameters “D” were 5 mm(type 5), and 11 mm(type 11).

To determine themanufacturer's coefficient of variation (CV) 20×3 sand drippers were made(type 5) which had 10 cm length and sand diameters of 1, 0.8, 0.63 mm. The discharge "q" was measured at each case and CV was calculated.

RESULTS AND DISCUSSION

To determine the discharge equation of sand dripper at different characteristics (L, D, and d) and different effective heads "H",ninety six experiments were done with three replicates for each experiment. At any case, the discharge was measured. Also dimensional analysis and regression analysis methods were used to determine of discharge equation of sand dripper.

Figs.(2)and (3) present the relation between the sand dripper discharge "q" and effective head "H" with different lengths of "L" 5, 10, 15, and 20 cm and different sand diameters of "d" 0.63, 0.8, and 1 mm at sand dripper diameter "D" of 5 and 11mm.The relation between effective head "H" and discharge "q" of sand dripper was fitted as power equation $q = kH^X$ (R^2 = 99 %).The constants "k" and "x" depend on specifiedof emitter. Result of "x" approaches(0.8: 1.2) 1.These results agreebecause the flow regime is laminar. The maximum discharge of type 5 and type 11 were 7.2 and 41.82 L/h at effective head 12 m.Also, the minimum discharges were 0.14 and 1.1 L/h at effective head 3 m, respectively.

Fig.(4)illustrates therelation between Π_1 (q/g^.5D^2.5) andΠ_2 (H/L)at different Π_4 (L/D).The relation shows that Π_4 has non-significanteffecton relation between Π_1 and Π_2, Also, statistical analysis; analysis of variance (F test) gave the relation between Π_1 ($q/g^{0.5}D^{2.5}$) and Π_4 (L/D) as non-significant.

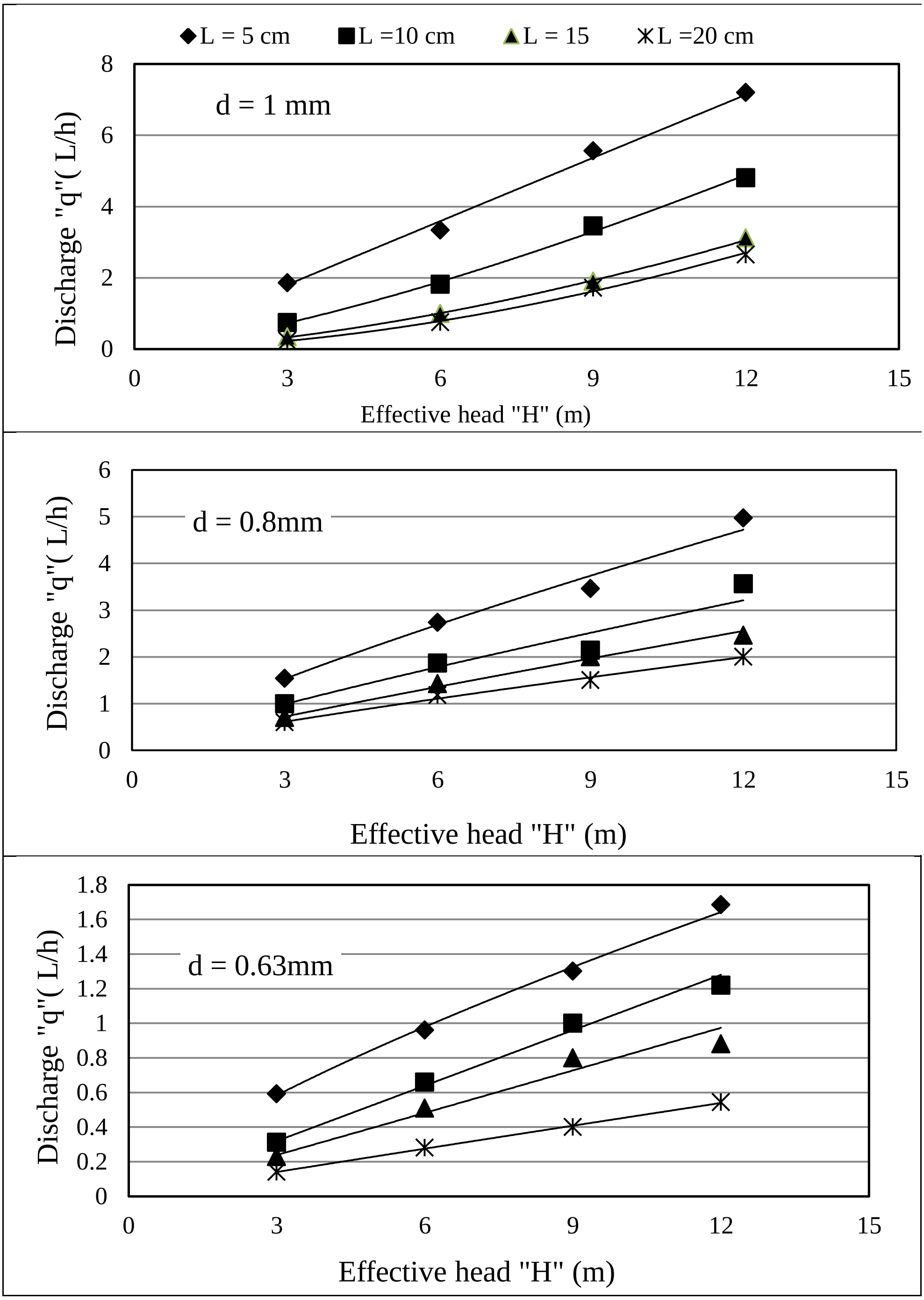

Fig . (2): Relation between sand dripper discharge "q" and effective head "H" at different sand dripper lengths (Type 5).

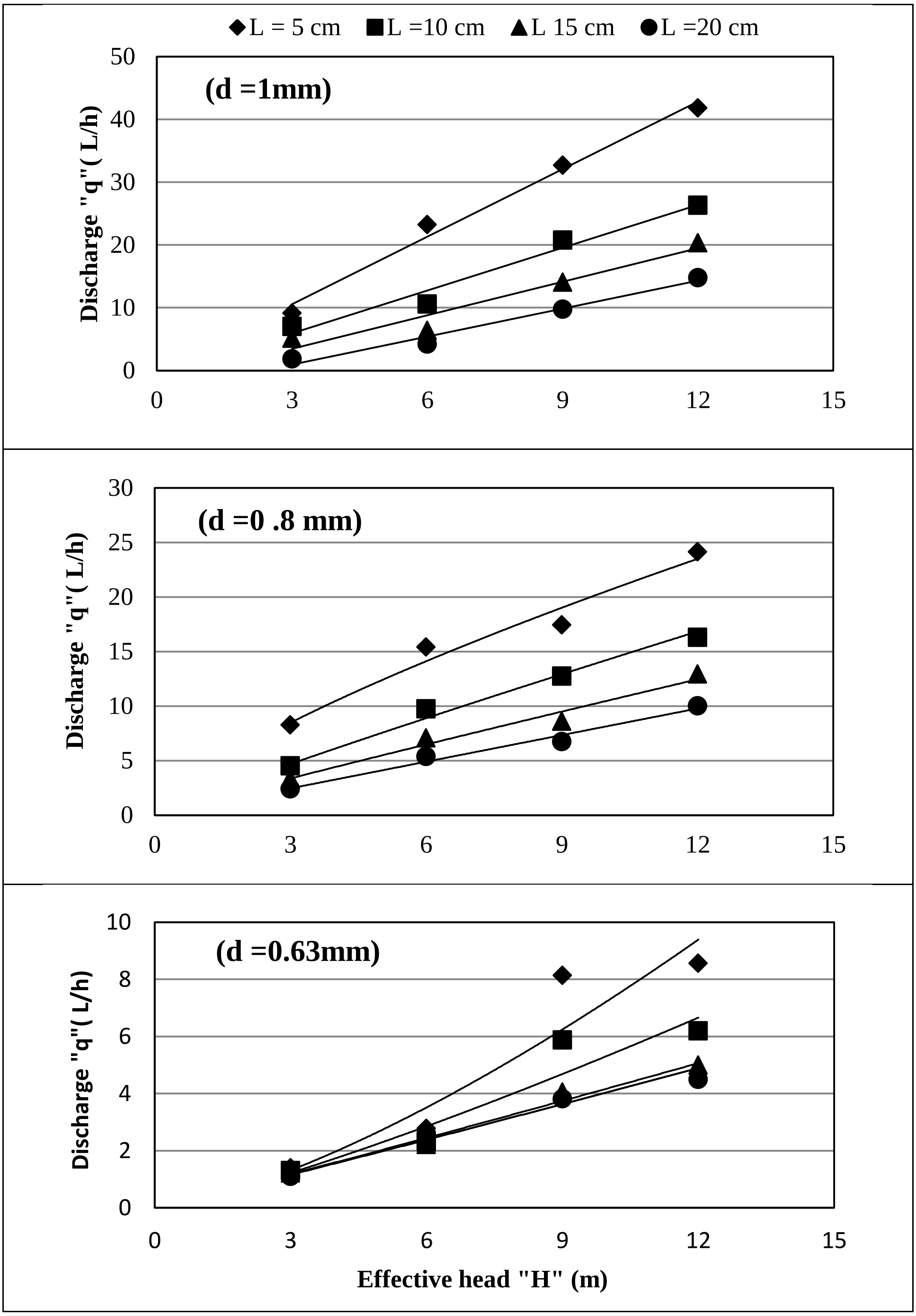

Fig . (3): Relation between sand dripper discharge 'q'and effective head "H" at different sand dripper lengths (Type 11).

Figs.(5) and (6) illustrate the relation between Π_1 and Π_2 which depends on values of Π_3. The relation between Π_1 and Π_2 was fitted with liner equation as followings:

$$\Pi_1 = a\ \Pi_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Parameter "a" depends on Π_3, (the exponent of Π_3 must be equal to 2 because its represents a cross area of the tube and sand). Fig. (6) shows the relation between parameter "a" and $(\Pi_3)^2$ at each sand dripper 0f 5 mm and 11mm diameters. The relation between "a" and Π_3 was fitted as followings: for the type 5 of sand dripper.

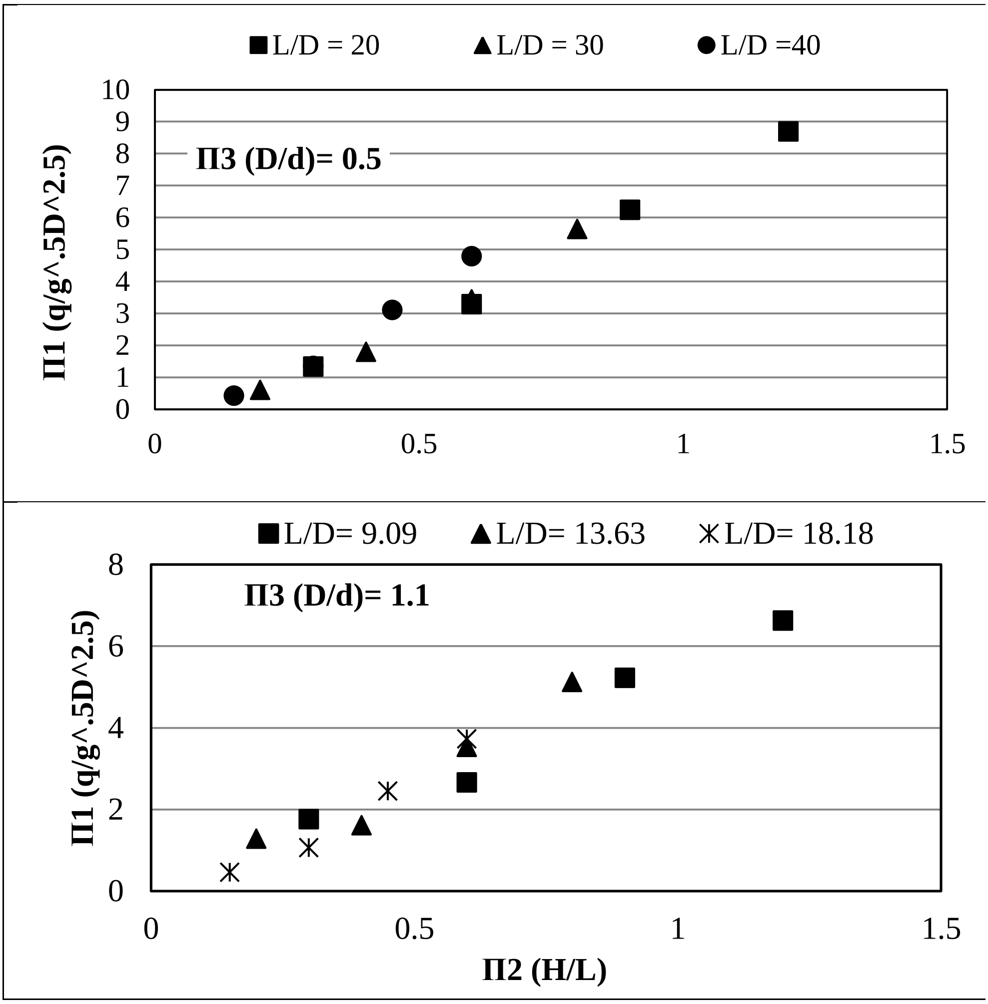

Fig. (4): Relation between Π_1 $(q/g^{0.5}D^{2.5})$and Π_2 (H/L) at different Π_4 (L/D).

$$a = 1.45\,(\Pi_3)^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

From equations (4) and (5)

$$\Pi_1 = 1.45(\Pi_3)^2\,\Pi_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (6)$$

$$\mathbf{q = 1.45g^{0.5}\,d^2D^{0.5}\,(H/L)} \quad \ldots\ldots\ldots\ldots\ldots\ldots..\ (R^2 = 92)\ (7).$$

For the type 11 sand dripper:

$$a = 5.52(\Pi_3)^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\ldots(8)$$

$$\Pi_1 = 5.52\,(\Pi_3)^2\,\Pi_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

$$\mathbf{q = 5.52g^{0.5}\,d^2D^{0.5}\,(H/L)} \quad \ldots\ldots\ldots\ldots\ldots(R^2 = 93) \qquad (10)$$

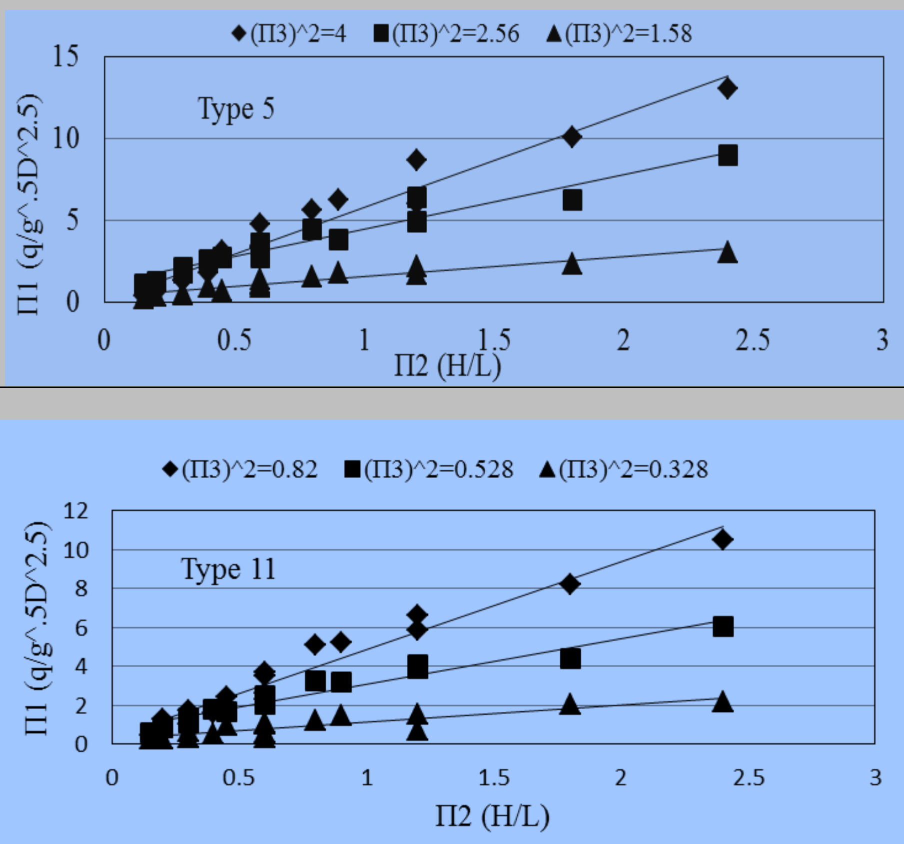

Fig. (5): Relation between Π_1 ($q/g^{0.5}D^{2.5}$) and Π_2 (H/L) at different Π_3 (d^2/D^2).

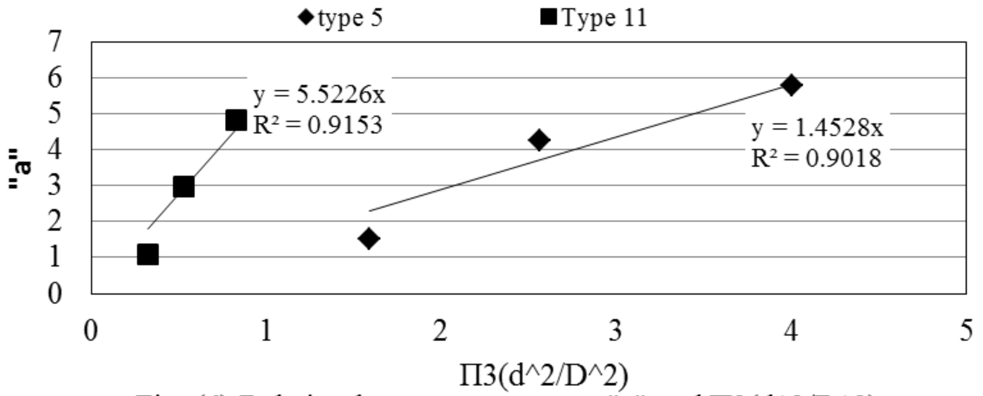

Fig. (6) Relation between parameter "a" and Π3(d^2/D^2)

Where:

q: sand dripper discharge (L/h),

g: gravitational acceleration (m/s^{2}),

H: effective head (m),

D: sand dripper diameter (cm),

L: sand dripper length (cm),

d: diameter of graduated sand which fills the dripper (mm).

Fig. (7)shows the relation between observed and calculated discharge by equations (7) and (10). The relation gave agreement between observed and calculated data.

Statistical analysis:

The results ofStatistical analysis (multi regression- non linear) gave the following equation:

$$\mathbf{q = 9.7\ h^{1.07} L^{-0.75} D^{2.17} d^{2.63}} \quad \ldots\ldots\ (R^2 = 92)\ (11)$$

Also, the statistical analysis; analysis of variance (F test) gave the relation between Π_1 (q/g^0.5D^2.5) and Π_4 (L/D) as non-significant. Also statistical analysis gives results of CV for sand dripper 10cm length with different effective heads and different sand diameters. These results are acceptable as shown in Fig. (8). It shows the relation between CV and the effective head "H" at different sand diameters "d". The results indicate that sand diameter0.8 mm with effective head 12 m was best with CV = (0.07).

CONCLUSION

The objectives of this study are: Designing and evaluating a new sand-filled dripper which can use available materials. The laboratory experiments were carried out to determinethe sand-filled dripper discharge "q" at different

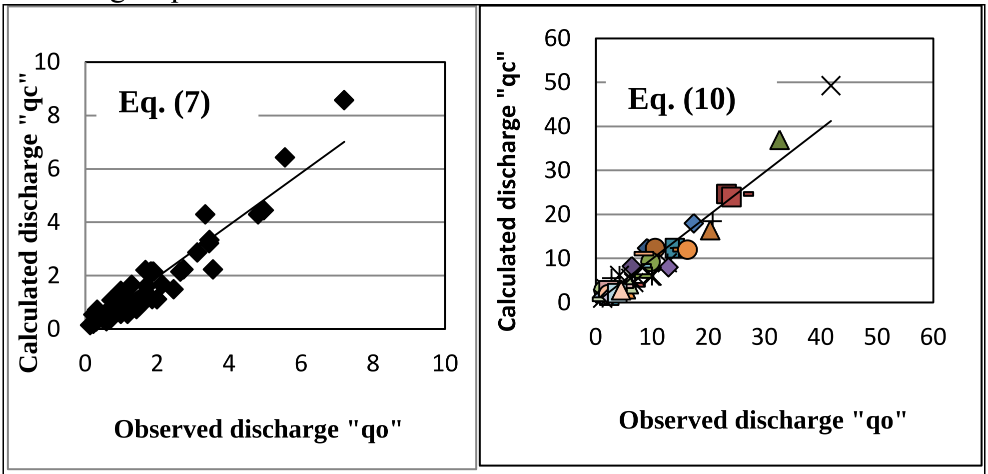

Fig. (7) Relation between calculated and observed discharge "qo" for S. filled dripper.

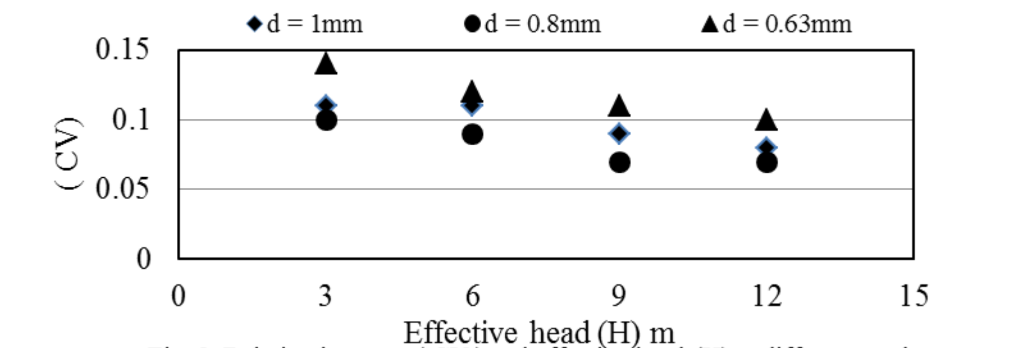

Fig. 8. Relation between (CV) and effective head (H) at different sand diameters (L=10cm, D = 5mm)

effective heads "H" and characteristics of sand dripper as length "L", diameter "D" and diameter of sand granules "d". Length, diameter and sand diameter were varied as (5, 10, 15 and 20 cm), (5and 11 mm) and(1, 0.8 and0.63 mm) resp..Also, the effective head “H” was changed at each variable from 3, 6, 9, and12 m.Dimensional analysis and statistical analysis (regression analysis-multi regression- nonlinear) were used to determine discharge at different parameters. The results of dimensional analysis were as followings: For the type 5sand dripper result is:

$$\mathbf{q = 1.45g^{0.5}\, d^{2} D^{0.5}\, (H/L)} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots \;(R^{2} = 93).$$

For the type 11sand dripper is:

$$\mathbf{q = 5.52g^{0.5}\, d^{2} D^{0.5}\, (H/L)} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots \;(R^{2} =93)$$

The results ofStatistical analysis (nonlinear - multi regression) gave the following equation:

$$\mathbf{q= 9.654\, h^{1.07} L^{-0.75} D^{2.17} d^{2.63}} \ldots\ldots\ldots\ldots\ldots \;(R^{2} = 92)$$

Wheresymbols are as defined as before.

The result of CV for sand dripper 10cm length with different effective heads and different sand diameters were 0.07 to 0.14.

Recommendation: The type 5sand dripper is a new emitter device which has some advantages as: made of local material, easily used, high cv, acceptable with low pressure operation and range of discharge from7.2 to 0.14 L/h is suitable for different crops.

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الملخص العربي

تصميم وتقييم نقاط محشو بالرمل

د/ علاء الدين علي المسيري*

النقاط المحشوبالرمل فكرة جديدة عبارة عن أنبوبة بولى إيثيلين(اسبجتى) مملوئةبالرمل المتجانس الأقطار وطول الأنبوبة يتراوح من ٥إلى ٢٠ سم وقطرها ٥مم ومغلقة من طرفيها بشبكة من سللك

غربال وبداية اسبجتى تشبه النقاط العادى.

وتهدف الدراسة إلى معرفةتصرف النقاط الرملى عند ضغوط تشغيل مختلفة وخصائصالنقاط المختلفة.

متغيرات الدراسة:

١) طول النقاط كان ٥ و ١٠ و ١٥ و٢٠ سم.

٢) قطر حبيبات الرمل المتجانس داخل النقاط كان ١ و ٠,٨ و ٠,٦٣مم.

٣) قطر الانبوبة كان ٥و١١ مم.٤ ـ ضاغط التشغيل المؤثر تم تغبره حيث كان ٣و٦و٩و١٢ م

طرق البحث:

تم استخدام طريقتى التحليل البعدى والتحليل الإحصائى لإيجاد العلاقة بين المتغير التابع (تصرف النقاط الرملى) والمتغيرات المستقلة السابقة.

النتائج:

التحليل البعدى

$$q = Cg^{0.5}\ d^{2}D^{05}\ (H/L)\ldots\ldots\ldots\ldots\ldots\ (R^{2} = 94\%)$$

التحليل الإحصائى

$$q= 9.654\ h^{1.07}L^{-0.75}D^{2.17}d^{2.63}\qquad \ldots\ldots(R^{2} =92\%)$$

حيث:

q: تصرف النقاط الرملى (لتر/ساعة).g: عجلة الجازبية الأرضية (م/ث).

d:قطر حبيبات الرمل (مم). D: قطر الأنبوب (سم).

L: طول النقاط (سم).H: ضاغط التشغيل (م).

C: ثابت =١,٤٥ للنقاط ٥مم و=٥,٥٤ للنقاط ١١مم.

تم حساب معامل الأختلأف التصنيعى للنقاط (قطر ٥مم وطول ١٠ سم) ومدىتأثره بضغط التشغيل وقطر حبيبات الرمل، حيث وجد أنه فى حدود ٠,٠٧ و ٠,١٤.

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