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Water Application Performance of Automated Drip System Installed in Guava Orchard in Vertisols

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Abstract

An automated drip system was installed in six year old guava orchards in vertisols. Controller of automated system consisted of 32 output port digital, and 14 analog input, with provision for independent and sequence programming of valves and programming for backwash sand filter and fertilizer injecto. Irrigation and fertilizers were provided to guava based on crop water requirement and scheduling; 50% of recommended dose of fertilizer was provided as fertigation with irrigation based on sensor and ET, and 100% fertilizer as conventional. The water application performance of automated drip system was evaluated based on head-discharge relationship of emitters; standard deviation of emitter flow; discharge variation and coefficient of variation of emitter flow; uniformity coefficient; statistical uniformity, and distribution uniformity of emitters. It was found that automated drip system could perform excellent with uniformity coefficient, distribution uniformity and statistical uniformity varied from 96—98%; coefficient of variation of emitter discharge from 0.022—0.032; and emitter flow variation, 7.1—11.6%.
Key words : Automated drip system, Performance, Guava orchard.

The drip irrigation system is quite popular in our country, and the area under it is increasing at faster rate. It is being used for irrigating wide range of crops such as vegetables, orchards and spices. The net potential area for drip irrigation is estimated to be 21.3 Mha for the country (1). The water and fertilizer are among the importation inputs to indian agriculture. Therefore, their efficient use and management is the need of present time to save cost, and avoid misuse and environmental hazard. The drip irrigation system with fertigation is the most efficient method of water and fertilizer application, as it ensures their application directly to the plant roots (1). This has resulted in increased yield of various crops and reduction in amount of use of fertilizer at different locations (2—5). These studies were conducted using most of the drip irrigation system operated manually. While at present, the operations of many drip systems are being automated, which has many advantages over manually operated and managed system. To get better understanding and information suiting to field requirements, need is felt to evaluate the water application performance of automated drip system. Hence, this study was undertaken to evaluate water application performance of automated drip fertigation system installed in guava orchard in vertisols.

Methods

The study was carried out in black vertisol at research farm of Central Institute of Agricultural Engineering (CIAE), Bhopal, Madhya Pradesh, India (at 77°25′ E and 23°21′ N at an elevation of 495 m above mean sea level). The texture of the soil and other physical properties are presented in Table 1.

Details of Study

The automatic drip fertigation system was installed in guava orchards of six years old. The components of system consisted of drip irrigation system, Controller, solenoid valves, fertilizer injector

Table 1. Physical properties of soil at experiment site.

Properties		
1.	Soil texture :	
	Clay (%)	49.7—53.7
	Silt (%)	27.9—29.6
	Sand (%)	8.2—20.8
	Gravel (%)	2.9—3.8
2.	Soil structure	Sub angular blocky
3.	Bulk density (g/cc)	1.39—1.75
4.	Porosity (%)	38.0—40.0
5.	Water holding capacity (%)	33.0—36.0
6.	Field capacity (%)	28.5—31.0
7.	Permanent wilting point (%)	19.0—19.5
8.	Infiltration rate (m/h)	0.011

Table 2. Parameter of emitter flow over time for drip in guava. $T_{1.1}$: Values for treatment 1 in the beginning, $T_{2.2}$: Values for treatment 2 after six months.

Statistical parameters	Parameters values under different treatments			
	$T_{1.1}$	$T_{1.2}$	$T_{2.1}$	$T_{2.2}$
Mean flow rate of emitter (lph)	8.03	8.07	8.07	8.01
Variation in flow rate of emitters	0.095	0.095	0.071	0.107
Uniformity coefficient (%)	97.5	97.3	98.3	97.1
Statistical uniformity (%)	96.9	96.8	97.8	96.5
Distribution uniformity (%)	96.3	95.9	97.0	95.6

pump, semi-automatic sand filter, and screen filters, rain sensor, voltage stabilizer, relay and toggle switch, electrical conduit and connecting wire along with other fittings and accessories required.

The system was operated using controller, which consisted of 32 output port digital and 14 analogue input, having provision for independent and sequence programming for valves and backwash programming for sand filter. It has capacity to run independent fertilizer injector either on time basis or volumetric basis fertigation with programming facility for water before and after fertigation event. The schedules of irrigation and fertilizer for guava was based on water requirement and recommended dose of fertilizer.

The design of experiment consists of three treatments (T_1, T_2 and T_3) of different methods of application of fertilizer and irrigation water. T_1 and T_2 consisted of 50% of recommended doze of fertilizer with sensor base and ET based drip irrigation, respectively. In treatment T_3, 100% of recommended dose of fertilizer was applied. The treatments were planned for six replications.

Water Application Performance

The parameters considered for the performance evaluation of the drip system were head-discharge relationship of emitters (6), emitter flow rate variation (7), coefficient of variation of emitter flow (7), uniformity coefficient (8), distribution uniformity (9) and statistical uniformity (10). Drip system was operated at constant pressure of 1 kg/cm² and discharges from emitters of laterals were collected in cans for three minutes and repeated for three times.

The system was also operated at pressure of 0.75, 1.25, 1.50, 1.75 and 2.00 kg/cm² for head-discharge relationship of emitters. The respective emitter discharge rates at above operating pressures were estimated. The values of uniformity coefficient, distribution uniformity, and coefficient of variation of emitter discharge were evaluated. The criteria for rating the performance of was based on Micro irrigation system uniformity classifications and manufacturer's coefficient of variation were as adopted from ASAE (1996) (11).

Results and Discussion

Emitter Discharge-Pressure Characteristics

The emitter discharge-pressure characteristics

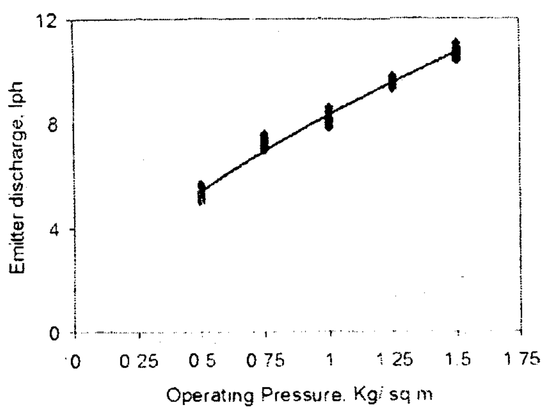

Figure 1. Head discharge relationship of emitters.

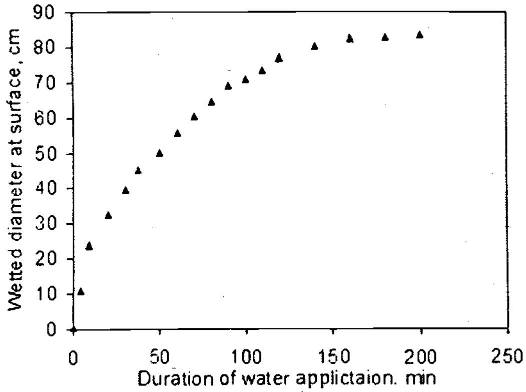

Figure 2. Wetted diameter at soil surface through emitters of 8 lph discharge rate.

curve for emitters with discharge rate of 8 lph on laterals is shown in Figure 1. The emitter discharge exponent was found as 0.623. The relationship between head and discharge has been represented through equations (1). The R^2 value for above equations was found as 0.977.

$$Q = 8.32\ H^{0.623}$$

where, Q = discharge rate of emitter, lph, H = Operating pressure of emitters, kg/cm^2.

Wetted Pattern at Soil Surface

Wetting pattern at soil surface using 8 lph discharge rate drippers for different duration and volume of water application were determined (Fig. 2). The soil wetted depth for different wetted diameters were also determined.

The wetted diameter as a function of duration of water application could be described by six-order polynomial (equation 2) with R^2 value of 0.997 and error of-1.63 cm.

$$d = (-5\times10^{-11}) \times t^6 + (3\times10^{-8}) \times t^5 - (8\times10^{-6}) \times t^4 + 0.001\times t^3 - 0.0677 \times t^2 + 2.6045 \times t + 1.6267$$

The relationship between wetted depth (z) and wetted diameter (d) of soil followed power equation (3) as given below with value of R^2 as 0.98.

$$z = 10.04\ d^{0.34}$$

Uniformity of Water Application

The evaluated performance parameters of automated drip irrigation system under various treatments in the beginning and after six months of operation irrigation system are presented in Table 2. The standard deviation of flow of emitters with discharge rate 8 lph varied from 0.18—0.25. Coefficient of variation of emitter flow rates varied from 0.022—0.031 for three treatments. The values for uniformity coefficient, statistical uniformity and distribution uniformity for the system were found 96—98%. It may be observed that the parameter values for water application performance were almost same over the period six months.

The coefficient of variation of emitter flow rate was found less than 0.05 that is considered as excellent (11). Emitters were classified as Class A as per BIS code (IS : 13487, 1992) for coefficient of variation of emitter flow rate from 2—4%. The emitter flow variation of less than 20% was considered acceptable (12). The uniformity coefficients of flow rate of emitters for all the laterals were 96—98%.

The values of the coefficient of variation and uniformity coefficient were in agreement with the statement of Dasberg and Or (12) who stated that modern emitters should have coefficient of variation less than 0.05 and uniformity coefficient of more than 96%. Based on ASAE (11) values of evaluated statistical performance parameters indicate excellent water application performance of automated drip system. This may be attributed to good filtration and management of the system.

Conclusion

An automated drip fertigation system installed in guava orchards could perform excellent with uniformity coefficient, distribution uniformity and statistical uniformity varied from 96—98%; coefficient of variation of emitter discharge from 0.022—0.032, and emitter flow variation 7.1—11.6%. Over the period of one-year operation the water application performance of the automated drip system was excellent.

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