International Journal of Agricultural Engineering, Vol. 4 No. 2 (October, 2011) : 152 -155

Research Paper :

Performance evaluation of three different types of micro-sprinklers

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Received : April, 2011; Revised : June, 2011; Accepted : August, 2011

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ABSTRACT

Laboratory Studies on hydraulic performance of micro-sprinklers was undertaken to study the pressure discharge relationship, manufacturers coefficient of variation and precipitation pattern for the operating heads in the range of 1.0 to 2.40 kg/cm^2 with increment of 0.2 kg/cm^2. Pressure discharge relationship of form $Q=aH^b$ were developed for all three micro-sprinklers under study. The discharge exponents (b) were found as 0.5487,0.5036 and 0.6459 proportionality constants (a) as 72.424, 49.807 and 32.216 for S-1,S-2 and S-3 micro-sprinklers, respectively. High value of coefficient of correlation R^2 greater than 0.97 indicated the close goodness of fit. Manufacturer's coefficient of Variation for S-2 and S-3 Micro-sprinkler recorded in the range of 0.0262 to 0.0462 and 0.0236 to 0.0356, respectively reflecting better precision in their manufacturing whereas, the S-1 micro-sprinkler, recorded the value in the range of 0.2516 to 0.3654 indicating it's poor manufacturing quality from above results, no definite trend was observed between the operating pressure and manufacturer's coefficient of variation.

Patil, P.V., Patil, M.S. and Kadam, U.S. (2011). Performance evaluation of three different types of micro-sprinklers. *Internat. J. Agric. Engg.*, **4**(2) : 152-155.

Key words : Manufacturer's Coefficient of variation (MCV), Standard deviation, Correlation, Discharge exponent

Water is a prime natural resource, a basic human need and a precious national asset. Therefore, efficient utilization of water for irrigation is necessary. Water is the most important input among all inputs required by the plant to fulfill its water requirement for its biological activities. As water is scarce, its efficient utilization is the need of time. Irrigation is nothing but the artificial application of water to soil for the purpose of crop production and to supplement the water available from rainfall and soil moisture from ground water.

Drip and sprinkler systems are the leading pressurized irrigation systems. In Drip irrigation system, after limited use it requires more maintenance due to clogging and the vast pipe network.

The sprinkler irrigation systems require high energy and high investment and, therefore, limitations for adoption on the fields. The micro-sprinkler irrigation systems have the advantages over sprinkler and drip irrigation system. This is intermediate irrigation system over drip and sprinkler.

Micro-sprinklers are designed to distribute water in the form of a fine rain like shower. By applying the right amount of water at the correct irrigation rate , there will be neither seepage beyond root zone nor problem of aeration in the root zone caused by water logging.

Micro-sprinklers wet only about 40 to 80 per cent of the soil surface in a mature orchard. The area wetted by the micro-sprinklers can be adjusted according to the development of root system without any additional expenses.

Visual inspection of the micro-sprinklers is simple and fast, less time is required for inspection as compared to several system. A large mesh filter screen used in micro-irrigation allows for longer operating time between cleaning. Fertilizers are directly applied to the root zone of the plants. Even elements of low soil mobility *i.e.* (N.P.K) shows good distribution in the soil when applied through micro-sprinkler.

Micro-sprinklers give better results in orchards and due to this, it has great scope in Maharashtra. Govt. provides 75% subsidy on micro-sprinklers for oilseed, pulses, cereals and cotton and 50% for horticulture crops.

Considering the several benefits/advantages of micro-sprinkler irrigation system over drip and sprinkler irrigation system, for efficient utilization the special attention need to be given to the design of system. Therefore, it was felt necessary to evaluate the hydraulic parameter of micro-sprinkler with the following objectives which are useful for proper design of system.

– To establish the pressure discharge relation-ship of micro-sprinkler.

– Determination of coefficient of manufacturer's variation of micro-sprinkler.

METHODOLOGY

The experiment was conducted at Water Management Laboratory Dept. of Irrigation and Drainage Engineering, college of Agricultural Engineering,Mahatma Phule Krishi Vidyapeeth Rahuri (M.S). India situated at an altitude of 657m from Sea level. The latitude and longitude of site are $19^0$24N and $74^0$39E, respectively. The trials were conducted during month of October to December, 2001.

Specifications of Micro-sprinklers:

Three makes of micro-sprinklers were evaluated in this study. Specifications of three micro-sprinklers are reported in Table 1.

Table 1 : Details of micro-sprinklers used in the study

Makes name	Recommended pressure range (kg/cm^2)	Discharge range (LPH)	Stake height (cm)
Jain- S-1	1.00 to 2.00	69.0 to 93.0	30.0
EPC-S-2	1.05 to 2.10	52.9 to 75.2	30.0
Plastro-S-3	1.50 to 2.50	44.0 to 56.0	25.0

Micro-sprinklers S-2 is fixed head type whereas S-1 and S-3 have the rotating head or rotating type. The recommended stake height for all three micro-sprinklers is in the range of 25 to 30 cm.

A leveled plot was selected for operating the micro-sprinkles. An electrical mono block pump was used to supply water at desired pressure heads. On delivery side of pump screen filter pressure gauges and regulating valve were fitted. The Micro-sprinklers of each make out of three selected make were run simultaneously to get average representatives values for pressure discharge relationship .The water supply was given to micro-sprinkler through main and sub main of G.I pipe having diameter 50 and 25 mm, respectively. Laterals made of LDPE of size 16mm and 4 mm diameter tubes were used to connect micro-sprinkler with laterals. The pressure was measured with the help of pressure gauge installed just behind micro-sprinkler on delivery side. The two micro-sprinklers which were operated simultaneously were spaced 7.5 m apart to avoid the overlapping of sprinkler pattern. All the test were carried out between 7 to 9 A.M to avoid influence of temperature and wind velocity.

The pressure discharge relationship for the micro-sprinklers was determined at operating pressure heads of 1,1.2,1.4,1.6,1.8,2,2.2 and 2.4 kg/cm^2 (100 to 240 Kpa with increment of 20 kpa). To determine volume of water discharged from micro-sprinkler at predetermined operating pressure the micro-sprinkler was turned up side down in bucket for fixed time period of five minutes. The water collected in bucket was then measured with the help of graduated cylinder and collection was thus converted into discharge per unit time(lph) care was taken to avoid the loss of water due to evaporation by covering bucket by steel plate. Each test was repeated for three times to have representative average value.

Twenty five Micro-Sprinklers of same make were operated at pressure of 1 kg/cm^2, 2 kg/cm^2 and 2.5 kg/cm^2 for operating period of 5 minutes. The volume of water collected in each can was measured with graduated cylinder and converted into discharge (lph). The procedure was repeated for 25 micro-sprinklers of other to makes for all operating pressure under study. Manufacturer's coefficient of variation was determined by using equation:

$$\text{M.C.V.} = \frac{\text{Standard deviation}}{\text{Mean discharge}}$$

The standard deviation was calculated as

S.D = under root of [Σ(X')2/N]

where,

S.D = Standard deviation

X'= Numerical deviation of an individual discharge from mean discharge, LPH

N= Number of Observation

RESULTS AND DISCUSSION

Micro-sprinklers of three different makes *i.e.* S-1,S-2 and S-3 were used for the study. The stake height of 25 cm ws kept constant throughout the experiment.

Two micro-sprinklers out of the set of 25 micro-sprinklers, having some what same discharge were selected from each type micro-sprinkler. The operating pressures 1.0 to 2.4 kg/cm^2 with an increment of 0.2 kg/cm^2 were taken for this study. The discharge obtained from both the Micro-sprinklers corresponding to operating pressure are reported. The average discharge of all the three different types of micro-sprinklers for operating pressure of 1.0 kg/cm^2 and maximum discharge of 120.96 lph was recorded for S-1 micro-sprinkler for operating pressure of 2.4 kg/cm^2.

With the pressure range *i.e.* 1.00 to 2.4 kg/cm^2 the discharge for S-1, S-2 and S-3 micro-sprinkler were observed in the range of 73.38 to 120.96, 49.00 to 77.55 and 31.79 to 58.81 LPH, respectively. It is seen from Table 2 that S-3 micro-sprinkler had lower discharge range and S-1 micro-sprinkler had higher discharge range for the operating pressure range under study. The similar results were obtained by Sakore (1992), Firake *et al.* (1991) reported the discharge in the range of 44 to 63 LPH and 33 to 57 LPH, respectively for the operating pressure in the range of 1.2 to 1.8 kg/cm^2. Similarly, Sharma (2001) reported the discharge in the range of 32 to 122 LPH for the operating pressure in the range of 1.0 to 2.4 kg/cm^2.

Table 2 : Average discharge of micro-sprinkler as influenced by operating pressure

Operating pressure (kg/cm^2)	Discharge of micro-sprinkler, LPH		
	S-1	S-2	S-3
1.0	73.38	49.00	31.79
1.2	79.00	55.22	36.56
1.4	89.21	59.52	41.81
1.6	92.04	63.46	43.49
1.8	99.17	67.43	45.05
2.0	102.75	69.93	49.78
2.2	111.67	73.47	52.83
2.4	120.96	77.55	58.81

Further, it was also observed from the Table 2 that discharge of micro-sprinklers increases with increase in operating pressure. These results are with close agreement with results reported that Firake and Salunkhe (1992), Sakore (1992), Shinde(1993), Aragade and Thombal (1994), Gawali and Badhan (1994), Lonkar and Dhage (1998), Suryavanshi (1999) and Sharma (2001). The pressure relationship of the form $Q = aH^b$ were developed for all the micro- sprinklers under study and are given by equations(I to III).

S-1 $Q = 72.42\ H^{0.5487}$ $R^2 = 0.9833$ (I)

S-2 $Q = 49.807\ H^{0.5036}$ $R^2 = 0.9956$ (II)

S-3 $Q = 32.216\ H^{0.6459}$ $R^2 = 0.9789$ (III)

where,

Q= Discharge, LPH

H= Operating pressure, kg/cm^2

a = Characteristic coefficient

b = Discharge exponent.

High values of 'R^2' for all the micro-sprinklers are indicative of close goodness of fit. From above relationships, it is observed that S-2 has the lowest exponent (0.5036) which is desired quality. The low value of exponent indicates the minimum fluctuation in discharge with variation in operating pressure resulting in comparatively higher uniformity. Graphical representation of pressure discharge relationship is presented in Fig. 1, Fig. 2 and Fig. 3, for micro-sprinkler S-1, S-2 and S-3, respectively.

The manufacturer's coefficient of variation is the parameter which indicate preciseness in manufacturing. The manufacturer's coefficient of variation determined by adopting the standard procedure given in materials and methods for all the three different types of micro-sprinkler under study.

The observation of discharge for twenty five different

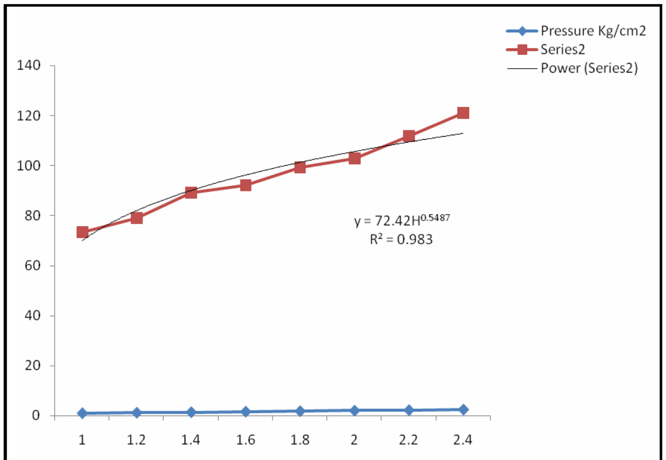

Fig. 1 : Pressure discharge relationship of S-1type of micro-sprinkler

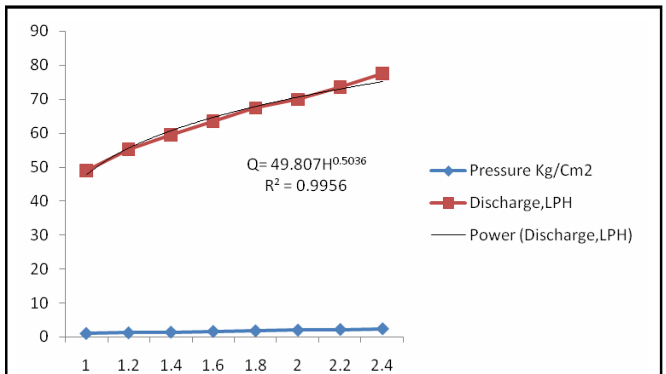

Fig. 2 : Pressure discharge relationship of S-2 type of micro-sprinkler

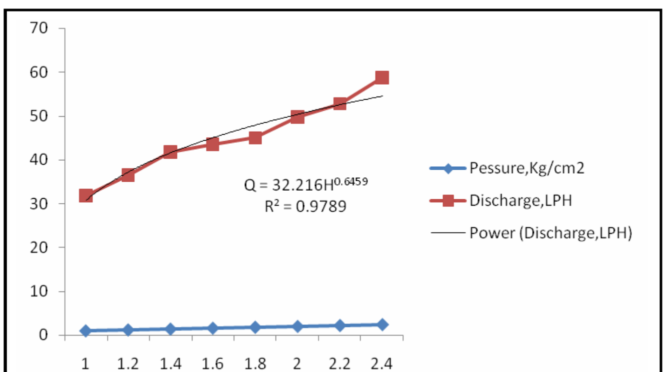

Fig. 3 : Pressure discharge relationship of S-3 type of Micro-sprinkler

micro-sprinklers of the same make for a particular time were recorded and reported. The average values of Manufacturer's coefficient of variation are reported in Table 2 given below:

From the Table 3 it was observed that manufacturer's coefficient of variation was influenced by operating pressure. The minimum value of manufacturer's coefficient of variation (0.0236 and 0.0262) was observed for S-3 and S-2 micro-sprinklers, respectively for operating pressure 1.0 kg/cm^2. Where as the maximum value of manufacturer's coefficient of variation (0.3654) was observed for S-1 micro-sprinkler with an operating pressure of 2.5 kg/cm^2. These

Table 3 : Manufacturer's coefficient of variation as estimated for different types of micro-sprinklers

Pressure (kg/cm^2)	Manufacturer's coefficient of variation of micro-sprinklers		
	S-1	S-2	S-3
1.0	0.2516	0.0262	0.0236
1.5	0.3124	0.0276	0.1044
2.0	0.3098	0.0445	0.0315
2.5	0.3654	0.0462	0.0356

coefficient of variation indicate that the S-1 micro-sprinkler was very poor and fell in the range of non acceptable zone (Kellar *et al.,* 1990). The values of manufacturer's coefficient of variation for other two micro-sprinklers lie in the excellent zone (Keller *et al*., 1990). The values of manufacturer's coefficient of variation of S-2 and S-3 micro-sprinklers ranged from0.0262 to 0.0462 and 0.0236 to 0.1044, respectively for operating pressure 1 to 2.5 kg/cm^2. Thus from above range it may be concluded that S-2 and S-3 micro-sprinklers had better precision in their manufacturing than S-1 micro-sprinkler. These results are with close agreement reported by Lonkar and Dhage (1998). They reported the value of manufacturer's coefficient of variation 0.12 for acceptable range rather than excellent zone for which the value should be less than 0.05 (Keller *et al*., 1990) Sharma (2001) reported the average range of manufacturer's coefficient of variation between 0.05 to 0.10 and excellent less than 0.05.

Conclusion:

Pressure discharge relationship can be very well established by the power type of equation of the form $Q = aH^b$ indicating that discharge with increases increasing operating pressure. The values of discharge exponent close to 0.5 for all the three type of micro-sprinklers are of desired quality in terms of their response to variation in operating head.

Estimated values of manufacturer's coefficient of variation indicated that out of three micro-sprinklers under study, more precision was observed during the manufacturing process for the S-3 and S-2 type of micro-sprinklers. Whereas poor manufacturing quality was observed for S-1 type of micro-sprinkler.

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