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EFFECT OF DISTRIBUTOR ON FLOW RATE IN A DRIP IRRIGATION SYSTEM

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Abstract: The effect of distributor on flow rate was studied. For each diameter of microtube, different length combinations of inlet tubes and drippers were tried. It was found that the discharge rate from the system with the distributor was higher than that of microtube having the same length and size. The frictional losses, the combined minor losses and distributor losses for different flow conditions were estimated. From the observed data, a few combinations which satisfied the requirements, viz., length, discharge and pressure head were selected to use as a guideline for design of the KAU drip irrigation system.

Key words: Distributor, drip irrigation, flow rate

INTRODUCTION

The distributor is an additional component introduced in the conventional drip irrigation system. George (1977) developed a drip irrigation technique with distributors in the Agronomic Research Station of the Kerala Agricultural University at Chalakudy. The distributor is a polyethylene pipe of 15 cm length and 1.25 cm diameter, plugged at both ends with plastic caps. It is connected to the lateral by a microtube. From the distributor, four microtubes are taken out. The former and latter tubes will be referred to as inlet tubes and drippers respectively. The function of distributor is to reduce the high discharge rate. This new drip system incorporating distributors is named as the KAU drip irrigation system. The present study was conducted with an objective to determine the effect of distributor on flow rate. The friction losses and the combined minor losses and distributor losses for different flow regions were determined

MATERIALS AND METHODS

The experimental site was the quadrangle near the Agricultural Engineering Research Workshop of the Kerala Agricultural University at Mannuthy. Black polyethylene tubes of 25 mm and 12.5 mm diameters were used as main and lateral respectively. Three different microtube sizes, viz., 1 mm, 2 mm and 3 mm were used. For each diameter of the microtube, the combinations of lengths for inlet tubes and drippers used were; 50+50 cm; 50+100 cm; 50+150 cm; 100+50 cm; 100+100 cm; 100+150 cm; 150+50 cm; 150+100 cm; 150+150 cm.

In each case, the four drippers were of the same length and diameter. The inlet tube and drippers were also of the same diameter. Experiments were done at different pressure heads, viz., 50 cm, 100 cm and 150 cm. The time taken for collecting a certain volume of water from the drippers was noted.

RESULTS AND DISCUSSION

It was observed that the discharge rate from the system with distributors was higher than that of microtubes having the same length and size. For example, a 50+50 cm distributor combination gave more discharge than a microtube of 100 cm length for the same head.

Experiments were conducted from 0.5 m to 1.5 m pressure heads. The highest and lowest discharges obtained per dripper were 11 l h^{-1} and 0.02 l h^{-1} respectively.

The KAU drip system works on low pressure. The maximum pressure head recommended is 2 m. A high pressure head may cause leaks in the system. In this system, no accessories are used for connecting the microtubes, all are push-fit types and this limits the use of high pressure. Due to some practical difficulties at the site, the experiments were conducted only up to a pressure head of 1.5 m.

Table 1. Effect of distributor on flow rate (3 mm tube)

	Length of tubes (cm)		Discharge $l\,h^{-1}$		Renolds number		Firction loss (m)		Minor loss + Distributor loss (m)
	Inlet L_1	Dripper L_2	Inlet Q_1	Dripper Q_2	Inlet Re_1	Dripper Re_2	Inlet H_{f1}	Dripper H_{f2}	
Pressure head 1.5 m									
	50	50	44.3	11.08	6493	1623	0.69	0.14	0.67
		100	42.0	10.50	6154	1541	0.63	0.26	0.61
		150	38.6	9.65	5657	1414	0.54	0.35	0.61
	100	50	36.8	9.20	5396	1351	1.00	0.11	0.39
		100	35.1	8.78	5146	1287	0.92	0.21	0.37
		150	33.5	8.38	4914	1228	0.85	0.29	0.36
	150	50	32.9	8.23	4825	1205	1.23	0.10	0.17
		100	31.2	7.80	4575	1146	1.13	0.18	0.19
		150	29.9	7.48	4388	1097	1.04	0.26	0.20
Pressure head 1 m									
	50	50	41.1	10.28	6030	1507	0.61	0.13	0.26
		100	38.9	9.73	5705	1425	0.55	0.24	0.21
		150	37.2	9.30	5451	1362	0.51	0.33	0.16
	100	50	30.6	7.65	4485	1123	0.73	0.09	0.18
		100	29.4	7.35	4313	1078	0.68	0.17	0.15
		150	28.5	7.13	4179	1045	0,64	0.24	0.12
	150	50	20.8	5.20	3052	765	0.83	0.05	0.12
		100	19.8	4.95	2903	728	0.77	0.10	0.13
		150	19.0	4.75	2787	698	0.72	0.15	0.13
Pressure head 0.5 m									
	50	50	27.2	6.80	3989	996	0.41	0.08	0.01
		100	21.3	5.33	3123	780	0.28	0.11	0.11
		150	20.1	5.03	2944	735	0.26	0.16	0.08
	100	50	15.3	3.83	2243	560	0.35	0.04	0.11
		100	14.1	3.53	271	519	0.31	0.07	0.12
		150	13.4	3.35	1963	493	0.35	0.10	0.05
	150	50	11.5	2.88	1683	422	0.43	0.03	0.04
		100	10.6	2.65	1552	388	0.39	0.05	0.06
		150	9.9	2.48	1451	362	0.36	0.07	0.07

Table 2 Effect of distributor on flow rate (2 mm tube)

	Length of tubes (m)		Discharge $1h^{-1}$		Renolds number		Firction loss (m)		Minor loss + Distributor loss (m)
	Inlet L_1	Dripper L_2	Inlet Q_1	Dripper Q_2	Inlet Re_1	Dripper Re_2	Inlet H_{f1}	Dripper He	
Pressure head 1.5 m									
	50	50	17.8	4.45	3910	978	1.00	0.19	0.31
		100	16.5	4.13	3627	908	0.89	0.35	0.26
		150	15.7	3.93	3453	863	0.83	0.50	0.17
	100	50	11.4	2.85	2510	627	1.04	0.11	0.35
		100	10.3	2.58	2264	567	0.90	0.20	0.40
		150	9.63	2.40	2114	530	0.81	0.27	0.42
	150	50	9.3	2.33	2042	510	1.16	0.09	0.25
		100	8.5	2.13	1868	468	1.28	0.16	0.06
		150	7.9	1.98	1734	433	1.17	0.21	0.12
Pressure head 1 m									
	50	50	12.9	3.23	2833	709	0.62	0.13	0.25
		100	11.8	2.95	2597	649	0.55	0.23	0.22
		150	11.1	2.78	2438	610	0.50	0.33	0.17
	100	50	8.9	2.23	1955	490	0.90	0.08	0.02
		100	8.0	2.00	1759	440	0.79	0.14	0.07
		150	7.4	1.85	1632	408	0.72	0.20	0.08
	150	50	5.8	1.46	1284	321	0.81	0.05	0.14
		100	5.1	1.29	1132	284	0.69	0.08	0.23
		150	4.6	1.14	1005	251	0.60	0.11	0.29
Pressure head 0.5 m									
	50	50	8.63	2.16	1900	475	0.43	0.06	0.01
		100	6.85	1.71	1505	376	0.33	0.12	0.05
		150	6.66	1.67	1465	366	0.32	0.17	0.01
	100	50	4.64	1.16	1022	256	0.41	0.04	0.05
		100	3.88	0.97	856	214	0.33	0.06	0.11
		150	3.27	0.82	719	179	0.26	0.07	0.17
	150	50	3.27	0.82	719	179	0.40	0.02	0.08
		100	2.66	0.67	584	147	0.31	0.04	0.15
		150	2.23	0.56	490	122	0.25	0.05	0.20

Table 3. Effect of distributor on flow rate (1 mm tub)

	Length of tubes (m)		Discharge $l\ h^{-1}$		Renolds number		Firction loss (m)		Minor loss + Distributor loss (m)
	Inlet L_1	Dripper L_2	Inlet Q_1	Dripper Q_2	Inlet Re_1	Dripper Re_2	Inlet H_{f1}	Dripper H_{f2}	
Pressure head 1.5 m									
	50	50	2.06	0.52	905	226	0.90	0.17	0.43
		100	1.36	0.34	598	149	0.54	0.20	0.76
		150	1.30	0.33	572	143	0.51	0.29	0.07
	100	50	1.31	0.33	576	144	1.03	0.10	0.37
		100	0.53	0.13	233	58	0.34	0.06	1.10
		150	0.27	0.07	118	30	0.15	0.04	1.31
	150	50	0.75	0.19	330	82	0.78	0.05	0.67
		100	0.36	0.09	158	40	0.32	0.04	1.14
		150	0.12	0.03	52	14	0.08	0.02	1.40
Pressure head 1 m									
	50	50	1.40	0.35	616	154	0.56	0.10	0.34
		100	1.10	0.28	484	122	0.42	0.16	0.42
		150	0.48	0.12	210	52	0.15	0.08	0.77
	100	50	0.86	0.22	378	95	0.62	0.06	0.32
		100	0.43	0.11	189	47	0.26	0.05	0.69
		150	0.18	0.05	80	20	0.09	0.03	0.88
	150	50	0.66	0.17	290	72	0.67	0.04	0.29
		100	0.48	0.12	210	52	0.45	0.06	0.49
		150	0.21	0.05	92	24	0.16	0.03	0.81
Pressure head 0.5 m									
	50	50	0.84	0.21	369	94	0.30	0.06	0.14
		100	0.65	0.16	285	72	0.22	0.08	0.20
		150	0.18	0.05	80	20	0.05	0.03	0.42
	100	50	0.61	0.15	267	68	0.41	0.04	0.05
		100	0.28	0.07	123	32	0.16	0.03	0.31
		150	0.11	0.03	47	13	0.05	0.02	0.43
	150	50	0.26	0.07	114	29	0.21	0.01	0.28
		100	0.09	0.02	41	10	0.06	0.01	0.43
		150	0.07	0.02	30	8	0.04	0.01	0.45

Table 4. Guideline for KAU drip irrigation system

Pressure head (m)	Diameter of micro tube (mm)	Length of tubes (cm)		Discharge from dripper $l\ h^{-1}$
		Inlet	Dripper	
H	D	L_1	L_2	Q
1.5	3	100	100	8.78
			150	8.38
		150	100	7.80
			150	7.48
1.0	3	100	100	7.35
			150	7.13
		150	100	4.95
			150	4.75
0.5	3	100	100	3.53
			150	3.35
		150	100	2.65
			150	2.48
1.5	2	100	100	2.58
			150	2.40
		150	100	2.13
			150	1.98
1.0	2	100	100	2.00
			150	1.85

In general, both major and minor losses occurred in a pipe flow. The major loss is the friction loss. The minor loss includes, entrance and exit losses and losses due to fittings and bends. When the distributor was introduced in the system, there were some distributor losses.

An attempt was made to separate all these three losses, i.e., the friction loss, the minor loss and the distributor loss. However, it was found that more elaborate study was necessary to separate the minor losses and the distributor losses. The friction losses and the combined minor losses and distributor losses for different regions are given in Table 1, 2 and 3.

The major loss, i.e., the total friction loss was the summation of the friction losses in the inlet tube and in the drippers. In parallel connection, the friction loss of one of the drippers need only be considered.

$$H_f = H_{f1} + H_{f2} \quad (1)$$

where

Hf = total friction loss, m

H_{f1} = friction loss in inlet tube, m

H_{f2} = friction loss in drippers, m

In a previous study of the hydraulics of microtube emitters, friction loss equations were developed. The relationships between pressure head H, length L, diameter D and discharge Q were estimated by fitting multiple log-linear regression equations. Minor loss (H_m) was separated from total pressure head and friction loss (H_f) equations were developed by fitting multiple log-linear regression equations for different flow conditions, viz., turbulent, transition and laminar. The equations obtained are:

Turbulent flow

$$H_f = 0.00359 \frac{Q^{1.74866}}{D^{4.80544}} L \quad (2)$$

Flow in transition region

$$H_f = 0.00397 \frac{Q^{1.46302}}{D^{3.74436}} L \quad (3)$$

Laminar flow

$$H_f = 0.00743 \frac{Q^{1.22546}}{D^{3.58420}} L \quad (4)$$

where

H_f = friction head, m

D = diameter of microtube, mm

Q = discharge, $l\ h^{-1}$

L = length of microtube emitter, cm

Generally, the accepted average discharge rate per dripper is 1.5 - 10 $l\ h^{-1}$. In the present study, it was observed that 3 mm and 2 mm tubes gave discharge rates in the above range for all the pressure heads. Very low discharge rates were obtained from 1 mm tubes and hence they were not recommended.

Generally, in the case of close growing crops, the minimum area commanded or irrigated by a dripper is 1 m^2. This means that an area of 4 m^2 can be irrigated with the distributor which has four drippers. In such cases, the distributor has to be positioned in the centre of the 4 m^2 area it commands. For this, it was seen that the minimum length of inlet tube and dripper should be 1 m.

Even though many combinations of lengths, heads and diameters were tried, only a few combinations that satisfied the minimum requirements listed below, were selected. Those are:

Discharge rate : 1.5 - 10 l ha^{-1}

Minimum length of drippers : 1 m

Minimum length of inlet tube: 1 m

The discharges obtained for different combinations of lengths, pressure heads and diameters are given in Tables 1, 2 and 3. The selected combinations are given in Table 4. This table gives discharge rates from 1.85 1 ha^{-1} to 8.78 l h^{-1} per dripper. This table can be used as a guideline for the design of the KAU drip irrigation system.

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