R.P.F. III

FINAL REPORT

1. Institute Code No : Tech.XV (231)
2. I.C.A.R. Code No:
3. Name and Address of Research Institute/Centre:
   Central Plantation Crops Research Institute, Ksaragod - 671124, Kerala.
4. Project Title : Design of an electronic tensiometer and an auto irrigation system .
5. Name and Designation of Project Leader : K.Madhavan, Sr.Scientist, Electronics and Instrumentation

6. Name(s) and Designation of Project Associates including Project Leader and work to be done:

Sl No:	Name and Designation	Time spent	Work done
1	K.Madhavan, Sr.Scientist	20 man months	1. Design of an electronic tensiometer and auto irrigation system, installation and testing in the field. 2. Design of sequential irrigation system, installation and testing in the field. 3. Design of resistance type sensors for heavy textured soils installation and testing in the field.
2	A.C.Mathew Scientist (Soil Water Conservation Engg.)	20 man months	4. Calibration of these instruments 5. Field evaluation of these systems 6. Design of an automatic control System for pumping water to the Overhead tank for irrigation

7. Location of Research Project with complete address (Division/Section/Sub-Center)
   Post Harvest Technology, Physiology & Biochemistry Division,
   CPCRI, Kasaragod

copy to PMT

8. Date of start : April 1994

9. Date of termination : June 1999

10. (a) Objectives (Not more than 150 words)

To obtain maximum crop yield out of the inputs like water, fertilizer, food seed etc, invested in crop production, the most important single factor is the field water management. Crops should be irrigated at the proper soil wetness with just enough water to replenish the soil moisture deficit created in the root zone. Therefore a well-controlled irrigation system is one which optimizes the spatial and temporal distribution of water, not necessarily to obtain the highest yield or to use the least amount of water possible, but to maximize the benefit-to-cost ratio

An automated irrigation control system is envisaged with sensors to monitor the soil moisture status by the soil moisture suction or tension and by the amount of water it contains. The main objective of the study is to design suitable sensors to monitor the soil moisture status by both these methods and to develop an auto-irrigation system with the same.

Resistance blocks and tensiometers are the two commonly used sensors. Since resistance blocks are designed to measure water depletion over a wider range of water tension (1-15 bars), the block would not be as useful in measuring the water depletion in light textured soil as a tensiometer which is designed to measure water tension over a narrow range at low tension (0-1 bar).

When evaluating clay soils, the tensiometer may indicate that it is necessary to irrigate or at least the instrument will cease to function when only 20 percent of the soil moisture has been depleted (soil water tension 0.8 bars). Therefore in a heavy clay soil the use of resistance blocks would allow evaluation of moisture depletion over a greater range of available moisture than would a tensiometer. However, the tensiometer would be most useful when scheduling irrigation in the low suction range, which is the primary objective of localized irrigation.

The following are the specific objectives of the study:

1. To develop a sensor/sensors suitable for different soil types which give the user an audio or video signal to switch on and switch off the irrigation.

2. To develop an auto-irrigation system which can operate either a solenoid valve or an electric motor to switch on / switch off the irrigation system at preset soil moisture levels.

3. To evaluate the system developed in the field.

(b) Practical Utility including background information (Not more than 150 words)

Crops should be irrigated at the proper soil wetness with just enough water to replenish the soil moisture deficit created in the root zone of the plant. But farmers irrigate their land by visual observation of the soil dryness or by the feel of the soil, which very often may not be accurate. An automatic irrigation control system can monitor the soil moisture status and accordingly irrigate the land to the required level. The main practical utility of the study is to use suitable sensors to monitor the soil moisture status and to control an auto-irrigation system with the same. The other utility is to save labour.

11. Technical Program:

1. Design and development of soil moisture sensors:

Soil moisture sensors suitable for different soil types are to be developed. This gives an audio/video output to the farmer at any preset soil moisture level.

i) Design of an electronic tensiometer:

Tensiometer is the only instrument to measure soil moisture tension directly in the field. Tensiometer measures the condition rather than the quantity of soil water and their operation is largely independent of the type of soil. Basic principle of the tensiometer is simple. As the soil dries out and draws water from tensiometer, a negative pressure develops inside the tensiometer, which will be converted into electric signal by a pressure transducer and electronic circuit attached to it. Since a tensiometer is designed to measure water tension over a narrow range at low tension (0-1 bar), it is very suitable for light textured soil.

ii) Design of an alternate sensor with gypsum block:

Since resistance blocks are designed to measure water depletion over a wider range of water tension (1-15 bars), the block would be suitable for heavy soils. Working principle of gypsum block sensor is the change of resistance of the block with moisture. This resistance, which is inversely proportional to the surrounding soil moisture, is converted to electric signal thereby activating an audio/video output.

2. Calibration of the sensors developed:

The above sensors are to be calibrated for different soil types. For this, simultaneous soil moisture measurements are to be taken by these sensors and by gravimetric method at different soil moisture levels. Once calibrated, the instrument can be set at any moisture levels as per the user requirement.

3. Design and development of an auto irrigation system:

i) Automatic sequential systems:

A suitable control system is to be designed to turn the pump / solenoid valve on at any point of time, allow it to run for a predetermined period of time and then to shut it off.

ii) Non-sequential operated systems:

These are fully automatic systems operating independently both in time and in quantity.

4. Field evaluation of the system:

The auto irrigation system will be installed in three different soil types, i.e., sandy soil, sandy loam soil and laterite soil and evaluated. Accuracy and consistency of the equipment will be worked out. It will again be evaluated against the conventional irrigation system.

12. **Final Report:**

1. Design and development of soil moisture sensors:

Soil moisture sensors suitable for different soil types were developed. These give an audio/video output to the farmer at any preset soil moisture level. For example, if the instrument is set at 50 percent of available moisture as `on time' and at field capacity as `off time', the same will give the user an audio/video signal when the soil moisture status reaches 50% of the available moisture(preset value) so that he can start irrigation. Similarly it will give another signal at field capacity so that the user can switch off irrigation.

i) Design of an electronic tensiometer:

Tensiometer is the only instrument to measure soil moisture tension directly in the field. Tensiometer measures the condition rather than the quantity of soil water and their operation is largely independent of the type of soil. Basic principle of this electronic tensiometer is simple. As the soil dries out and draws water from tensiometer, a negative pressure develops inside the tensiometer, which will be converted into electric signal by a pressure transducer and electronic circuit attached to it. Since a tensiometer is designed to measure water tension over a narrow range at low tension (0-1 bar), it is very suitable for light textured soil.

The electronic tensiometer consists of the basic tensiometer with vacuum gauge and a switching circuit. Basic tensiometer consists of a ceramic cup fused to a PVC pipe and a vacuum gauge. Distilled water is filled up in the tensiometer without any air bubble. The Electronic circuit diagram of the switching circuit is shown. There are two electrodes T1 and T2 provided just above the dial of the vacuum gauge so that the needle can just touch the electrodes when reaching at the pressure point where the two electrodes are set. The needle acts as the third electrode T3. T1 is the upper tension electrode and T2 the lower tension electrode. 12 V power supply is given to energise the switching circuit. There is a slot provided on the acrylic top cover of the vacuum gauge through which T1 and T2 can be slid to fix the tension points. (photo 1)

When soil dries out and draws water from the tensiometer through the porous ceramic cup, negative pressure develops inside the tensiometer, which will be measured in the vacuum gauge. The pressure gauge needle moves up and touches the upper limit tension electrode through which 12V supply is given to the base of the emitter follower circuit. The circuit energises the 12V relay. 220V ac line is then extended through the relay contact to the solenoid valve connected on the irrigation pipeline. The valve opens and starts irrigation. Alternately the relay contact can also be connected to a 220V / 440V coil of the motor starter to switch on the water pump.

Once irrigation starts, the soil moisture tension reduces, the needle starts moving down, but the switching circuit continue to remain energized through the second contact of the relay as shown in the diagram. (fig.1).

The irrigation will be continued till the vacuum gauge needle touches the lower limit tension electrode T2. Since T2 is connected to ground, the switching circuit gets inactivated, relay de-energises and solenoid valve closes or the water pump stops. The tensiometer cup is fixed at a depth in the most active root zone of the plant. This depth and the maximum and minimum tension points vary from soil to soil and from crop to crop.

We have conducted this study in a coconut garden of sandy loam soil. The tensiometer cups were fixed at 50 cm depth and 50 cm away from the bole. T1 was fixed at 0.1 atm. and T2 at zero tension. This was connected to a drip irrigation system. The system was tested for three seasons and found working well. (Table 1, photo 2)

Field layout of irrigation with electronic tensiometer and solenoid valve

Table-1 **Irrigation details of three seasons using electronic tensiometer and auto-irrigation system**

A . Irrigation Season 1995 - 96

Month	No: of irrigation		Quantity of water / palm	
	R1	R2	R1	R2
Dec.	5	5	485	440
Jan.	10	11	930	1023
Feb.	12	12	1101	1131
March	13	13	1229	1189
April	13	12	1209	1116
May	15	14	1395	1302

B. Irrigation Season 1996 - 97

Month	No: of irrigation		Quantity of water / palm	
	R1	R2	R1	R2
Dec.	3	2	279	186
Jan.	10	11	930	1023
Feb.	11	12	1023	1116
March	12	11	1128	1012
April	15	15	1418	1464
May	15	15	1395	1209

C. Irrigation Season 1997 - 98

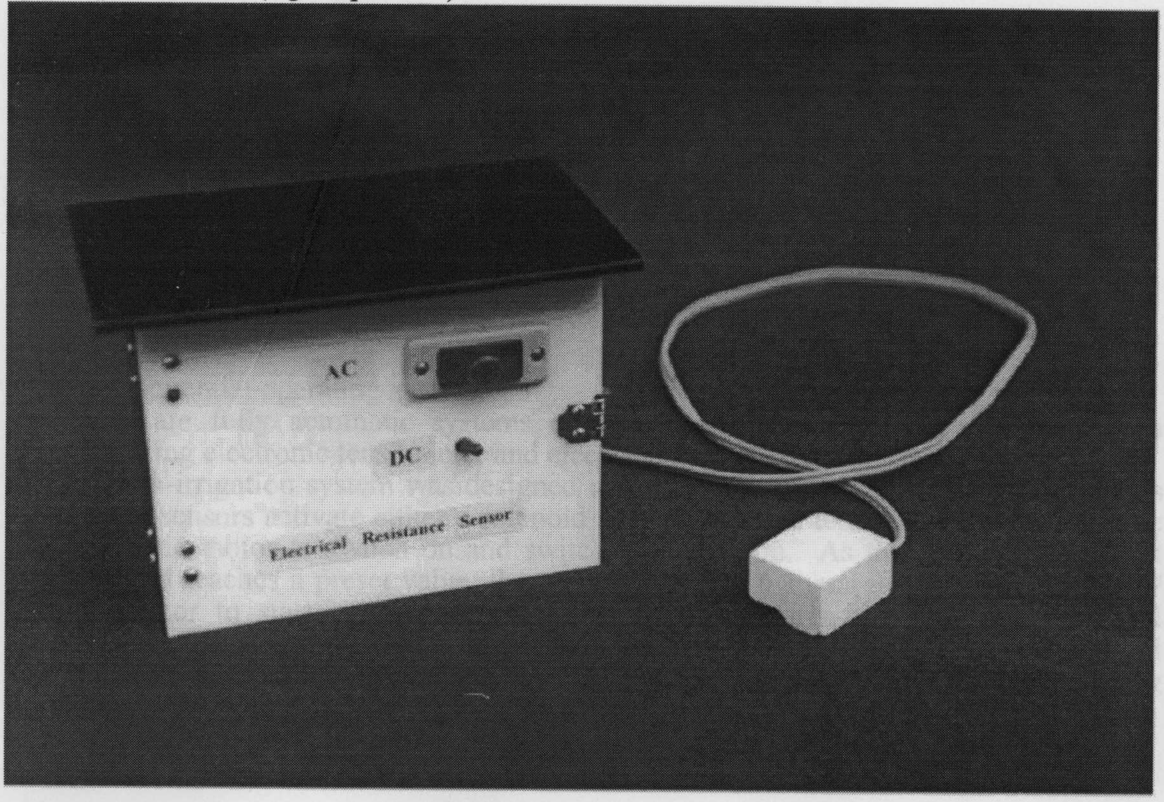
Month	No: of irrigation		Quantity of water / palm	
	R1	R2	R1	R2
Dec.	8	8	740	790
Jan.	10	11	930	1023
Feb.	12	12	1120	1116
March	12	11	1128	1012
April	14	15	1330	1464
May	15	15	1398	1430

The electronic tensiometer can be connected to any high frequency irrigation system such as sprinkler irrigation, drip irrigation, perfo-irrigation etc. As the tensiometer can hold the negative pressure up to 0.8 atm only, it is better used in sandy and loam soils.

ii) Design of an alternate sensor with gypsum block (Electrical Resistance sensor):

Since resistance blocks are designed to measure water depletion over a wider range of water tension (1-15 bars), the block would be suitable for heavy soils. Working principle of gypsum block sensor is the change of resistance of the block with moisture. This resistance which is inversely proportional to the surrounding soil moisture, is converted to electric signals to activate an audio/video output.

It consists of a pair of electrodes fused inside a gypsum block , a pre amplifier and an electronic comparator circuit. When the soil moisture is reduced below the preset level the comparator energises the relay circuit, which in turn switch on the solenoid valve or the water pump as the case may be. In the same way the system is switched off when the moisture level moves up to the pre set level. Alternately the system can be switched off after a preset time. (fig.2 , photo 3)



2. Calibration of the sensors developed:

The above sensors were calibrated for different soil types. For this, simultaneous soil moisture measurements were taken by these sensors and by gravimetric method at different soil moisture levels. Once calibrated, the instrument can be set at any moisture levels as per the user requirement.

3. Design and development of an auto irrigation system:

i) Automatic sequential systems:

A suitable sequential control system was designed to turn the pump/solenoid valve on at any point of time, allow it to run for a predetermined period of time and then to shut it off. This consists of a time switch and a switching circuit. The heart of the time switch is a quartz oscillator vibrating a particular frequency. This frequency is converted to a 1 Hz. pulse in an integrated circuit. This pulse drives a stepper motor, which in turn drives a gear train that is connected to a switching dial. According to a set time in the time switch, a control circuit operates the solenoid valve either to switch on or switch off the irrigation. This system was installed in the coconut garden in front of the Kalpaka Guest House and was tested for one season. .

Table-2 Irrigation details of One season using sequential system

A . Irrigation Season 1998 - 99

Month	No: of irrigation		Quantity of water / palm	
	R1	R2	R1	R2
Dec.	5	5	485	440
Jan.	10	11	930	1023
Feb.	12	12	1101	1131
March	13	13	1229	1189
April	13	12	1209	1116
May	15	14	1395	1302

ii) Non-sequential operating systems:

These are fully automatic systems operating independently both in time and in quantity using electronic tensiometer and electrical resistance sensor as explained above.

An auto-irrigation system was designed using the above-developed sensors. Signals from these sensors activate either a solenoid valve connected to an online irrigation pipe or an electric motor to switch on and switch off irrigation. As the soil moisture level depletes and reaches a preset value, the sensor will send a signal to the solenoid valve / electric motor to start irrigation. Once the irrigation starts, the soil moisture level gradually increases and reaches a preset value, generally field capacity, the sensor will send another signal to switch off the solenoid valve or electric motor there by stopping irrigation.

Table –3 Irrigational details with electrical resistance sensor

Month	No. of irrigations		Qty. of water (lit/palm/irr)	
	R1	R2	R!	R2
Jan.	6	5	1254	1049
Feb.	5	6	1086	1297
Mar.	7	7	1529	1508
Apr.	8	7	1757	1509
May.	9	9	1917	1888

5. Field evaluation of the system:

The auto irrigation system was installed in three different soil types, i.e., sandy soil, sandy loam soil and laterite soil and evaluated. Accuracy and consistency of the equipment was worked out. It was evaluated against the conventional irrigation system. The control system with electronic tensiometer as sensor and the sequential irrigation system were found consistent where as the control system with electrical resistance sensor was inconsistent because the gypsum block, which was used for resistance variation, was not adequately sensitive and was slow to moisture variation in the soil.

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14. Publications and material (one copy each to be supplied with this proforma)

a) Research papers -1) K.Madhavan, AC Mathew (1997) Irrigation Management using electronic tensiometer
Proceedings of the National Symposium on Irrigation Management held at Irrigation Management and Training Institute, Trichi , 1997

2) K.Madhavan, AC Mathew (1998) Design & development of an auto irrigation system- a case study in coconut plot Jnl. of Plantation Crops 26(2) 144-148 Dec.1998
3) K.Madhavan, AC Mathew (2000) 'Automation in Irrigation' Proceedings of the Zonal Seminar (IETE-2000) on Electronics Communication and Information Technology for Agriculture held at Dr.P.Deshmukh Krishi Vidyapeeth , Akola Jan.21-22, 2000

b) Popular articles - 1) AC Mathew, K.Madhavan (1997) Swayam Niyandritha Jalasechana Samvidhanam (Mal.) Proceedings of the Swadeshi Science Congress 1997
2) AC Mathew, K.Madhavan (1998) Self Controlled Irrigation System for water preservation in coconut plantations Indian Nalikera Jnl. (Mal.) 2(8) Nov.98

c) Reports : Reportd in the Institute Annual Reports 1995, 1996, 1997 & 1998 and in the Institute Research Highlights during 1995, 1996 & 1997.

d) Seminars and workshops (Relevant to the Project) in which the Scientists have participated:

Participated in the National Symposium on Irrigation Management held at Irrigation Management and Training Institute, Trichi , Feb.6-8, 1998

Participated in the technical Session on Drought and Water Management , Swadeshi Science Congress held at CPCRI on Nov. 6-8, 1997

Participated in the Zonal Seminar (IETE-2000) on Electronics Communication and Information Technology for Agriculture held at Dr.P.Deshmukh Krishi Vidyapeeth , Akola Jan.21-22, 2000

e) Material developed (such as new varieties of crops or breeds of farm animals, implements, products etc.)

i. Electronic Tensiometer
ii. Automatic irrigation system with Electronic Tensiometer
iii. Resistance type sensor with gypsum block
iv. Automatic irrigation system with timer circuit

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15. Details (Nos. etc.) of Field/Laboratory Note books and final material and their location

Available in the Laboratory.

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16. Comments / suggestions of Project Leader regarding possible future line of work that may be taken up arising of this project:

Presently vacuum gauge and electrodes are used in the tensiometer to convert negative pressure into electric signals, and the process is slow, . This can be avoided if semi conductor transducers are used, for which research is to be taken up. But the system is accurate and consistent and cost effective. The electronic tensiometer and auto irrigation system is to be popularised for which experiments are to be laid out in farmer's field. The system is reliable and the cost of tensiometer and solenoid valve will be around Rs. 5000. If tensiometer is used along with pump directly the cost will be Rs. 1500/ only.

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17. Signatures with name of Project Leader and Associates:

K Madhavan [signature]

A C Mathew [signature]

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18. Signature (with comments, if any) of Head of Division/Section/Station:

It is a good system for an effective irrigation in coconut garden

V. T. [signature]

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19. Signature (with comments, if any) of Director:

Demonstrate in a two farmers plots

V T [signature]