ladras Agric. J. 91 (4-6) : 215-220 April-June 2004
https://doi.org/10.29321/MAJ.10.A00094


# Evaluation of an automated furrow irrigation system using soil moisture ensor

\.C. MATHEW AND S. SENTHILVEL
Dept. of Soil and Water Conserv. Engg., Tamil Nadu Agrl. University, Coimbatore - 641 003, Tamil Nadu

**Abstract:** An automatic furrow irrigation system based on soil moisture sensing was installed and tested to assess its field performance. An electronic tensiometer monitored the prevailing soil moisture status and switched on a solenoid valve commencing irrigation. Once irrigation started the instrument kept on monitoring the soil moisture level and when it reached zero tension, it switched off irrigation. The automatic irrigation system was used to irrigate maize (CO 1). Conventional furrow irrigation method was kept as a control. The system performed well and it could save nearly 20% of water compared to conventional furrow irrigation. Grain yield of both the crops were only marginal different. Besides, water use efficiency of automatically irrigated crop (63.14 kg/ha/cm) was considerably higher than of conventional method (51.43 kg/ha/cm).

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

## Introduction

Automated furrow irrigation is not so common in India even as similar types of irrigation systems are quite popular in developed countries. This helps them not only to save costly labour but also to exercise a control in irrigation management as required to maintain the yield and quality of the produce. Automation in irrigation offers some specific advantages.

- Accurate control of the amount and frequency of water application for effective crop management and water use.
- Saving labour, transport and other costs related to the opening and closing of irrigation line in the field.
- Convenience and flexibility in planning the work programme so that there is no need to go to the field at night or any other inconvenient times.

To obtain maximum crop yield out of the inputs like water, fertilizer, seed etc. invested in crop production, the single most important factor is the field water management. Crops should be irrigated to the proper soil wetness with just enough water to replenish the soil moisture deficit created in the root zone. There fore a well controlled irrigation system is the one which optimizes the spatial and temporal distribution of water, besides maximising the benefit cost ratio.

The system is based on the continuous sensing of the soil water potential, using a suitable sensor located at the active root zone of the crop, and comparing the same to a given threshold value. When the condition for start or stop of the irrigation was met a control unit automatically sent commands to start (or stop) the water application.

The crop consumptive use rate depends on the soil moistue tension prevailing rather than the actual soil moisture content. Hence it is preferable to schedule irrigation as and when a critical soil moisture tension level is reached which can be perceived by a suitable sensor. In the present study the soil moisture sensor used is based on the relation between soil moisture tension and soil moisture content.

The introduction of automatic irrigation system would overcome many of the difficulties encountered in collecting and analyzing field data for estimating soil moisture status. During the last two decades various trials were made

Table 2. Effect of mode of irrigation on water applied

| Mode of irrigation | Operating time, minutes | Water applied, cm | Effective rainfall, cm | Water saving |
|---|---|---|---|---|
| Conventional | 620 | 77.5 | 10.5 | 14.5 cm |
| Automatic | 504 | 63.0 | 10.5 | (18.71%) |

Table 3. Effect of mode of irrigation on water use efficiency

| Mode of irrigation | Grain yield, kg ha$^{-1}$ | Depth of irrigation, cm | Effective rainfall, cm | Water use efficiency, kg/ha/cı |
|---|---|---|---|---|
| Conventional | 3986 | 77.5 | 10.5 | 45.3 |
| Automatic | 3978 | 63 | 10.5 | 54.12 |

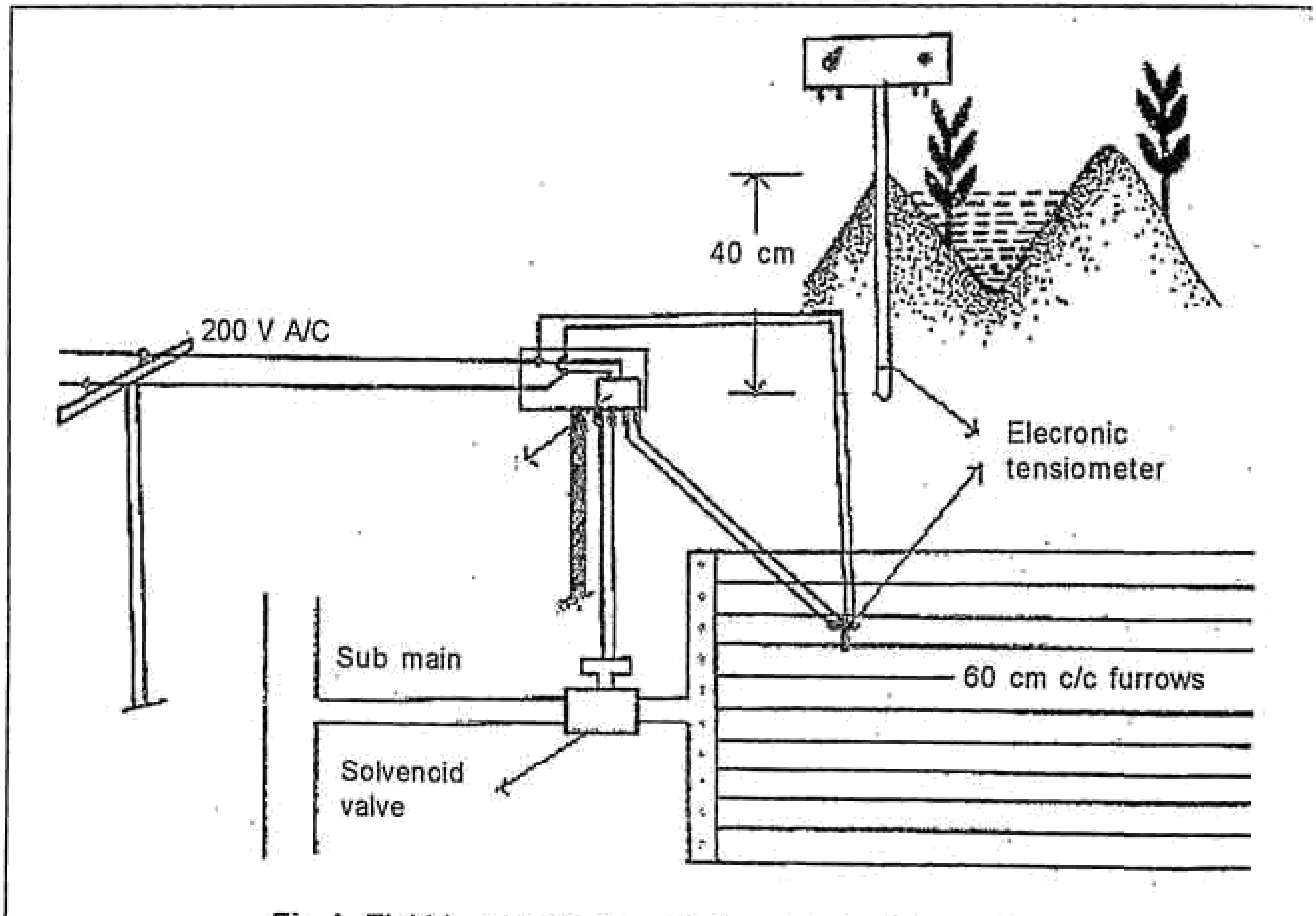



Fig.1. Field layout of automatic furrow irrigation system

using automatic irrigation scheduling based on soil water sensing. A digital irrigation controller was used satisfactorily to maintain the soil water within the desired level for a solid set system usign gypsum blocks (Shull and Dylla, 1980). In a study of the feasibility of using tensiometers for scheduling turf irrigation, a substantial water saving was obtained in sensor controlled plots (Augustine and Snyder, 1984). Automatic scheduling based on continuo monitoring of the matric potential by tensiomete equipped with pressure transducers has be successfully used (Feyen and Giley, 1985; Grism 1987; Marril et al. 1987; Maclendon et : 1983; Pougue, 1987; Grismer, 1992). Anoth technique employing an infrared (IR) telemet system was used to read tensiometers and oth variables by IR field stations (Thompson a

Fig.2. Soil moisture characteristics (Field using tensiometer)

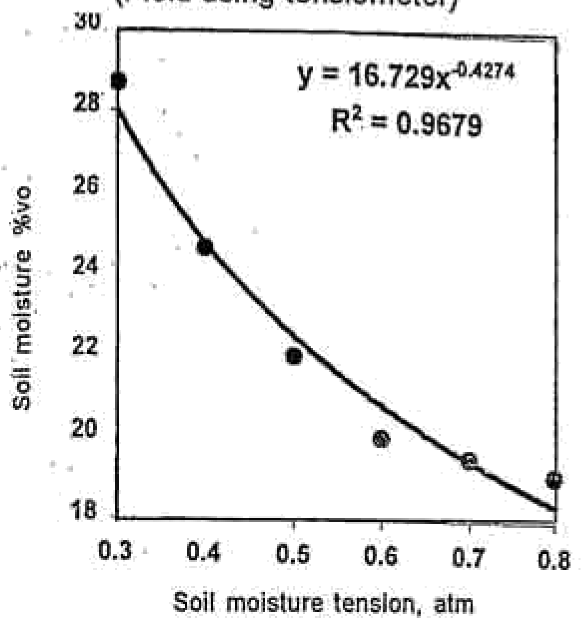
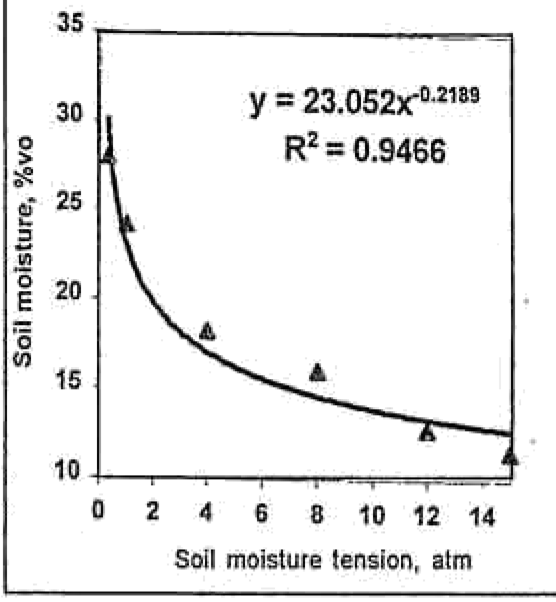



Fig.3. Soil moisture characteristics (lab using pressure plate apparatus)




Threadgill, 1987; Drum, 1988). Results from experiments on a center pivot system for corn using radio communication in Colorado showed an improvement in center pivot management and saving water, labour and energy (Haise and Hagan, 1967; Heerman et al. 1985). Using such a system, it is estimated that many man hours of labour are saved (in reading soil sensing devices and operating the irrigation system) while allowing a more precise measurement and management of the irrigation system (Heerman et al. 1987).

## Materials and Methods

A fully automatic irrigation scheduling experiment based on soil moisture tension was carried out at Field No.69 of Tamil Nadu Agricultural University, Coimbatore by providing furrow irrigation to Maize (CO 1) automatically. Soil characteristics of the selected field is given in Table 1. An electronic tensiometer developed by Central Plantation Crops Research Institute, Kasaragod has been used as soil moisture sensor and thereby automatically scheduling irrigation.

Table 1. Soil characteristics

| | |
|---|---|
| Infiltration rate | 1.25 cm/hr |
| Bulk density | 1.34 kg/m3 |
| Non capillary porosity | 15.72% |
| Capillary porosity | 21.87% |
| Field capacity | 28.02% |
| Wilting point | 11.56% |
| Hydraulic conductivity | 2.94 cm/hr |

*Working of electronic tensiometer*

The instrument worked on 220 volt A/C power supply. Following two tensions could be set in the tensiometer prior to its use.

1. Upper tension limit - at which irrigation starts, and
2. Lower tension limit - at which irrigation stops

The upper limit of tension should be less than 0.8 atm. Even though the lower limit of tension could be any where between 0 and 0.8, usually it woul dbe kept at slightly above zero or at field capacity. After pre setting the upper and lower tensions the electronic tensiometer is kept at a proper depth within the active root zone of the crop. As the soil get dried tension develops in the tensiometer and when it reaches the set upper limit an LED in the control panel illuminates indicating the time to start irrigation. Simultaneously the instrument switches on an online electro magnetic valve/electric pump to switch on irrigation. Once irrigation starts the soil moisture tension in the soil decreases and when it reaches the set lower limit the instrument switches off the valve/pump thereby stopping irrigation.

Fig.4. Soil moisture fluctuation under conventional irrigation

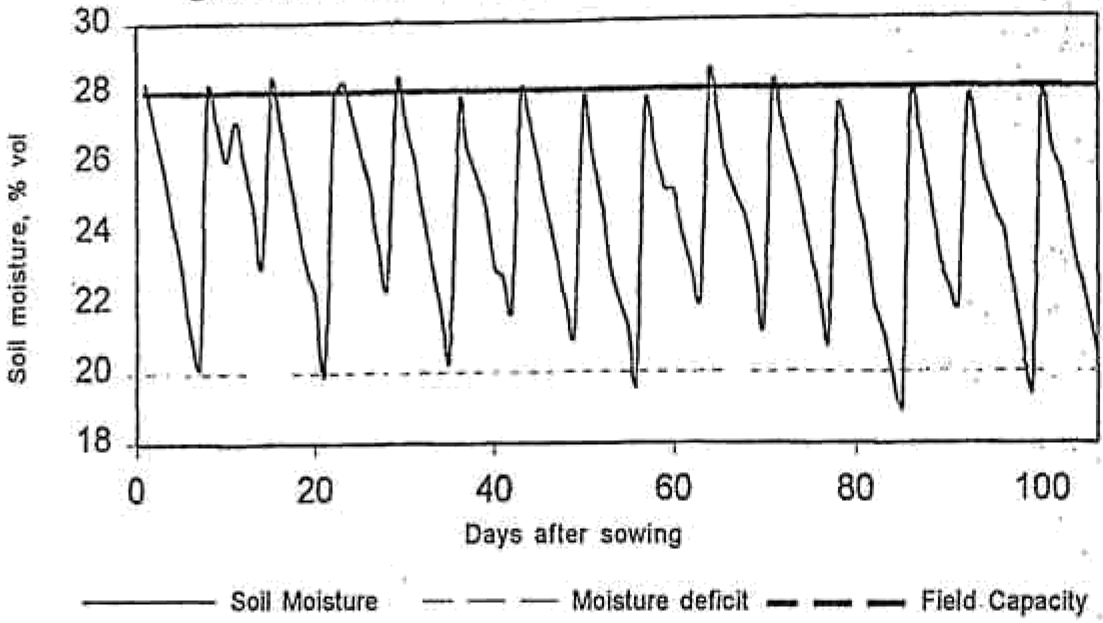
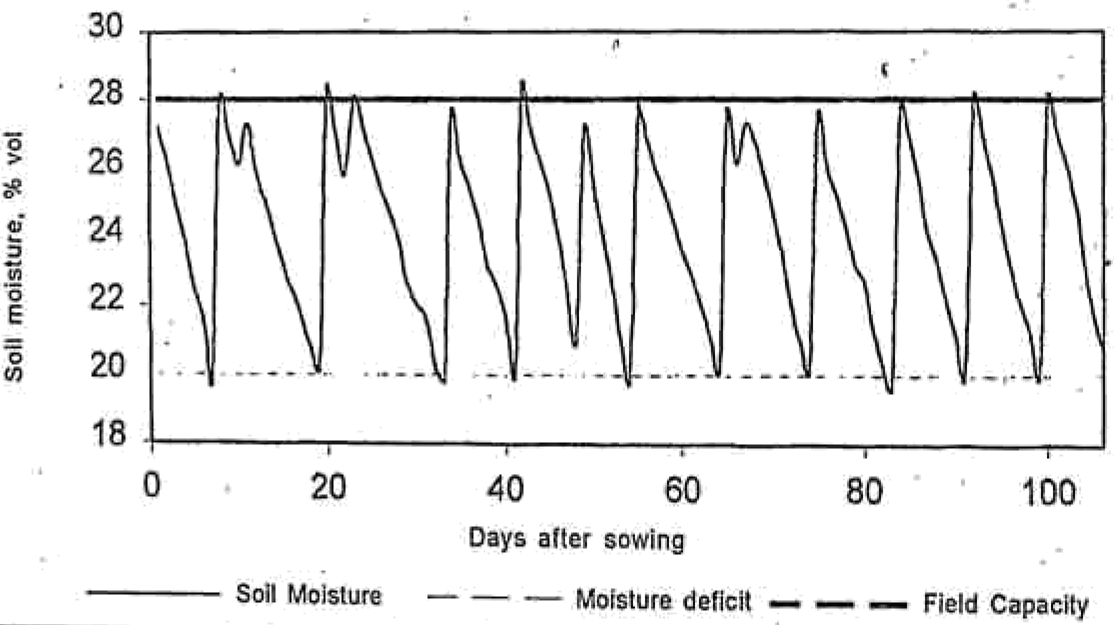



Fig.5. Soil moisture fluctuation under automatic irrigation




*Experimental set up*

The field selected was composed of sandy clay loam soil precision leveled to a longitudinal slope of 0.0035m/m. Field length was 80m with furrows spaced at 60cm centres. The field set up (Fig.1) of the device comprised of a 50mm dia and 15m long PVC pipe with 25mm dia orifices spaced 60cm apart to suit the furrow spacing of 60cm 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 magneti valve was provided at the head end of th PVC pipe. The valve in turn was connecte to a main pipeline to which a continuous wate supply was provided. The valve was connecte to the electronic tensiometer which in tur was provided with electric supply. The electroni tensiometer was placed at a distance of 20m away from the head end at a depth of 20 cm from the ridge. This position would be most suiable for a discharge rate of 1 litres per second and for the given slope and soil type. Conventional method of furrow irrigation, manual irrigation, was kept as control. The experiment was conducted with randomized block design with three replications and four furrows per replication. Upper limit of tension was kept at 0.6 atm and lower limit at zero tension. Irrigation was provided to the control furrows at the rate of 5cm per week. Both are approximately 50% of the available water holding capacity.

## Results and Discussion

Both the conventional and automatic irrigation plots were irrigated @ 7.5 cm of water immediately after sowing to bring the soil within the root zone to field capacity. After this first irrigation the conventional plot was irrigated @ 5cm once in seven days, manually, through out the life period of the crop. Whereas automatic plot irrigation was done by the electronic tensiometer by sensing the prevailing soil moisture and according to the set tensions. The electronic tensiometer was calibrated in the field prior to the experiment. Calibration curve of the same is given in Fig.2. Soil moisture characteristics also was determined simultaneously using pressure plate apparatus (Fig.3). A constant discharge rate of 1 lit/sec was used to irrigate the plots.

Effect of mode of irrigation on irrigation scheduling is given in Fig.4 and Fig.5 and water applied is given in Table 2. It may be noted from Fig.4 that a total number of 15 irrigations were provided to the crop in conventional method. For automatic irrigation (Fig.5) this came down to 12. In the conventional irrigation the irrigation fluctuated between 38 minutes to 46 minutes except for the first irrigation where it was 60 minutes as in the case of conventional irrigation.

Conventional irrigation was operated for a total duration of 620 minutes. This resulted in applying an amount of 37.2 $m^3$ of water per furrow that is equivalent to a depth of 77.5cm. However the automatic irrigation system provided irrigation for 504 minutes thereby applying 30.24 $m^3$ (63 cm) of water. An effective rainfall of 10 cm also was received during this period for both the treatments.

It may be observed from Fig.4 that in conventional irrigation, many times irrigation was given before the soil moisture deficit reached the stipulated 50% of the available water holding capacity. Whereas in automatic irrigation (Fig.5) it was much closer. This was the main reason for the water saving in automatic irrigation. More over few rains occurred during the experiment also reduced irrigation in the case of automatic irrigation. In the case of conventional method this was not accounted since irrigation was provided @5cm per week irrespective of the prevailing soil moisture deficit.

### *Water use efficiency*

Effect of mode of irrigaton on the yield of the crop (Maize-CO1) and its water use efficiency is given in Table 3. Grain yield under conventional irrigation (3986 kg/ha) was marginally lesser than that of automatic irrigation (3978 kg/ha). However there was no significant difference between the two yield levels. Even though the grain yield in the case of automatically irrigated field was less than that of conventional irrigation the water use efficiency of the automatically irrigated crop was considerably higher than the conventional system of irrigation. This was mainly because of the significant saving of irrigation water when the field was irrigated automatically.

## Conclusion

The electronic tensiometer adopted to automatically schedule furrow irrigation based on soil moisture worked satisfactorily. The installation and maintenance did not present any major problem. The system has a great potential for water and labour saving. The system optimized irrigation water use with 18.71% water saving in maize production.

## References

Augustine, B.J. and Snyder, G.H. (1984). Moisture sensor controlled irrigation for maintaining Bermuda grass turf. *Agronomy J.* 76: 848-850.

Drum, D. (1988). Infrared telemetry: A promising new management tool. *Irrigation J.* Vol. 38, No.6, Nov/Dec.

Feyen, J. and Giley, J. (1985). Irrigation timing throuh micro-processor controlled tensiometers : principle and application to a pear orchard. 3rd Int. Irrigation Congress (ASAE). Vol.2, pp.773-780.

Grismer, M.E. (1987). Automated monitoring of soil remote sensors. ASAE winter meeting, Chicago, USA. Paper No. 87-2095.

Grismer, M.E. (1992). Field sensor networks and automated monitoring of soil water sensors. *Soil Sciences,* **154**: 482-489.

Haise, R.H. and Hagan, R.M. (1967). Soil, plant and evaporative measurements as criteria for scheduling irrigation. In irrigation of agricultural lands. American Society of Agronomy, pp.577-604.

Heerman, D.F., Duke, H.R. and Buchleiter, G.W. (1985). User friendly software for an integrated water-energy management system for center pivot irrigation. *Computers and Electronics in Agriculture,* **1**: 41-45.

Heerman, D.M., Skold, M.D. and Heerman, D.F. (1987). Tensiometer transducer system: Calibration and testing. ASAE summer meeting, Paper No. 83-9999.

Maclendon, B.D., Thompson, S.J. and Chesness J.L. (1983). Irrigation scheduling, a vali option with micro-processor based controls *Agricultural Engineer,* **9**: 12-14.

Marril, J.D., Flint, A.L. and Davis, W.J. (1987) Tensiometer transducer system: calibration and testing. ASAE summer meeting, Pape No. 83-9999.

Pougue, W.R. (1987). Remote sensing of tensiomete data to schedule irrigation. ASAE winte meeting, Paper No. 87-2555.

Shull, H. and Dylla, A.S. (1980). Irrigation automatio with a soil moisture sensing system. *Trans ASAE,* **23**: 649-652.

Thompson, S.J. and Dale Threadgill, E. (1987) Microcomputer control for soil moisture base scheduling center pivot irrigation systems *Computer and Electronics in Agricultur* **1**: 321-338.

(Received: January 2003; Revised: October 2003