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Development of Tensio-Emitter- A Soil Moisture Tension Controlled Emitter

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***Abstract:** Timely application of irrigation water in precise amounts increases crop yield due to decreased moisture stress to plants and loss of water through percolation and subsequent nutrient leaching. Many times, automatic scheduling of irrigation is desired as it ensures timely and precise application and reduced labour cost. Automatic scheduling of irrigation usually involves sophisticated instrumentation which is expensive and requires external power. Irrigation can be scheduled by measuring the moisture tension in the soil which is an indicator the amount of water available to the crop. A system which utilizes the sensed moisture tension to directly control the water applied without using an external power source is desired. This study was carried out to develop a simple and cost effective soil moisture tension controlled irrigation emitter that works without any external power sources. The developed Tensio-Emitter consists of a porous cup and emitter assembly and it functions on the same principle as that of a tensiometer. The Tensio-Emitter can be calibrated by adjusting the conical valve and the top assembly, so that water flows through the emitter only when the soil becomes dry and closes when the soil receives enough water. The tensio-emitter was successfully developed, fabricated and calibrated for use in potted plants.*
***Keywords:** Soil Moisture Tension, Emitter, No Power Emitter, Porous Cup, Tensiometer*

1. Introduction

Irrigation uses more than 70% of the world's water, and thus, improving irrigation efficiency is very important to sustain the food demand from a fast-growing world population (Pardossi *et al*, 2009). Hence different kinds of micro irrigation techniques are being widely used that aids in precise application of water to the plants. In larger farms automated irrigation controllers are also installed that applies right amount of water at the right time thereby reducing wastage, increasing crop produce and also requires lesser human intervention. When such technologies are helping bigger farms or nurseries for better utilization of available resources it is seen that they are very sophisticated and expensive thereby making them inaccessible to small scale applications like kitchen gardens or potted plants at home. Hence, this study is carried out to develop a simple irrigation control device which is easy in operation and can control irrigation without employing sophisticated technology or use of external power source. Most of the automated irrigation control units are successfully and accurately using tensiometer as sensor. Irrigators often use tensiometer for irrigation scheduling because they provide direct measurements of soil moisture status and they are easily managed (Smajstrla, 1998). In this study the working principle of the tensiometer is used to develop the emitter that automatically opens and closes depending up on the metric potential of the soil. The Tensio-Emitter contains a top and bottom assembly, a diaphragm attached with a cone and the porous cup that is commonly used in tensiometer. Hence a Tensio-Emitter was successfully developed with no complex attachments and which works solely on the metric potential developed in the soil and does not require an external power source for its operation.

2. Development of Tensio-Emitter

Tensiometers can effectively be converted into an irrigation controller with little changes in the design (Smajstrla et al, 1998). The main advantage considered in this type of arrangement is that it the tensiometer can simultaneously act as a sensor, controller and an actuator with little adjustments. Different modifications were made in the commercially available tensiometer using diaphragm attachment (Tal, 1975), pistons attachment

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(Peterson, et al, 1993) etc in the past. Hence in this study too different mechanisms were coupled with the porous cup in order to find out the simplest one for the proposed Tensio-Emitter. It was seen that the rubber diaphragm coupled with the porous cup was very responsive according to the soil moisture content variations. Hence the membrane coupled mechanism was used for the further development of the Tensio-Emitter.

2.1 Components of Tensio-Emitter

As in any automated irrigation system this system also has sensor as its prime component along with a watering assembly attached to the sensor. The sensor here is the porous cup that can be seen in any tensiometer commercially available and has a pore size of 2 µm. The porous cup is attached with a tight cap made by plastic molding and it contains an opening at the side so as to fill the cup with water whenever needed and has to be closed tightly. Then there is the top component that has two openings for water to enter from the source and the other is the outlet. In between these assemblies come the rubber diaphragm and the cone that helps in opening and closing of the water supply. The cross section of the whole assembly is shown n Fig. 1

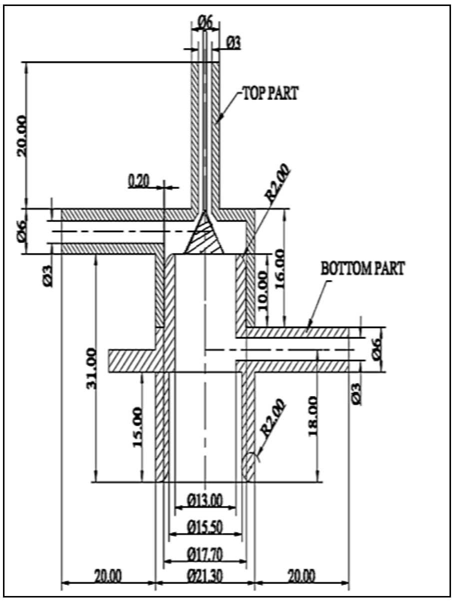

Figure 1 Cross sectional view of Tensio-Emitter

Figure 2 Tensio-Emitter assembly

2.2 Assembling and installation of the Tensio-Emitter parts

The various components of the Tensio-Emitter are to be assembled as shown in Figure 2. It has to be checked for water tightness as well as air tightness. Wet the soil until saturated and install the emitters near to the root zone of the plant such that the porous cup fully comes in contact with the soil. Here the emitter was installed in the pot filled with potting mixture of soil, sand and cow dung powder (2:1:1) (Figure 3). Then turn on water to the drip hose. For the purpose of running test, loosen the upper part of the Tensio-Emitter till a strong stream of water flows out of the drip tube. Slowly tighten the upper part of the emitter until just a single drop of water remains hanging on the end of the drip tube. This "zero adjustment" ensures that the sensor shuts off automatically when enough moisture is available (i.e. after rain or irrigation). The zero adjustment should be done after the sensor adapts to the soil moisture. This takes about 3- 4 h after insertion into the wet earth.
Adjust the sensor on the following days for about a week. Dripping should start when the earth surface is dry; otherwise, loosen the upper part a little. If the earth remains wet, then drips should not be seen even gradually emerging from tube; in this case, press the upper part a little more. Proper adjustment requires a certain degree of delicate touch.

Figure 3 Tensio-Emitter installed in a pot

2.3 Working of Tensio-Emitter

At the time of installation the soil as well as the porous cup is saturated so there won't be any movement of water in between. As the soil moisture is used up and it starts to dry up the water inside the porous cup starts to move out due to the pressure difference and thus suction is developed inside the cup. Owing to this suction the rubber diaphragm starts to move down opening the inlet. Thus water starts to flow thought the emitter to the outlet. When soil becomes wet the suction inside the cup reduces thereby the diaphragm moves up and closes the water inlet.

2.4 Performance of the Tensio- Emitter

It was seen that the emitter worked satisfactorily and the valve opened whenever the pressure was below 7.5 kPa. Once the soil is wet the valve closed to stop the flow of water. The graph plotted between the time and the deflection in diaphragm is shown in the Figure 4. It can be seen that as the time increase the deflection also increases which indicates that the soil is becoming drier and there is suction built up in the sensor. The deflection decreases and becomes zero thus indicating that the emitter opened and water was applied to the plant. This also shows an increase in suction in the soil at the initial stages and then it is reduced as the emitter starts working. The time and pressure relation for the tensiometer also has been plotted in Fig 5. The shape of the graphs is in accordance with the study conducted by Peterson *et al* (1993).

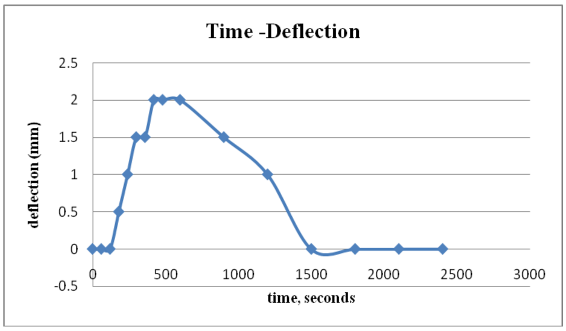

Figure 4 Time -deflection relationship

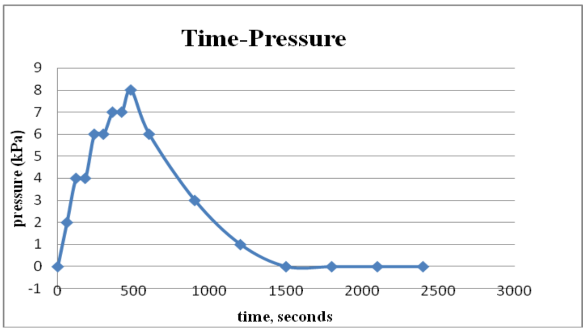

Figure 5 Time -pressure relationship

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3. Conclusion

The developed Tensio-Emitter worked satisfactorily by opening and closing in accordance with the soil moisture condition and the main point is that no external power source is required for the operation. Hence the objective of developing an emitter that can be used in small scale gardens or potted plant was achieved. Since the sensor used was of tensiometer the cost was on a higher side. Further studies can be carried out so as to replace the cup with any indigenously manufactured material which can drastically bring down the cost of the emitter so that it can be availed and used extensively.

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A Brief Author Biography

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