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Research Paper :

Hydraulics performance evaluation of porous pipe (Sub surface) irrigation system

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ABSTRACT

Irrigation water is the most critical input and plays a crucial role for realizing the full potential of agriculture. However, water is very scarce and it needs its efficient use for irrigation with most commonly used surface irrigation systems and micro irrigation systems. So it is necessary to determine the hydraulic performance of these irrigation systems. The sub surface irrigation with porous laterals made up of recycled rubber having 12 mm diameter buried at 15-30 cm below surface level was placed 0.6 m apart. Four porous laterals, continuous emitting lateral, the discharges were collected into a PVC pipe made discharge collection device of 6.0 m long having 30 hermitically sealed portions of 0.2 m each at 20 and 30 kPa pressure head maintained through overhead tank. The variation of water application of porous lateral was found to be 13.21 per cent and 23.52 per cent in various tests at 20 kPa pressure head. Similarly, the variation of water application was found to be12.52 per cent and 15.36 per cent at 30 kPa pressure head. The coefficient and exponent of pressure were found to be 28.70 and 0.1871, respectively for pressure discharge relationship. The high values of variation of emissions rate were found with respect to length and the pipe tested did not perform qualities of good micro irrigation lateral.

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Key words : Sub surface irrigation system, Porous pipe, Hydraulic performance, Micro irrigation lateral

From the ancient times man has used irrigation to grow the crops. Water is an important factor to grow the crops and its survival. Development or advancement of irrigation is not comparable to any other field of agricultural development. Irrigation means the artificial supply of water to the crop for its better crop growth sown in the field. India is one of the important countries in the production of agricultural commodities. The present population of India is increasing day by day and it is more than 1000 million. To feed this population we have to produce food grains in ample quantities. Water being a limited natural resource, there is a need to increase production by efficiently utilizing the available water resources of the countries. Most of the farmers apply irrigation water by flooding, with border irrigation system. The other systems are to apply it beneath the soil surface, by spraying it under pressure over surface in raindrop form or by applying it in drops near to plant. So it is necessary to determine performance of each method of application of water and crop performance in each system. Here the efforts had been made to evaluate the hydraulic performance of porous pipe (Sub surface irrigation system). The porous pipe sold for irrigation is a flexible micro porous tube made up of finely ground rubber, mixed with virgin polyethylene granules and extruded into a tube under heat and pressure. It is commonly made from recycled automobile tyres and as such is regarded as an eco-friendly product. Similar products have been used in US in orchards and turf grass plots as sub surface micro irrigation laterals (Alam, 1991; Rauschkolb *et al.*, 1990). The porous pipe emits water throughout its entire length as water is passed through it under pressure. Since the porous pipe is both conveying and emitting water, the relationship between flow and discharge is critical. Melano and Kamaldasa(1993) and Smajstrla (1992,1994) have worked on this aspect and found that emission rates of the pipe decline continuously with the time. Since the porous pipe emits water continuously along its length when used as a micro irrigation lateral, its porosity with respect to its length must be uniform to ensure uniformity in the water application. Yoder *et al.* (1995) reported on some of the quality control problems facing manufacturers of porous pipe. When this type of porous lateral used as a micro irrigation lateral, it's important to know discharge variation within length, where does the variation occur? How stable is the discharge with the time? The answers

of the above questions can be given by determining the hydraulic characteristic of the porous pipe used as micro irrigation lateral.

METHODOLOGY

The experiment was conducted at Junagadh Agricultural University (JAU), Mechanized Cultivation Farm, Junagadh in the year 2003-04. The soil of experiment site was medium black with bulk density 1.26 g/cc, field capacity 28%, saturation percentage 49.75, porosity 52.01% and specific weight 2.632 gm/cc. pH and electrical conductivity was 8.18 and 0.88 dsm^{-1} for soil extract (1:2.5) and 7.64 and 1.01 dsm^{-1} for irrigation water.

The climate of this area can be described as sub-tropical and semi-arid with average annual rainfall of 750 mm and is situated on 21.31^0 N latitude and 70.36^0 E longitude at altitude of 60 m above mean sea level. January is the coldest month with mean monthly minimum temperature varying 7 to 10^0 C and maximum mean monthly temperature in the month of May varying from 35 to 45^0 C.

In the sub surface irrigation system, the porous pipe lateral of 12 mm dia. was buried at 15 – 30 cm below ground surface in root zone as per convenient and water was supplied at head of 2-3 m head (20-30 kPa) with the overhead tank. Field lay out for sub surface method of irrigation is given in Fig. 1. All the hydraulics studies were done with porous lateral pipe on level ground.

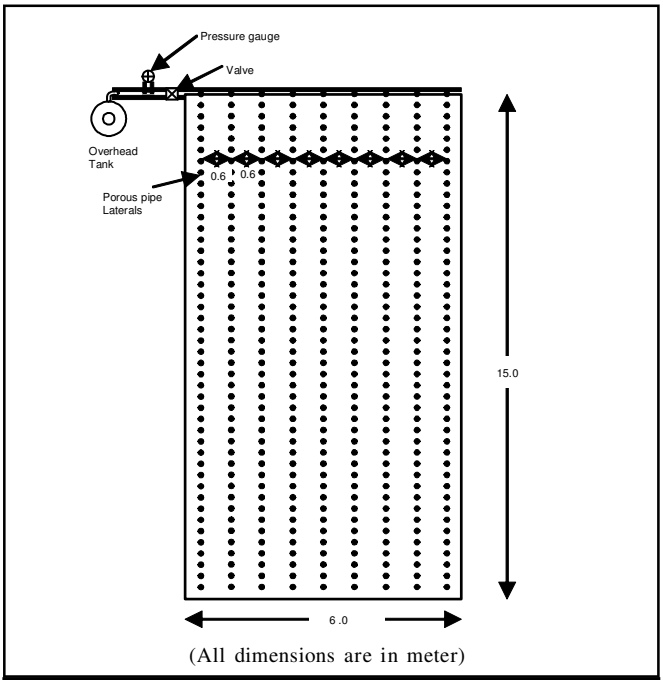

Fig. 1 : Field layout of the sub surface irrigation system with porous pipe

Preliminary test:

The preliminary tests were necessary to determine the time required for the establishment of stable discharge and hence, the duration of subsequent tests. The tests were done at 20 kPa and 30 kPa pressure in 2 replications. Water was allowed to flow through the porous pipe for about 6-12 hrs. The discharge of the entire length of each pipes were taken at regular interval by measuring the volume of water coming out from the tubes for 1 hr. The collection of discharged water from lateral was done by placing semi circular PVC pipe of 63 mm dia. collecting flows at tail end.

Uniformity of water application:

In the drip irrigation system, uniformity of water application can be determined by measuring coefficient of variation from the flow measurement of individual emitters (Solomon, 1985). However, in case of porous pipe due to continuous emission of water along the lateral length the discharges were measured from 0.2 m portion of pipe along the particular lateral length to calculate coefficient of variation. For this purpose a PVC pipe, 6 m long and 63 mm dia. was portioned in to 30 hermitically sealed portions Fig. 2. The each numbered portions had semi circular cut outs on top to accommodate the porous pipe and opening hole at middle of lower end for the capture of water. The testes were performed for two laterals at beginning of operation for t = 10 min. and after 6 hr. of operation for t = 10 min. The discharge uniformity was measured at 20 kPa and 30 kPa pressure.

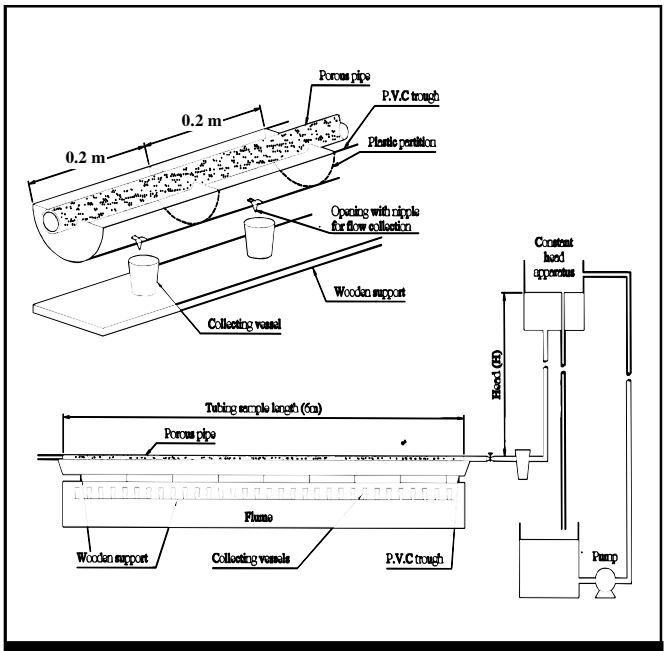

Fig. 2 : Schematic diagram of PVC pipe made discharge collection setup for porous pipe

Pressure – discharge relationship:

As stated above, discharges at operating pressure of 20 kPa and 30 kPa were measured. The relationship between pressure and discharge could be given by

$$Q=kH^x \qquad (1)$$

where, Q = discharge flow (lph/m), k = constant of proportionality, H = operating pressure head (m), x = discharge exponent

RESULTS AND DISCUSSION

The porous pipe, being a continuous emitting lateral tube, determination of hydraulic characteristics is critical task and relationship among hydraulic parameters is critical. However, efforts have been to find pressure-discharge relationship, distribution uniformity and water emission pattern as per discussed above.

Preliminary and curing tests:

The purpose of preliminary tests were to determine the time required for establishment of stable discharge and hence the duration of subsequent tests. The discharges in liter/hr/m at different pressure head were measured for certain duration. The discharge-time relationship of porous pipes at 20 kPa and 30 kPa pressure head is presented in Fig. 3 and Fig. 4 for two laterals. The scattered points are joined by trend line. Here scattered point indicates the flow variation. From the Fig. 3 and Fig. 4, it is seen that the flow rate (lph/m) drops from 17.53 lph/m to 6.23 lph/m after a curing period of 10 hr. duration when pipe was tested at 20 kPa and flow rate drops from 21.34 lph/m to 6.63 lph/m when it was tested at 30 kPa pressure head.

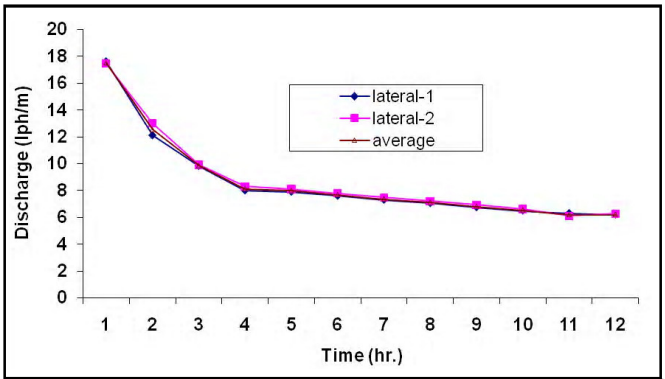

Fig. 3 : Relationship between emission pattern and time at 20 kPa pressure head

Uniformity of water application:

By measuring the variation of flow rates of 0.2 m segment of pipe over a total length of 6 m lateral length assessed the uniformity of the pipe. Statistical parameter expressed as the ratio of standard deviation of flow rate to the mean flow rate gives a measure of variation. Uniformity of water application was measured at beginning of experiment and after 6 hr duration of experiment. At the beginnings of experiment, the variation was 13.21 per cent and 12.52 per cent at 20 kPa and 30 kPa pressure head, respectively. While as variation was 23.52 per cent and 15.36 per cent at 20 kPa and 30 kPa pressure head after 6 hr duration of experiment, respectively.

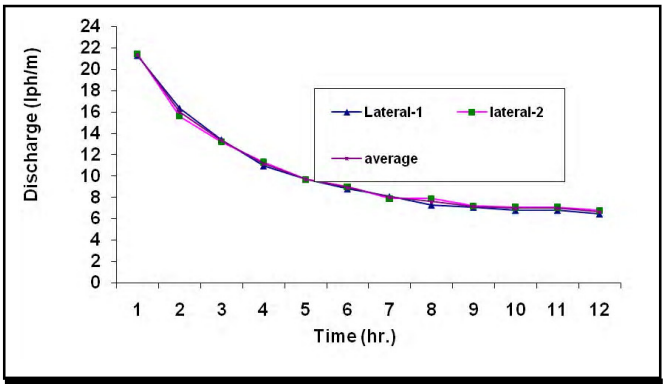

Fig. 4 : Relationship between emission pattern and time at 30 kPa pressure head

According to ASAE standard EP405.1, the variation more than 20 per cent is unacceptable for line source emitting, while as less than 10 per cent is good and between 10 to 20 per cent is acceptable. By over viewing the results, the variation of water application of porous pipe was found to be 13.21 per cent to 23.52 per cent of tests at 20 kPa pressure head. Similarly, variation of application was found to be 12.52 per cent and 15.36 per cent at 30 kPa pressure head. So, present porous pipe is not producing affordable uniformity for irrigation point of view.

Variation of emission rates along the pipe:

Porous pipe, as the continuous emitting lateral, discharge from segment of 0.2 m was measured. Fig. 5 and Fig. 6 represent the variation of flow rate along the lateral length at 20 kPa and 30 kPa pressure head. From the figure, it is seen that as length of pipe increases, flow rate is decreasing. Thus length of porous lateral is also a dominant factor in design of system. It is also seen that the flow rate (lph/m) is large at beginning of pipe while as it is small at the end of length and flow rate reduces as length of pipe increases.

Pressure-discharge relationship:

For porous pipe, pressure-discharge relationship can

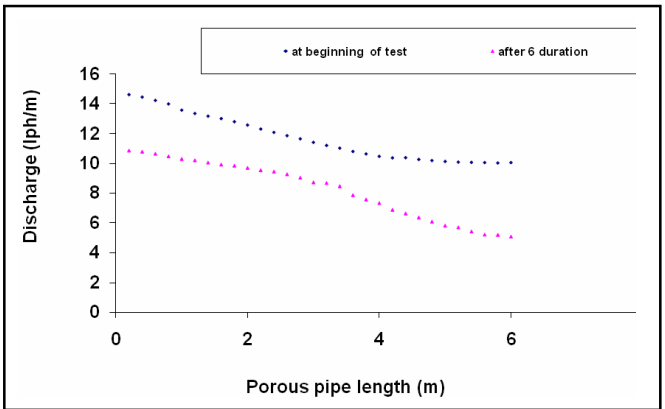

Fig. 5 : Variations of discharge emission rates along the lateral length at 20 kPa pressure head

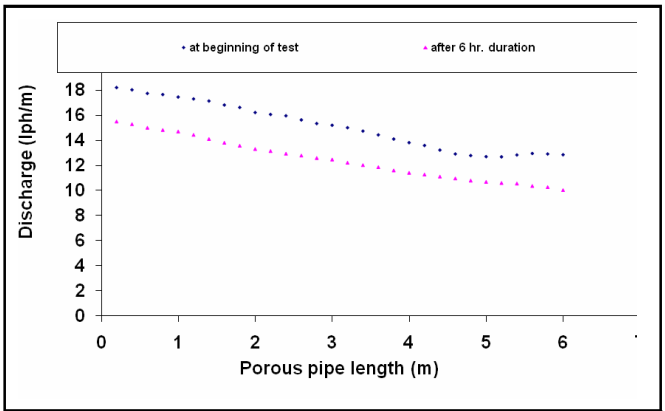

Fig. 6 : Variations of discharge emission rates along the lateral length at 30 kPa pressure head

be established by measuring the discharge at various operating pressure head. Discharges were measured at 2 m and 3 m (20 kPa and 30 kPa) pressure head. Here, only two pressure head is not sufficient to establish the relationship. However, efforts have been made to establish relationship for existing condition. The average discharges at 20 kPa and 30 kPa were found to be 8.67 lph/m and 10.30 lph/m, respectively. The value of discharge coefficient (K) and exponent (x) was found to be 28.70 and 0.1831 Hence, relationship could be given as.

Conclusion:

In case of sub surface irrigation with porous pipe, the porous laterals of 12 mm dia. made from recycled rubber tyre were buried at 15 to 30 cm below surface level at 0.60 m apart in corresponding treatment plots of summer groundnut. The water was supplied through overhead tank at 20 to 30 kPa. The porous pipe, being a continuous emitting lateral tube, discharges were collected in PVC made discharge collection device of 6.0 m long having 30 hermitically sealed portions of 0.2 m each. Subsequently, uniformity of water application, variation of emission rates along the pipe and pressure-discharge relationship was determined.

– Coefficient and exponent of the pressure head was found to 28.70 and 0.1831 for pressure discharge relationship.

– The variation of water application was acceptable at 20 kPa pressure head but it was not acceptable at 30 kPa pressure head. The high values of variation of emissions rate were found with respect to length.

– The results revealed that the porous pipe tested did not possess the qualities of good micro irrigation lateral.

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