GAU Res. J. 1993. 19 (1) : 21-28

Hydraulics and Surface Horizontal Movement Under Microtube Drip System

P. K. Srivastava*, N. G. Savani, M. M. Parikh and S. Raman

Soil Water Management Project, Gujarat Agricultural University, Navsari Campus, Navasari

ABSTRACT

The pressure discharge relationship of different diameter microtubes is expressed in power form equation. The value of an exponent of the equation has little variation compared to multypling constant for various length and diameter microtubes. A common power form equation is developed showing relationship among discharge rate, tube diameter, tube length and pressure head. The surface horizontal movement of the water is also expressed in power form, as a function of system parameters and time of application. The surface horizontal movement of water front under microtube drip system increased with increase in diameter and application time, for a given pressure head and decreased with increase in tube length.

(Received on 1st April, 1992)

INTRODUCTION

Among the various drip systems, micro-tube system is thought to be more economical. The hydraulic characteristics of micro-tube drip system differs from other systems owing to its diameter and length. For a given tube length and diameter, the discharge rate is a function of the pressure head. However to get uniform water application either different lengths or diameter of microtubes can be adopted such that the discharge rates are more uniform within the allowable pressure variations along the main and lateral lines of the system. Therefore it is necessary to know the pressure discharge relationship for various available microtubes to decide upon what length and diameter tube should be chosen for drip system. After selection of the system parameters, it is necessary to know the water distribution patterns for a given set of soil, hydraulic and system parameters and the time of application of irrigation water. Proper combination of these parameters provides uniform application as well as necessary moisture to the crop. This paper is an attempt to study (i) pressure discharge relationship for various sizes of microtubes, (ii) relationship among system and hydraulic parameters and (iii) the relationship among time of application, horizontal water front movement at surface, system parameters and hydraulic parameters.

*Present address : Assitant Research Scientist, Soil & Water Management Project, Gujarat Agricultutral University, Navsari Campus, Navsari.

MATERIALS AND METHODS

Microtube Hydraulics

For a given length and diameter microtube, the flow function described by Bralts *et al.* (1981) and Pitts *et al.* (1986) for drip emitters can be used.

$$q = KH^x \quad \text{(1)}$$

where, q = emitter flow rate, L/h

K = proportionality constant

H = pressure head, m

X = discharge exponent

The magnitude of x and k are measure of flow variations due to sensitivity and manufacturing variations. However, these constants are differing in their values with change in tube length and diameter. An equation showing relationship among system parameters (length, diameter) and hydraulic parameters (discharge, pressure) may be of the following form :

$$q = ad^b (H/L)^c \quad \text{(2)}$$

where d = inner diameter of tube, mm

L = Length of tube, m

a,b,c = constants

Other parameters are as explained in Eq.1. The values of constants a,b,c for laminar flow conditions are given as 1.272, 2.70 and 0.80 and for turbulent flow these are 1.776, 2.73 and 0.56 respectively (Nakayma and Bucks 1986). However these constants are different for different flow conditions.

Horizontal Advance

The moisture movement pattern depends on the type of soil, initial moisture content, discharge rate and time of application. The horizontal advance front under point source is studied by various workers. It is expressed as a function of time for a particular discharge rate (Sivanappan & Padmakumari (1980); Gupta *et al.* 1990; Kaul and Michael 1982; Ramadevi 1983). The wetted diameter is explained as a function of discharge rate (Gupta and Tyagi; 1987) and total water applied (Sivanappan and Padmakumari 1980). Instead od considering one or two parameters, the horizontal advance as function of tube dia and length,operating pressure and time of application may be expressed in power form as given below :

$$A_H = \alpha d^B (H/L)^{\eta} t\phi \quad \text{(3)}$$

where A_H = horizontal advance, cm

t = time of application, minutes

α, B, η, ϕ = costants

The microtubes having diameter of 0.645, 0.995, 1.312, 1.313 and 1.604 mm were used to study the pressure discharge relationship. A constant pressure was maintained by regulating a control value fitted near the pressure gauge on the screen filter. The discharge volumes from each microtube were collected pressure of 2, 4, 6, 8, 10, 15 and 20 m. The length of microtubes was 2.0 m for all sizes except 0.645 mm diameter tube whose length was 0.5 m. The testing was carried out with 10 microtubes of the same length and diameter size and replicated two times for each pressure.

For horizontal advance study the same set was used and the horizontal movement at surface was measured for 15, 30, 45, 60, 90 and 120 minutes of operation. The data are collected for 4 m and 8 m pressure. The soil characteristics are given in Table-1.

TABLE 1

Soil physical and chemical properties.

Sr. No.	*Soil properties*	
1.	Soil texture	Clayey
2.	Sand	8.83%
3.	Silt	26.16%
4.	Clay	62.86%
5.	Soil depth	100 cm
6.	Field capacity	32%
7.	Parmanent Wilting Point	17.5%
8.	Basic Infiltration Rate	0.3 cm/hr
9.	Bulk density	1.43 gm/cc
10.	pH	8.4
11.	Electric conductivity	0.2 mmhos/cm
12.	Organic carbon	0.25%
13.	Nitrogen	0.05%
14.	P_2O_5	20.5 kg/ha
15.	K_2O	580.0 kg/ha

RESULTS AND DISCUSSION

Microtube Hydraulics

The data collected for individual microtube are fitted to power Eq. 1. The results of the analysis of the microtube flow data are presented in the table 2. From this study it is revealed that the value of the exponent, x varied from 0.47 to 0.53 for microtubes considered for this study. The values of x are lower for higher diameter and higher for lower diameter. However the range of variation is very narrow, which suggests that all tubes under study are functioning almost like turbulent emitters. The values of proportinality constant, K, varied from 0.83 to 5.37 and are higher for higher diameter tubes. It shows that the discharge rate is more dependent on the system parameters than hydraulic parameters.

However for knowing the combined effect of all parameters, the data were fitted using Eq.2. The constant a, b and c for Eq.2 for microtubes under study were worked out to be

TABLE 2

Hydraulic characteristics of microtubes.

Microtube No.	*Microtube dia. (mm)*	*Microtube length (mm)*	*Constant K*	*Exponent x*	*Correlation r*
M_1	0.645	0.5	0.8318	0.530	0.9955
M_2	0.995	2.0	1.3032	0.523	0.9961
M_3	1.312	2.0	2.7542	0.520	0.9971
M_4	1.313	2.0	2.4378	0.517	0.9973
M_5	1.604	2.0	5.3703	0.470	0.9972

TABLE 3

Life table of *Tetranychus macfarlanei* on okra.

Pivotal age	*lx*	*Mx*	*lxmx*	*x lxmx*
1	*2*	*3*	*4*	*5*
5.	0.6875	—	—	Immature stages
6.	0.6875	2.18	1.499	08.993
7.	0.6875	6.18	4.249	29.74
8.	0.6875	4.727	3.2498	25.999
9.	0.6875	4.818	3.3125	29.813
10.	0.6875	4.273	2.938	29.379
11.	0.6875	3.364	2.313	25.438
12.	0.6875	3.364	2.313	25.438
13.	0.6875	1.818	1.25	16.25
14.	0.6875	0.636	0.0625	0.875
15.	0.6875	0.273	0.1875	2.8125
16.	0.5625	3.111	1.75	28.00
17.	0.5625	2.445	1.375	23.375
18.	0.5625	4.222	2.375	42.75
19.	0.4375	1.429	0.625	11.875
20.	0.4375	0.429	0.1875	03.75

1.	2.	3.	4.	5.
21.	0.3125	1.20	0.375	07.875
22.	0.2500	4.25	1.0625	23.375
23.	0.1875	3.00	0.5625	12.938
24.	0.1875	2.00	0.375	09.000
25.	0.1875	1.00	0.1875	04.688
26.	0.1875	0.667	0.1251	03.252
27.	0.1875	0.00	0.00	00.00
28.	0.00	0.00	0.00	00.00
			$\sum$ 1xmx = 30.3744	6x1xmx = 365.6155

Net reproduction rate (RO) = 30.3744

Mean duration of a generation (T) = $\frac{\sum x1 \times mx}{RO}$

= 12:037 days

Approximate value of rm = $\frac{\text{Loge RO}}{T}$

= 00.2836

Finite rate of increase = Antiloge rm

= 01.328 per head per day.

2.176, 2.545 and 0.481 respectively. The equation has correlated the observed values with a correlation coefficient of 0.9962. These values suggests that 10 per cent increase in value of diameter or pressure head or length of tube the change in flow rate will be +27.46%, + 4.68% and -4.49% respectively. Therefore the influence of tube diameter on discharge rate is very prominent in comparision to change in length or operating pressure. This implies that for a unit change in discharge rate it will be more convenient to choose the diameter or length of tube instead of changing the operating pressure. As higher pressure requires capacity pump unit which costs more.

Horizontal Advance

The movement of water mainly depends on soil texture, soil infiltration rate, soil hydralic conductivity, inital soil moisture status, application rate, total water applied and soil and water temperature. The horizontal movement of wetting at surface at different time intervals were observed for different microtubes under 4 and 8 m operating pressures as depicted in Fig. 1. It is clear that the horizontal advance increases with increase in time of application for a given set of tube diameter length and operating pressure. Higher diameter tube increases advance due to higher flow rates. Similarly higher pressure has resulted in higher horizontal advance.

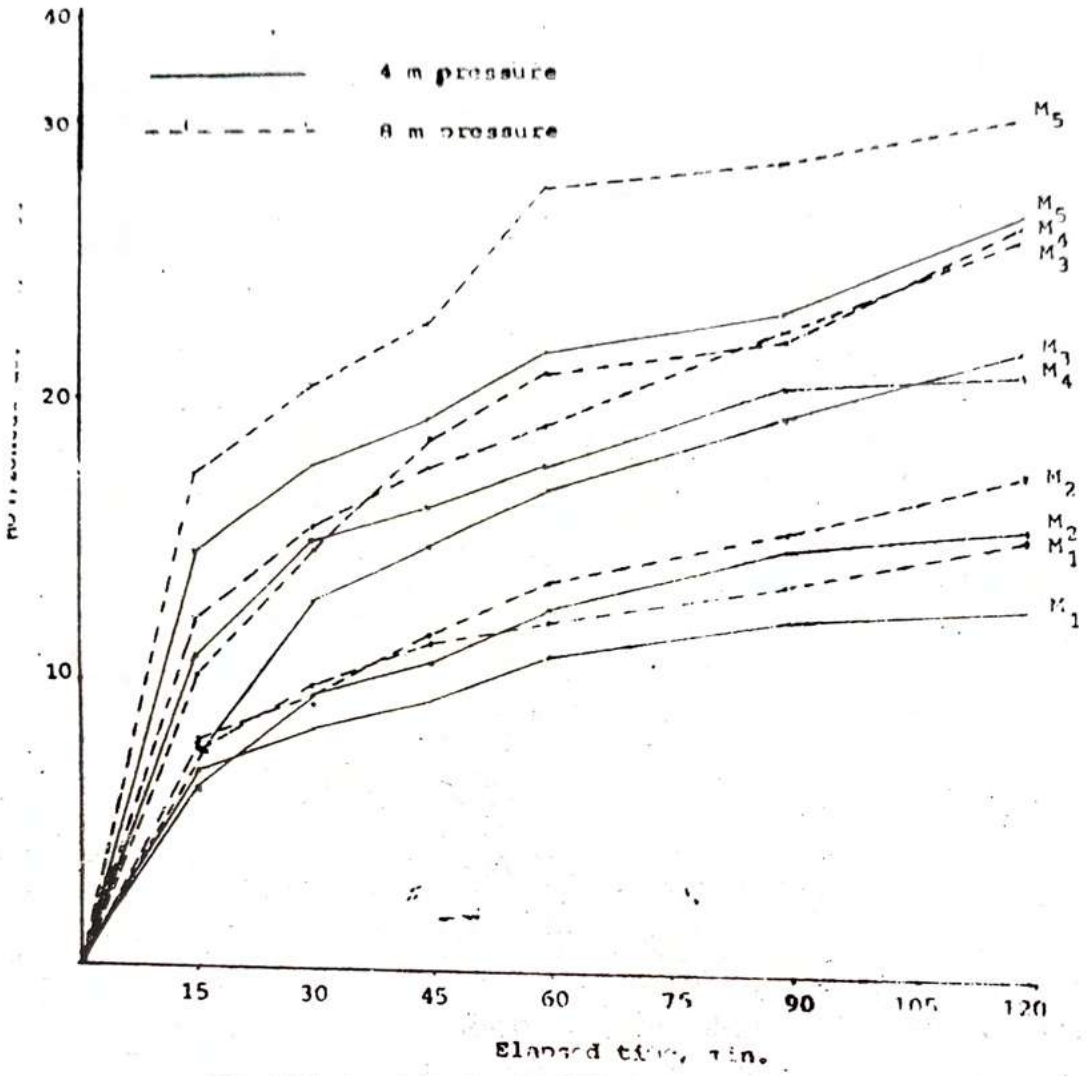

Fig. 1 Horizontal advance V/S elapsed time

An equation was derived to predict horizontal advance at surface considering microtube length, microtube diameter, operating pressure and time of application in power form as given in Eq. 3. The values of constants α, β, η and ϕ found to be 1.7285, 1.042, 0.250 and 0.4389 respectively. The correlation coefficient was observed to be 0.996.

It was observed that the horizontal advance at surface increased with increase in diameter, operating pressure but decreased with increase in length for a particular time of operation. For a given set of diameter, length and operating pressure, the horizontal advance at surface increased with increase in time of application (Fig. 2). Similarly higher horizontal advance at higher application rate (Fig. 3) was also observed.

From the study following conclusions can be made. The pressure discharge relationship may be approximately by power form equation.

The power form equation can be developed for surface horizontal movement.

For a particular pressure, the horizontal movement of water increased with increase in microtube diameter and time of application and decreased with increase in tube length. For getting higher water distribution uniformity in microtube drip system, selection of appropriate combination of tube diameter and length will be more suitable than pressure changes.

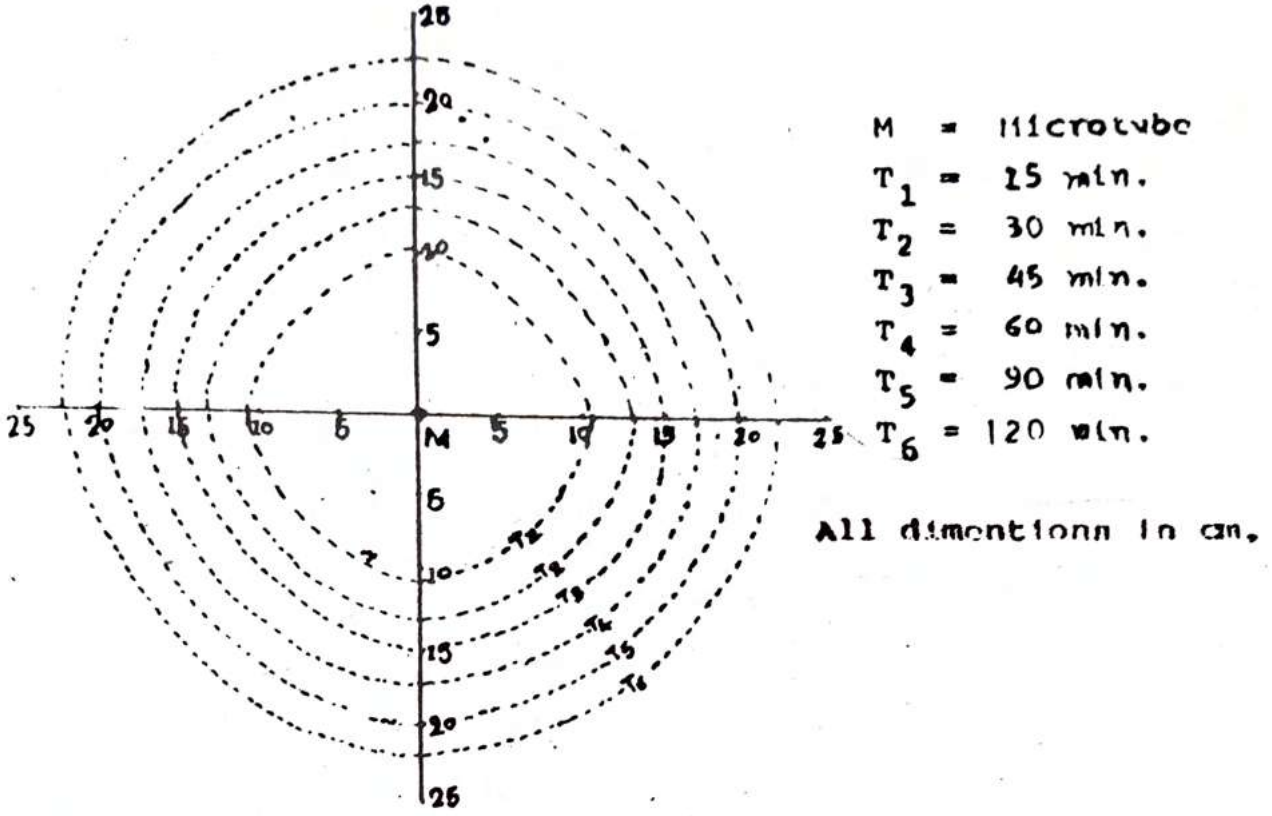

Fig. 2 : Effect of time of application on horizontal advance at surface (microtube M_3, operating pressure-4m).

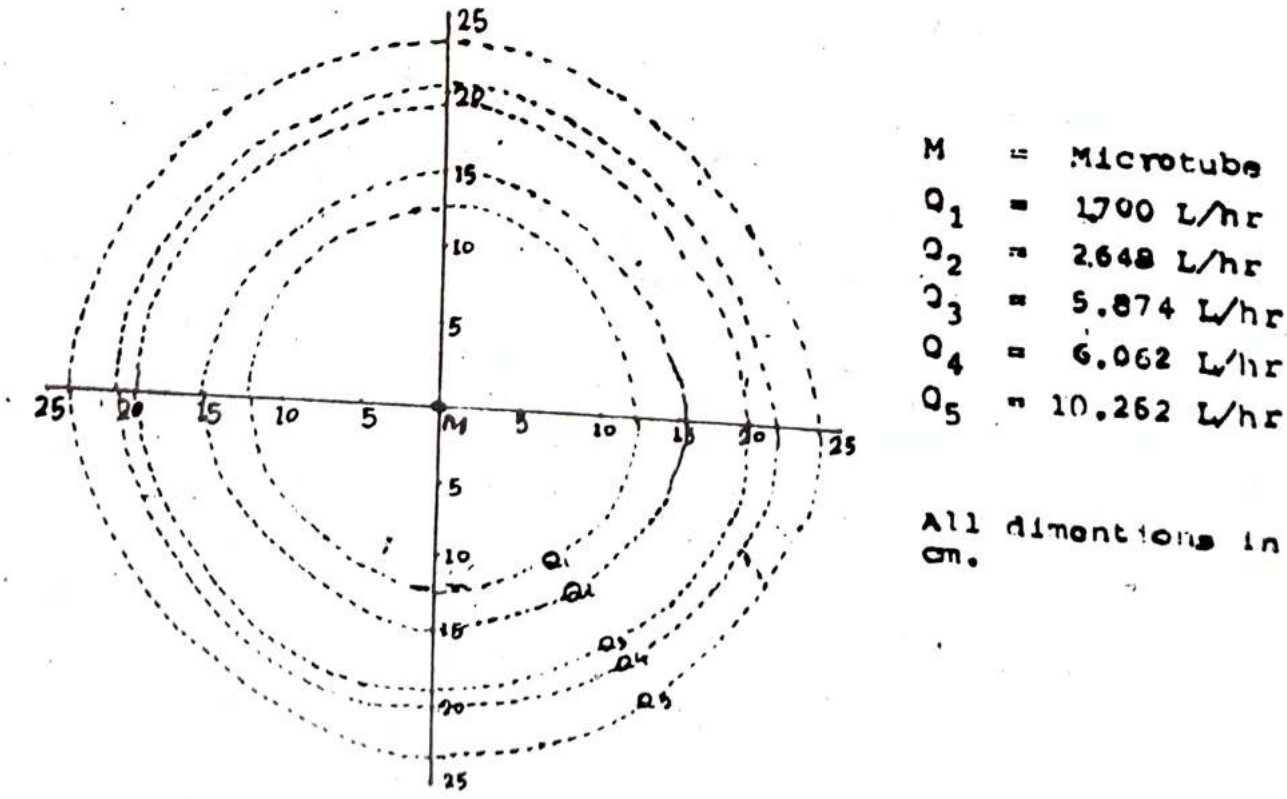

Fig. 3 : Effect of rate of discharge on horizontal advance at surface (Pressure - 4m, Application time-90 min.)

REFERENCES

Bralts, V. F., Wu, I. P. and Gitlin, H. M. (1981). Manufacturing variation and drip irrigation uniformity. *Transactions of the ASAE* **24** (1) : 113-119.

Gupta, R. K. and Tyagi, N. K. (1987). Effect of some trickle parameters on flow regimes XXIII Annual convention of ISAE at J.N.K.V.V., Jabalpur.

Gupta, A. P., Acharya, M. S. and Singh, A. K. (1990). Dyanamics of soil-water movement in study clay loan soil under point source. XI Int. Congress on Use of Plastics in Agril.PP. B-101 to B-109.

Kaul, R. K. and Michael, A. M. (1982). Moisture front advance under a point source of water application. *J. of Agril. Engg. ISAE* V. XIX, B-2; P.P. 1-8.

Nakayma, F. S. and Bucks, D. A. (1986). Trickle Irrigation for Crop Production. Elsevier Publishers.

Pitts, D. J., Ferguson, J. A. and Wright, R. E. (1986). Trickle Irrigation Latteral Design by Computer Analysis. *Transaction of the ASAE* **29** (4) p. 1320-1324.

Ramadevi, A. M. (1983). Soil moisture distribution pattern under drip irrigation system. Proceedings of second National seminar on Drip Irrigation pp. 86-93.

Sivanappan, R. K. and Padmakumari, O. (1980). Drip Irrigation published by T.N.A.U., Coimbatroe.