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# Studies on locating moisture sensor for automatic regulation of furrow irrigation systems

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**Abstract: Field trials were conducted to find out an optimum location, depth and distance from furrow head, to install an electronic tensiometer to facilitate furrow irrigation automatically. Response time of the sensor obtained from the study revealed various combinations of depth and distance suitable for sensor placement for three discharge rates, *viz.* 0.5 lit/sec, 1.0 lit/sec and 1.5 lit/sec. The electronic tensiometer was later used to automatically irrigate maize according to a set soil moisture tension.**

***Key words : Automatic irrigation, Soil moisture tension, Response time, Electronic tensiometer.***

## Introduction

During recent years mankind has become increasingly aware that water supply is rapidly decreasing in the face of expanding water consumption. The supply of water for agricultural crop production is beginning to dwindle, thus increasing the need for more efficient irrigation systems. Automating surface irrigation systems will increase water use efficiency and reduce human labour requirement.

Gravity irrigation by means of furrow is perhaps the most widely used and traditional method of water application. Water delivery requirements can be determined from the active plant root zone of the irrigated crop and the water holding capacity of the soil. One important segment of the automatic irrigation system that has not been thoroughly investigated, is the placement of moisture sensing devices to determine the need of irrigation. Thus, it becomes apparent that proper moisture sensor placement might be a key to developing more efficient surface irrigation methods. The purpose of this study was to find a suitable location to place moisture sensing devices in the soil profile to control an automated furrow irrigation system.

Many approaches, both analytical and empirical, have been developed for predicting the wetting front advance rate. An analytical approach based on variable infiltration rat has been proposed by Lewis and Milne (193 solved by Philip and Farrell (1964), and simplifi by Smerdon and Wilke (1965). Automat scheduling based on continuous monitoring the matric potential by tensiometers equipp with pressure transducers has been successful used (Feyen and Giley, 1985; Grismer, 198 Marril *et al.* 1987; Maclendon *et al.* 198 Pougue, 1987; Grismer, 1992). A digital irrigatio controller was used satisfactorily to maintai the soil water within the desired level for solid set system using gypsum blocks (Shu and Dylla, 1980).

In recent years, surface irrigation modelin has enabled scientists to simulate many irrigatior in order to develop irrigation managemer procedures applicable to a wide range of condition The validity of these procedures is highly depende on the accuracy of the infiltration functior described within the models. The extende Kostiakov infiltration function has been modifie by several investigators to incorporate the infiltratio during furrow irrigation (Izuno *et al.* 1985 However infiltration parameters estimated b infiltrometers may inaccurately represent th total field because of spatial variability of th soil in the field (Bautista and Wallender, 1985 It is therefore desirable to work out a prope location to install the sensor under field conditio itself. It is with this objective that the present study has been undertaken.

## Materials and Methods

An electronic tensiometer (Fig.1) developed by Central Plantation Crops Research Institute, Kasaragod has been used as soil moisture sensor and thereby automatically scheduling irrigation. The field selected in TNAU campus (Field No. 69), Coimbatore was composed of a sandy clay loam soil, precision leveled to a longitudinal slope of 0.003m/m. Soil characteristics of the selected field is given in the Table 1.

**Table 1.** Soil characteristics

| | |
|---|---|
| Infiltration rate | 1.25 cm/hr |
| Bulk density | 1.34 $kg/m^3$ |
| Non capillary porosity | 15.72% |
| Capillary porosity | 21.87% |
| Field capacity | 28.02% |
| Wilting point | 11.56% |
| Hydraulic conductivity | 2.94 cm/hr |

The field length was 80 dia m with furrows spaced on 60 dia cm centers. The field set up of the device comprised of a 50 mm dia and 15 m long PVC pipe with 25 mm dia orifices spaced 60 cm apart to suit the furrow spacing of 60 cm for row crops. The pipe was kept at the head end of the field in such a way that the orifices were at the center of each furrow. An online electro magnetic valve was provided at the head end of the PVC pipe. The valve in turn was connected to an electric supply through electronic tensiometer. The electronic tensiometer was placed at a distance of 0,20,40,60 and 80 m away from the head end at a depth of 10,20 and 30 cm. Upper limit of tension (tension at which irrigation starts) was kept at 0.6 atm and lower limit (tension at which irrigation stops) at zero tension. These settings of tensions would provide 5 cm of irrigation at 50% of the available water holding capacity. Irrigation was given at 0.5 lit/sec, 1.0 lit/sec and 1.5 lit/sec. Response time of the electronic tensiometer placed at different locations along the furrow at different depths for three discharge rates were noted. The experiment was conducted with randomized block design with three replications and eight furrows per replication.

## Results and Discussion

The design and operation of surface irrigation systems are significantly influenced by the infiltration rate of the field. Therefore, temporal and spatial variability of infiltration rates must be considered in the management procedures. In order to operate any automatic surface irrigation system based on soil moisture sensor the most important factor is the proper positioning of the sensor used. The same is true with furrow irrigation also when it is automated using electronic tensiometer. The instrument has to do two things. It has to switch on irrigation at a preset tension level. For this it could be placed anywhere in the active root zone of the crop. However things would be more complicated when it needs to switch off irrigation at another preset tension level. Response time required for the electronic tensiometer play an important role in switching off irrigation. It is less important in the case of switching on irrigation because the instrument would get ample time to respond since the drying process in an irrigation cycle would be much slower than the wetting process. Time required for the electronic tensiometer to respond to a particular soil moisture condition depends on the response time, an inherent character of the instrument that in turn depend on the manufacturing process of the tensiometer cup and age of the instrument, depth of installation and distance from the furrow head. For a given slope depending on the discharge rate, depth of irrigation and furrow length, the electronic tensiometer has to be located properly.

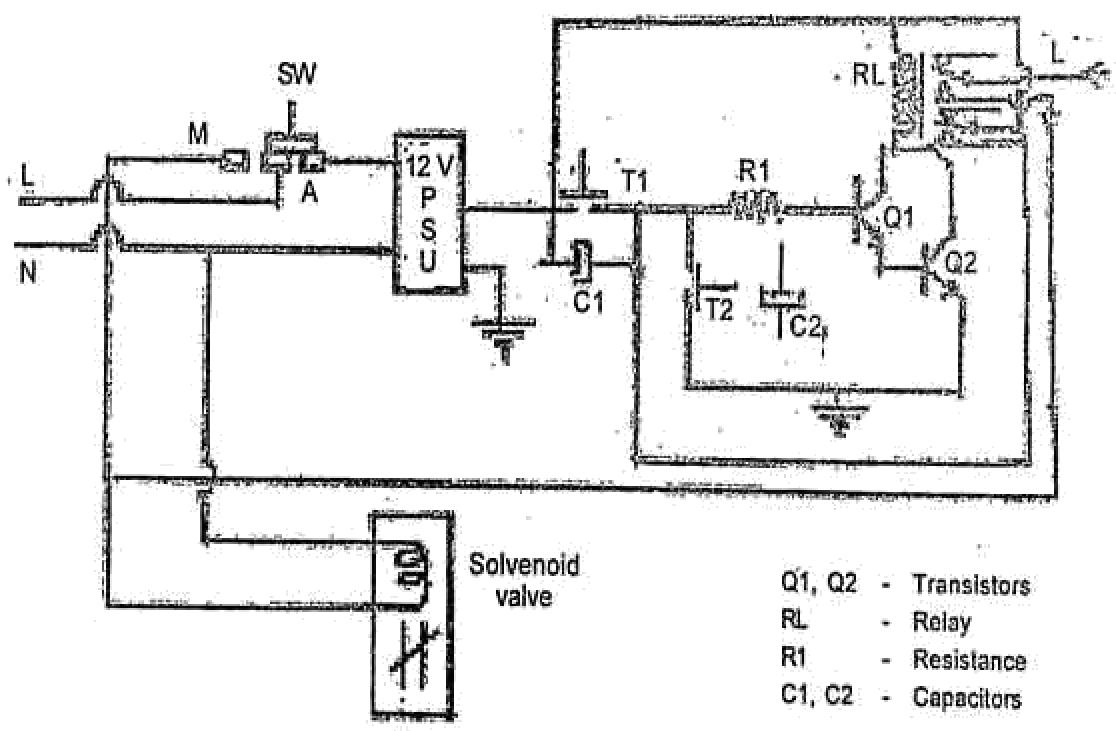
The response time required by the electronic tensiometer for different discharge rates and the time required to provide 5 cm irrigation in a furrow of 80 m length and 60 m width is given in Table 2. From this table the user can choose a best combination, interms of depth and distance from head end of furrow, which provides irrigation most accurately.

Table 2. Response time of electronic tensiometer for various discharge rates

| | | | Response time of electronic tensiometer, minutes | | | | |
|---|---|---|---|---|---|---|---|
| Discharge lit/sec | Irrigation time required, min | Depth cm | Distance from furrow head, m | | | | |
| | | | 0 | 20 | 40 | 60 | 80 |
| 0.5 | 80 | 10 | 13 | 20 | 28 | 40 | 60 |
| | | 20 | 43 | 48 | 56 | 68 | 88 |
| | | 30 | 81 | 87 | * | * | * |
| 1.0 | 40 | 10 | 14 | 16 | 21 | 27 | 38 |
| | | 20 | 42 | 44 | 49 | 55 | * |
| 1.5 | 27 | 10 | 14 | 15 | 17 | 20 | 24 |
| | | 15 | 19 | 20 | 23 | 27 | 29 |

*Readings were not taken for points where response time becomes more than duration of irrigation.

Fig.1. Circuit diagram of automatic irrigation system




It may be observed that for a discharge rate of 0.5 lit/sec the sensor may be located at a depth of 30 cm at the head end or some where between 60 cm and 80 cm at the tail end or some where between 60 m and 80 m along the furrow at a depth of 20 cm. In the case of 1.0 lit/sec discharge rate the sensor location could be at a depth of slightly more than 10 cm at the tail end or at a depth of slightly less than 20 cm at the head end. Th same for 1.5 lit/sec discharge rate would b a depth of 15 cm at a distance of 60 m ( between 10 cm and 15 cm depth at the ta end.

The electronic tensiometer was later use to automatically irrigate maize (CO 1) usin furrow irrigation. The electronic tensiomet

Fig.2. Soil moisture fluctuation under automatic irrigation

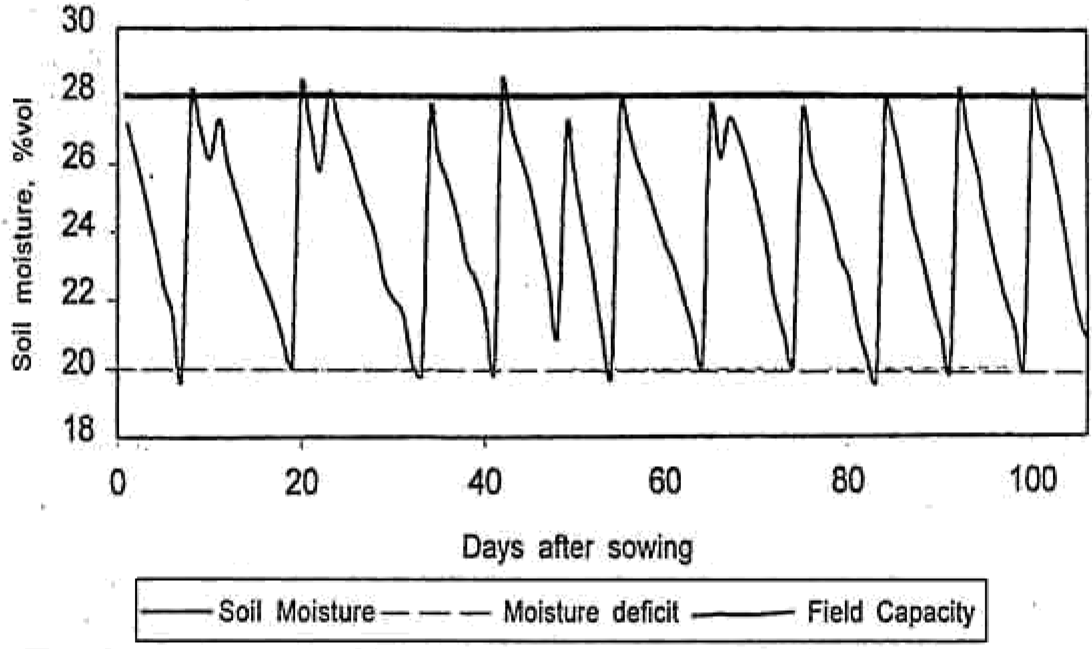
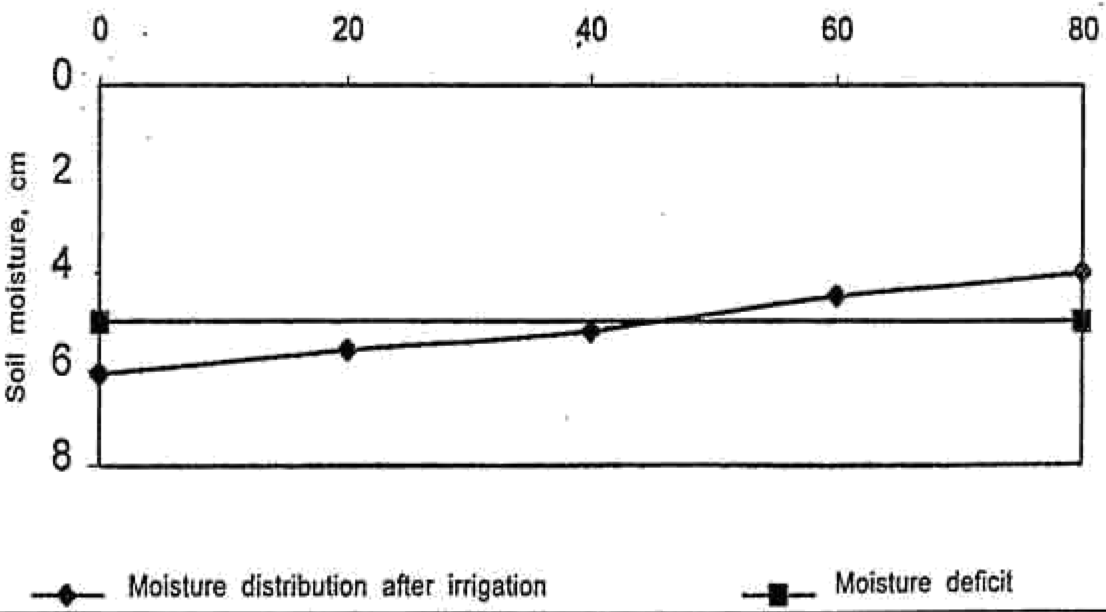



Fig.3. Moisture distribution after irrigation




irrigation starts, and zero tension at which irrigation stops, to provide 5 cm irrigation at 50 per cent of the available moisture content. The instrument was located at a depth of 20 cm and at a distance of 20 m from the head end of the furrow. Soil moisture around the electronic tensiometer was monitored gravimetrically all along the cropping period. Results of which is given in Fig.2. It may be observed from the figure that the soil moisture fluctuates more or less within the stipulated range. Rise in soil moisture immediately after first, second and seventh irrigations are due to rain.

Soil moisture distribution after irrigation is given in Fig.3. Christiansen's Uniformity

Coefficient (UCC) was worked out to be 89.5 per cent and irrigation application efficiency (Ea) was 73.13 per cent.

## Conclusions

The single most important criteria in any automatic surface irrigation system based on soil moisture sensing is the proper location of the sensor. This has been worked out and field tested by irrigating maize crop automatically using furrow irrigation.

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