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DESIGN AND DEVELOPMENT OF AN AUTO-IRRIGATION SYSTEM-A CASE STUDY IN COCONUT PLOT

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ABSTRACT

An electronic tensiometer has been developed which can automatically control all types of high frequency irrigation systems such as sprinkler irrigation etc. The user can set two levels of tensions in the instrument. Upper limit, at which irrigation is to be started and lower limit at which irrigation is to be stopped. When fitted to any high frequency irrigation system, the tensiometer will monitor the prevailing soil moisture tension and when it reaches the upper limit of set tension, it will activate either a solenoid valve or an electric pump thereby starting irrigation. Once irrigation is started, the instrument will again monitor the soil moisture tension and when it reaches the set level of lower limit, it will stop irrigation. The auto irrigation system was installed along with a drip irrigation system in a coconut garden and performed well for two irrigation seasons.

Keywords: Auto-irrigation, coconut, drip irrigation, tensiometer

INTRODUCTION

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. (Hillel, 1980).

Plant water uptake to satisfy growth and evapotranspiration processes follows a diurnal cycle with the water moving from a periodically replenished root zone (source) through the plant to the atmosphere (sink). At the end of a typical irrigation cycle, soil water storage becomes depleted, the hydraulic conductivity decreases drastically and the root system cannot resupply water fast enough to meet the atmospheric evapotranspiration demand of the plant, thereby creating a plant water deficit or stress condition. (Phene, 1986).

Irrigation methods capable of operating frequently, such as center pivots, lateral move, minisprinkler, trickle and subsurface offer the means to maintain soil water at nearly constant levels and thus, minimize or impose plant water stress at the desire of the irrigator (Phene *et al.*, 1982). However with frequent irrigations, control of the soil-water-root environment is critically dependent upon the irrigator, regardless whether the manager is a human or computer (Phene, 1986). Any disruption or disturbance to the irrigation schedule will result in water or oxygen stress on the crop. Therefore, control of high frequency irrigation must be automatic, redundant and capable of responding to small and rapid changes in soil water, plant water or evapotranspiration. With this objective, an automatic irrigation system has been developed and tested in coconut plantation.

MATERIALS AND METHODS

Design of an electronic tensiometer

The first step in the development of an autoirrigation system is to design a suitable sensor to sense the soil moisture tension. Tensiometers are used for this purpose. It will sense the prevailing soil moisture tension. There is a control unit attached to the tensiometer. This consists of a pressure transducer and electronic circuits (Fig. 1). The pressure transducer (vacuum gauge) is designed in such a way that it can be set at any two, upper limit and lower limit, tensions. The tensiometer will monitor the soil moisture tension continuously and when it reaches the present value of upper limit an LED will be 'on' indicating the user to start irrigation. The LED will remain in 'on' position till the user irrigate the field upto zero tension or the preset lower tension limit.

RESULTS AND DISCUSSION

Design of an auto-irrigation system

An auto-irrigation system has been designed using the electronic tensiometer developed as sensor. As per the present tension the electronic tensiometer will send a signal to the online solenoid valve/electric pump to control irrigation. When the soil moisture tension reaches the preset value of upper limit, the solenoid valve/electric pump will be switched on by the control unit. Similarly, once the soil moisture level reaches zero tension or any preset lower limit, it will switch off the solenoid valve or electric pump.

The system has been laid in a coconut garden with two electronic tensiometers and a solenoid valve with one replication. The solenoid valve is fitted to two inch PVC pipe which in turn is connected to an overhead tank. Outlet of the solenoid valve is connected to 50 mm HDPE main pipe. Irrigation has been given to coconut palms using microjets attached to 16mm LLDP laterals. Two microjets each having a range of 1m and water spreading at an angle of 180°, have been used per palm. These microjets are attached to the laterals very close to the trunk of the palm in opposite directions, there by getting a full circle (360°) wetting area. The lateral is connected to the main pipe using start connectors. A.C power supply has been given to the control unit attached to the tensiometer. Electrical connections are given to the solenoid valve from control unit to operate it. The electronic tensiometer has got a control knob having three positions-auto, off, and manual. When the switch is in off position, no power supply is given to the control unit. The tensiometer will keep on monitoring the soil moisture tension. But there will not be any electric signal to start/stop the solenoid valve and the LED will also be off. At any point of time, either

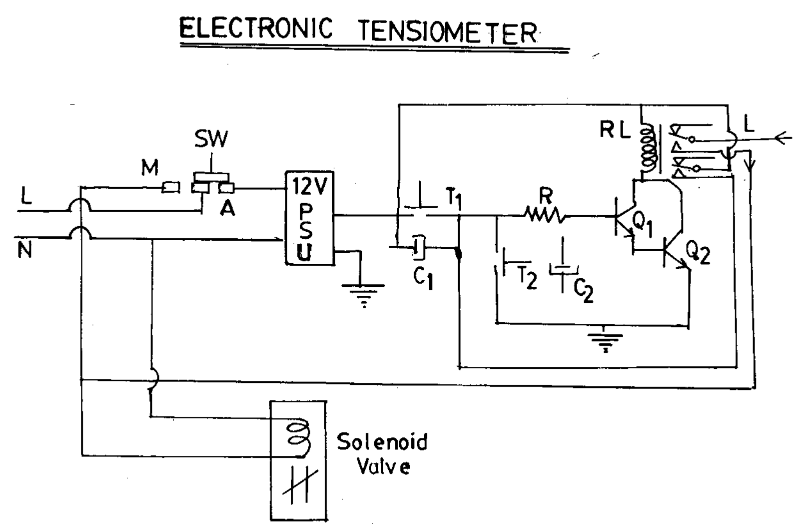
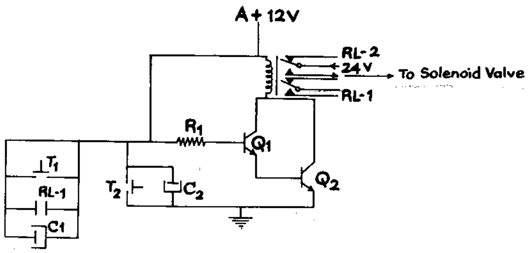


Fig. 1. Circuit diagram of electronic tensiometer



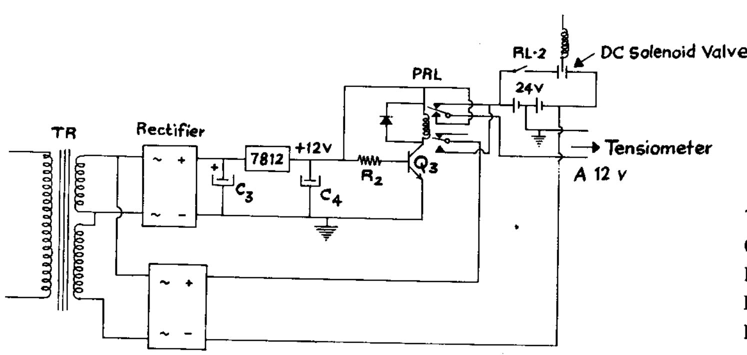
Q_1, Q_2 - Transistors
RL - Relay
R_1 - Resistance
C_1, C_2 - Capacitors

Fig. 2. Electronic Tensiometer

in auto or manual, if the user wants to stop irrigation, this position of the switch is useful. When the switch is in manual position irrespective of soil tension, irrigation will be started. Once the user starts irrigation, putting the switch in manual position, it can be shut off only by putting the switch in off position. In both these positions, the sensor is bypassed. The third position of the switch controls the irrigation system fully automatic. As the soil dries out and draws water from the tensio- meter, negative pressure develops inside the tensiometer, which will be measured by a vacuum gauge. When it reaches the preset value, the control system will activate the solenoid valve thereby starting irrigation. As the soil around the tensiometer is wetted by the irrigation, the tension inside the tensiometer decreases and becomes zero at field capacity. At that point, or any other preset value, the control unit will shut off the solenoid valve thereby stopping irrigation.

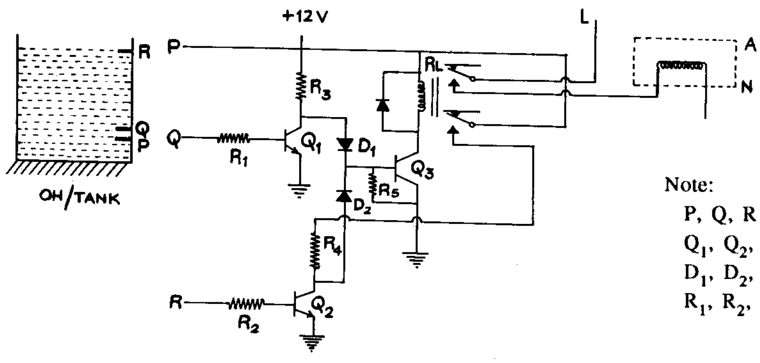
Two types of automatic irrigation systems were developed one working with 220V a.c. supply and the other with 24 Volt d.c.power supply unit. The latter type will be useful in places where there is frequent power failure or no power supply. Two 12 volts batteries connected in series were used as the power source. A battery charger provided along with keeps the battery charged whenever a.c. is available. Necessary modifications were made in the electronic tensiometer also to work with 24 V d.c. supply. The circuit diagram of d.c. electronic tensiometer and d.c. control system with battery charger is shown in Fig. 2 & 3.

A water level controller with an automatic pumping system also has been developed and integrated to the irrigation system so that over head water tank could be filled automatically when ever power supply is available. The instrument will monitor the water level in the tank and when it reaches a preset level it will switch on the electric pump to start filling. In case power supply is not available at that point of time the system will wait and start filling whenever power supply is resumed. When water level reaches the maximum capacity of the tank or the set value the controller will switch off the electic pump (Fig. 4).



7812 - IC Voltage Regulator
Q_3 - Transistor
PRL - Relay
R_2 - Resistance
RL2 - Contact of RL relay

Fig. 3. DC control system



Note:
P, Q, R - ELECTRODES
Q_1, Q_2, Q_3 - TRANSISTORS
D_1, D_2, D_3 - DIODES
R_1, R_2, R_3, R_4, R_5 - RESISTANCES
A - NO LOAD COIL OF STARTER

Fig. 4. Automatic water level control system

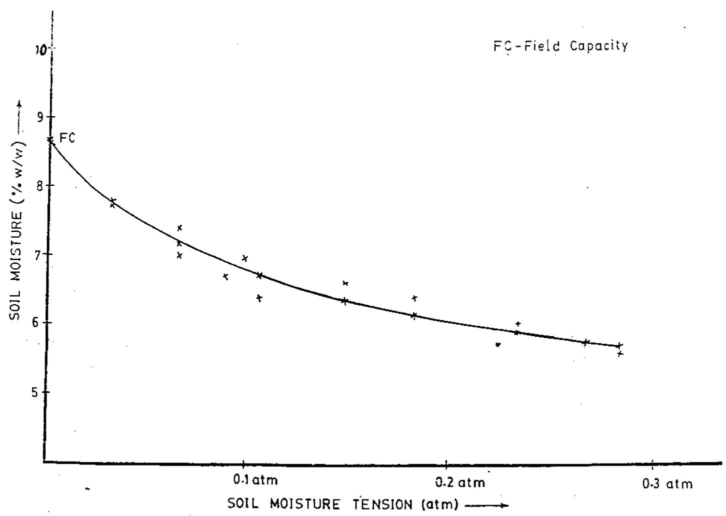


Fig. 5. Relation between soil moisture status and tension.

The system has been installed in a coconut garden with 36 trees of 10 year old dwarf varieties. The palms were planted at a distance of 7.5 m apart. Two tensiometers installed at the basin of two palms represented half the area of the experimental plot ie., 18 palms. These tensiometers were electrically connected to a solenoid valve, which in turn controls the irrigation system for these 18 palms. The tensiometers were kept at a distance of 50 cms each from the bole and the microsprinkler and at a depth of 50 cm. The same set up has been replicated for the other half of the field ie., remaining 18 palms with another set of tensiometers and solenoid valves.

The instrument has been calibrated in the field by standard air oven method (Gravimetrically) (Fig. 5). Lower limit of the tension was set at zero tension (8.6% w/w moisture content.) The upper limit of tension was kept at 0.1 atmosphere (6.85 w/w moisture content). AC system was operated for one irrigation season ie. December 1995 to May 1996. DC system was operated during the irrigation season December '96 to May '97. In both the cases, the system was installed in the field by second fortnight of December and dismantled by May end immediately after the onset of monsoon. The instrument was checked for its consistency and accuracy. Both the sytems

Table 1. *Irrigation details of two seasons*

1. AC System-Irrigation Season 1995-96

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

2. DC System - Irrigation Season 1996-97

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

performed well during this peiod (Table - 1). Quantity of water applied per irrigation was moitored by a water meter connected to the 16mm LLDP lateral at its head end. The less number of irrigations in the month of December is because the system was installed in the field by the second fortnight of the month. The frequency of irrigation increased from January to May in both the cases, obviously because of the increase in the rate of evapotranspiration. Irrigation frequency was slightly less during the month of April '96 ie., for the AC system. This was due to rains received on the 3rd and 14th of the same month. Apart from this, on an average, irrigation was done every alternate day. The system was in "on" position for approximately one and a half hours and a quantity of 93 litres of water has been applied per palm per irrigation.

The automatic irrigation system developed has been tested in the field by using it to irrigate coconut palms. The same system can be used to control irrigation for any other crops and soil type by suitably adjusting the upper limit and lower limits of set tensions.

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