The Andhra Agric. J 65 (3): 658-663, 2018

Performance Evaluation of Different Fertigation Equipment and Hydraulic Performance of Drip Fertigation System

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ABSTRACT

Fertigation saves fertilizers as it permits applying fertilizer in small quantities at a time matching with the plants nutrient need. Besides, it considers eco-friendly as it avoids leaching of fertilizers. Liquid fertilizers are best suited for fertigation however in India, inadequate availability and high cost of liquid fertilizers restricts their usage. Hence there is a need of selecting proper fertigation system for the application of fertilizers with water. Venturi injector, fertilizer injection pump and fertilizer tank were tested to study the hydraulic performance of the system. The suction rate of venturi injector progressively increased with increasing pressure differential. At a pressure increment of 0.1 kg cm^{-2} in case of fertilizer injection pump increment suction rate of 1.3 l min^{-1} was observed whereas at the same pressure increment venturi injector was recorded very less value of suction rate as 0.34 l min^{-1}. The suction rate of fertilizer injection pump recorded a higher value than the venturi injector at the same pressure gradient. The motive flow rate of venturi injector was 34.49 l h^{-1} which was higher than that of the fertilizer tank 32.79 l h^{-1} and Fertilizer injection pump 30.24 l h^{-1} for the pressure difference of 0.1 kg cm^{-2}. Due to the high motive flow rate the venturi injector is suitable for application with large number of drippers. Fertilizer injection pump recorded less motive flow rate when compared to venturi injector at same pressure difference hence fertilizer injection pumps can be used for smaller motive flow rates. When the operating pressure is 0.2 kg cm^{-2}, coefficient of manufacturing variation recorded as 0.15 whereas at the pressure of 1.2 kg cm^{-2} coefficient of manufacturing variation recorded as 0.04. For the pressure range of 0.2 kg cm^{-2} to 1.2 kg cm^{-2} emission uniformity varied from 74.58 % to 91.14 %.

Key words: *Fertilizer injection pump, Fertilizer tank, Emission uniformity, Venturi injector.*

For injection of the fertilizer solution into the irrigation system three different fertigators can be used are venturi injector, by-pass flow tank, pressure differential system or injection pump. The general advantages of the injection pump system are the high degree of control of dosage, timing of chemical application, centralised and sophisticated control, portability, and no serious head loss in the system, labour-saving and relatively cheap in operation. With this method the solution is normally pumped from an open unpressurized tank, and the choice of type of pump used is dependent on the power source. The pump may be driven by water flow, by an internal combustion engine, by an electric motor or by a tractor power take-off (Janos 1995). The right combination of water and nutrients is the key for high yield and the quality of produce. Fertigation saves fertilizers as it permits applying fertilizer in small quantities at a time matching with the plants nutrient need. Besides, it considers eco-friendly as it avoids leaching of fertilizers. Liquid fertilizers are best suited for fertigation however inIndia, inadequate availability and high cost of liquid fertilizers restricts their uses. Hence there is a need of selecting proper fertigation system for application of fertilizers with water. Venturi Injector, fertilizer injector pump and fertilizer tank are the available fertigation equipments in market among these venture is the most commonly used devicefor fertigation through drip irrigation because of its simplicity, ease in use and low cost.The suction rate of fertilizer equipments is depends on its size, pressure differential through it and viscosity of the fluid (Bhangare 2015).The amount of fertilizer injected into the system (suction rate) and motive flow rate is very important for proper crop raising. Keeping these points of view, the study was taken with the main objective of evaluating different fertigation equipments and its hydraulic performance. Venturi injector, fertilizer injector pump and fertilizer tank were the differentfertigation equipments used for the present study.

MATERIAL AND METHODS

To evaluate the performance of fertigation equipments, eight pressure differences of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 and 0.8 kg cm^{-2} between the inlet and outlet of fertigation equipment were chosen. The pressure indicated at the pressure gauge fitted at the outlet of the fertigation system is denoted as the operating pressure of the system. The inlet pressure were selected as 1 kg cm^{-2}, the normal operating pressure range of a drip irrigation system. The throttle valve was adjusted in order to maintain the inlet and outlet pressures.

Variation of Suction Rate with Pressure Difference

The hydraulic performance of the system will vary with respect to the suction rate of the fertilizer into the system. The amount of fertilizer injected into the system was a measure of the suction rate. The suction rate could be varied by varying the pressure difference. Variation of suction rate with pressure difference was studied for venturi injector and fertilizer injection pump unit.A bucket containing solution was placed near the fertilizer equipment. Then pressures of upstream and downstream side was adjusted and stabilized at predetermined level with the help of bypass valve. The suction tube of venturi or fertilizer injection pump was placed in the bucket of water. It allows the suction of water in bucket of was recorded. With the help of stopwatch operating time is noted. The volume change in the water bucket divided by operating time gives the injection rate of venturi or fertilizer injection pump. The same procedure was repeated with different upstream and downstream pressure Plates 1,2 and 3.

Plate 1. Experimental set up of venturi injector

Plate 2. Experimental set up of Fertilizer tank assembly

Variation of Motive Flow Rate with Pressure Difference

The inlet and outlet pressure of the fertilizer equipment were adjusted in order to obtain the various pressure differences. The procedure was repeated for various pressure differences. The volume of water collected from each emitter for various pressure differences chosen at a particular time period was noted. Variation of motive flow rate with operating pressure was studied for the venturi injector, fertilizer tank and the fertilizer injection pump equipment.

Variation of Motive Flow Rate with Suction Rate

For studying the hydraulic performance of the fertilizer injectors, the suction rate and motive flow rate for different inlet and outlet pressures were observed and operating time is noted with the help of stop watch.

Plate 3.Experimental set up of fertilizer injection pump

Hydraulic Performance of Drip Fertigation System

The hydraulic performance of the drip irrigation system was studied with respect to emitter coefficient of manufacturing variation and emission uniformity. These factors are dependent on the operating pressure of the system. The flow from each inline emitter was collected using catch cans for 10 minutes and the corresponding discharge rate was calculated.

Emitter Coefficient of Manufacturing Variation

The emitter coefficient of manufacturing variation was used as a measure of the anticipated variations in the discharge of emitters. The inline drippers were tested for various operating pressures of 0.2, 0.5, 0.7, 1.0 and 1.2 kg cm^{-2} and the coefficient of manufacturing variation were determined after connecting the fertilizer injection pump to the mainline. The pressure indicated by the pressure gauge fitted between the screen filter and throttle valve was denoted as the operating pressure of the system. The discharge from the emitters was collected for various operating pressures after connecting the fertilizer injection pump in the mainline for a period of ten minutes (Plate 4) and the manufacturing coefficient of variation was determined and interpreted the values using Table 1. The value of C_v can be computed with following equations (Michael, 2008).

$$CV = S/q = \frac{\sqrt{q_1^2 + q_2^2 + ...q_n^2 + n(q)^2}}{q\sqrt{n-1}} \quad ...... (1)$$

CV = emitter coefficient of manufacturing variation
S = standard deviation of the discharge rates of the sample
q = average discharge rate of the emitters sampled
q1,q2,..qn = individual emitter discharge - rate values
n = number of emitters in sample

Table 1: Interpretation of manufacturing coefficient of variation

Sl.No.	Emitter coefficient of manufacturing variation CV	Interpretation
1	CV <0.05	Excellent
2	0.05 < CV < 0.07	Average
3	0.07 < CV < 0.11	Marginal
4	0.11 < CV < 0.15	Poor
5	CV > 0.15	Bad

Emission Uniformity

The distribution efficiency and the application efficiency will depend upon the variation of emitter flow along the lateral line and the variation of amount of flow from the sub main into the lateral. The discharges were collected at emitters to study the emitter flow variation at various operating pressures of 0.2, 0.5, 0.7, 1.0 and 1.2 kg cm^{-2} respectively as shown in Plate 3.4. The operating pressures were adjusted by regulating the gate valve at the inlet of the laterals. The emission uniformity was determined by the equation suggested by Bralts *et al*. (1981) and the following equation is commonly used to estimate the emission uniformity in point source and line source in drip irrigation systems and interpreted the values using Table 2.

$$EU = 100\left[1.0 - \frac{1.27CV}{\sqrt{n}}\right]\frac{q_m}{q_a} \quad .....(2)$$

EU = design emission uniformity, %
n = number of emitters per plant
CV = the manufacturer's coefficient of variation
q_m = the minimum emitter discharge rate for a minimum pressure in the section (l h^{-1}).
q_a = the average or design emitter discharge for the section (l h^{-1}).

Plate 4 Collection of discharges for uniformity coefficient determination

Table 2: Interpretation of emission uniformity values for drip irrigation system

S.No.	Emission uniformity EU (%)	Interpretation
1	EU > 90	Excellent
2	80 < EU < 90	Good
3	70 < EU < 80	Fair
4	EU < 70	Poor

RESULTS AND DISCUSSION

By using the above methods, field work has been done and recorded the data for analysis to determine the performance of different fertigation equipment used in drip irrigation system.

Variation of suction rate with pressure difference

An increase in suction rate was observed in the case of the venturi injector with increased pressure difference. The variation of suction rate with pressure difference for venturi injector and fertilizer injection pump is given in Table 3. High pressure difference resulted in more injection rates of venturi injector. The suction rate of venturi injector progressively increased with increasing pressure differential. At a pressure difference of 0.1 kg cm^{-2} in case of fertilizer injection pump a higher value of suction rate of 1.3 l min^{-1} was observed whereas at the same pressure difference venturi injector was recorded very less value of suction rate as 0.34 l min^{-1}.The suction rate of fertilizer injection pump recorded a higher value than the venturi injector. The comparison of variation of suction rate with pressure difference for venturi injector and fertilizer injection pump is shown in Fig. 1.

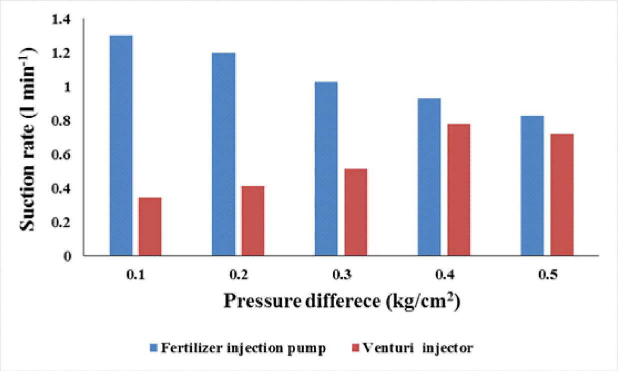

Fig. 1 Comparison of suction rate with pressure difference

Variation of motive flow rate with pressure difference

In order to compare the hydraulic performance of different fertigation equipments, the variation of motive flow rate with pressure difference was studied and shown in Table 4. For venturi injector the maximum motive flow rate was obtained as 34.49 l h^{-1} for a pressure difference of 0.1 kg cm^{-2}. The minimum flow rate of 20.34 l h^{-1} was obtained for a pressure difference of 0.5 kg cm^{-2} in fertilizer tank. For fertilizer injection, the motive flow rate was obtained as 30.24 l h^{-1} pump for a pressure difference of 0.1 kg cm^{-2}.

From Fig. 2 the motive flow rate of venturi injector was 34.49 l h^{-1} which was higher than that of the fertilizer tank 32.79 l h^{-1} and Fertilizer injection pump 30.24 l h^{-1} for the pressure difference of 0.1 kg cm^{-2}. The percentage decrease in motive flow rate for venturi injector was (76 %) which was higher than that of fertilizer injection pump (12 %) and fertilizer tank (51 %) for the pressure difference from 0.1 to 0.5 kg cm^{-2}. Due to the high motive flow rate the venturi injector is suitable for application with large number of drippers. Fertilizer injection pump recorded less motive flow rate when compared to venturi injector at same pressure difference hence it can be used fertilizer injection pumps for smaller motive flow rates which is in agreement with Nadiya *et al.* (2013).

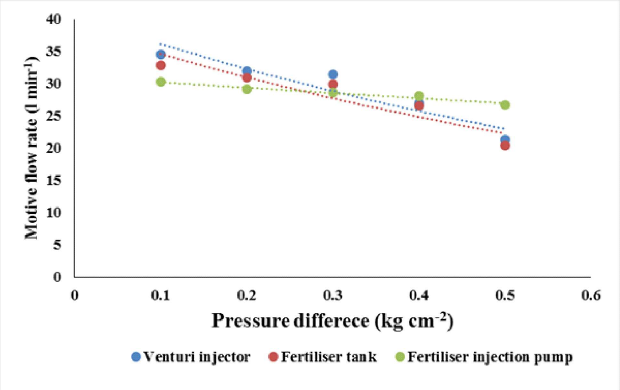

Fig. 2 Comparison of motive flow rate with pressure difference

Coefficient of Manufacturing Variation

The emitter coefficient of manufacturing variation is used as a measure of the anticipated variations in the discharge of emitters. The inline drippers were tested for various operating pressures and the coefficient of manufacturing variation was determined using Eq.1 of Material and Methods section. Variation of coefficient of manufacturing variation with operating pressures in the drip fertigation system is given in Table 5. From the table it is evident that when the operating pressure of drip system is decreased, coefficient of variation increases means the pressure directly affected the discharge rate of emitter. As per the manufacturing precision in terms of manufacturing coefficient of variation, the Cv e” 0.15 was bad as per Mohammed *et al*. (2013). For an operating pressure of 1.2 kg cm^{-2}, the emitter coefficient of manufacturing variation value was 0.04 which is recorded as excellent performance Fig.3.

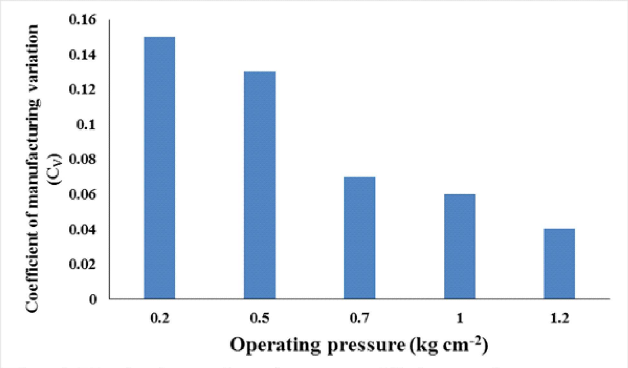

Fig. 3 Variation of emitter coefficient of manufacturing variation

Table 3: Variation of suction rate with pressure difference for fertilizer injection pump and venturi injector

S.No.	Pressure difference (kg cm^{-2})	Fertilizer injection pump (l min^{-1})	Venturi injector (l min^{-1})
1	0.1	1.30	0.34
2	0.2	1.20	0.41
3	0.3	1.03	0.51
4	0.4	0.93	0.78
5	0.5	0.83	0.72

Table 5: Variation of emitter coefficient of manufacturing variation with operating pressures in the drip fertigation system

S.No.	Operating pressure (kg cm^{-2})	Coefficient of manufacture variation
1	0.2	0.15
2	0.5	0.13
3	0.7	0.07
4	1.0	0.06
5	1.2	0.04

Table 4: Variation of motive flow rate with pressure difference for fertilizer injection pump and venturi injector

S.No.	Pressure difference (kg cm^{-2})	Venturi injector (l min^{-1})	Fertilizer injection pump (l min^{-1})	Fertilizer tank (l min^{-1})
1	0.1	34.49	30.24	32.79
2	0.2	31.90	29.08	30.95
3	0.3	31.46	28.63	29.83
4	0.4	26.95	28.1	26.6
5	0.5	21.31	26.69	20.34

Emission Uniformity

The maximum and minimum discharges from the set of emitters were measured for various operating pressures to calculate the emission uniformity and the emission uniformity was determined by using the equation 2 given in Material and Methods. Emission uniformity with various operating pressures of the drip system is given in Table 6. From the table it is evident that when the operating pressure of drip system is increased, emission uniformity increases means the pressure directly affected the emission uniformity. The increase in emission uniformity was 18 % for operating pressures from 0.2 to 1.2 kg cm^{-2}. From the Fig.4 it is clear that emission uniformity at 1.2 kg/cm^2 operating pressure is best. This is in agreement with the findings of Manisha *et al.*, 2015.

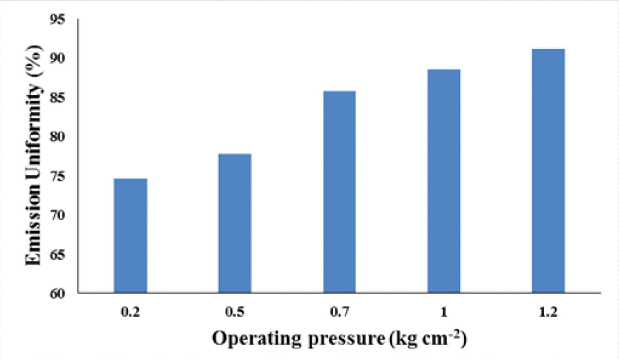

Fig. 4 Emission uniformity of the drip system

Table 6: Variation of emission uniformity with operating pressure

S.No.	Operating pressure (kg cm^{-2})	Emission uniformity (%)
1	0.2	74.58
2	0.5	77.78
3	0.7	85.75
4	1	88.52
5	1.2	91.14

LITERATURE CITED

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

Bhangare S C, Bansude S N and Shirkole S S 2015 Study on performance of venturi injector under different inlet and out let pressures for banana plantation. *International Journal of Agricultural Engineering,* 8(1):75-51.

Manisha, Sinha J and Tripathi M P 2015 Studies on hydraulic performance of drip irrigation system under different operating pressure. *International Journal of Applied Engineering and Technology,* 5(2):58-63.

Michael A M 2008 *Irrigation theory and practice*. Vikas publishers, Noida, India, 611 - 655.

Mohammed A, Almajeed A and Alabas 2013 Evaluation the hydraulic performance of drip irrigation system with multi cases. *Global Journal of Researches in Engineering, General Engineering,* 13(2):12-18.

Nadiya N, Kurien E K, Varughese A and Mathew EK 2013 Evaluation of different fertigation equipments and the hydraulic performance of the drip fertigation system. *Journal of Agricultural Science,* 1(1):12-17.

Received on 08.07.2016 and revised on 30.11.2016