International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048
Volume 6, Issue 2, pp 18-22, February-2022
https://doi.org/10.47001/IRJIET/2022.602004

Wireless Sensor Network for Farm Field Automated Drip Irrigation for Coconut

[1]Thennarasu. R, [2]Fathima Bibi. S

[1]Assistant Professor, Civil Department, Parisutham Institute of Technology and Science, Thanjavur, Tamilnadu, India
[2]Assistant Professor, Electrical and Electronics Engineering Department, Parisutham Institute of Technology and Science, Thanjavur, Tamilnadu

***Abstract* - In any good crop production, timely irrigation and demand-based water supply is very important. In this paper, we propose the conceptual design of an automated irrigation system for Palm trees, especially coconut trees. In Southern part of India, climate is more suitable for Coconut crop. In non-coastal areas where water is a scarce resource, automated drip irrigation is found to be a better solution. Various sensors like GPS (Global Position Sensors), soil moisture, temperature and climate are used to calculate site-specific, real-time irrigation requirement using Penman Monticth water demand model. In our design, palm trees are placed at every edge and middle of regular hexagonal structure which increases the coverage area of the Zigbee communication and reduces the installation cost compared to traditional square spacing.**

Keywords: Drip Irrigation, Coconut-Tree, Zigbee, Drip-Irrigation, Water-Demand-Model.

I. INTRODUCTION

In Arid and semi-Arid areas, drip irrigation is the most suitable type of irrigation. There are many advantages like no-water-to-runoff as it happens in the flood irrigation, deep percolation or surface evaporation. Water use efficiency is maximized and crop productivity increases. Application of fertilization can be integrated with drip irrigation for further cost reduction. Indian dry land agriculture improvement is very important as it helps to improve the standard of living of farmers residing in these areas as well.

The coconut palm is found throughout tropical and subtropical regions. Southern part of India's climate is more suitable for Coconut crop. This crop needs an even distribution of 1500-2500mm rainfall. In non-coastal areas, where water is a scarce resource, automated drip irrigation is found to be a better solution. In sanskrit, the coconut tree are called Kalpa Vriksham, which essentially means all parts of a coconut tree useful some way or other to the human being. [1] Traditional areas of coconut cultivation in India are the states of Kerala, Tamil Nadu, Karnataka, Goa, Andhra Pradesh, Konaseema, Orissa, West Bengal, Pondicherry, Maharashtra and the islands of Lakshadweep and Andaman and Nicobar. Four southern states account for almost 92% of the total production in the country: Kerala (45.22%), Tamil Nadu (26.56%), Karnataka (10.85%), and Andhra Pradesh (8.93%).Other states, such as Goa, Maharashtra, Orissa, West Bengal, and those in the northeast (Tripura and Assam) account for the remaining 8.44%.

[2] A tropical arid and semi-arid climate dominates southern region of India where the rate of moisture loss through evapotranspiration (ETo) exceeds that from precipitation. Below Table 1 shows the annual rainfall data [3]. It is drought-prone, as it tends to have less reliable rainfall due to sporadic lateness or failure of the southwest monsoon. In December, the coldest month, temperatures still average around 20–24 °C (68–75 °F). The months between March to May are hot and dry; mean monthly temperatures hover around 32 °C, with 320 millimetres (13 in) precipitation. Hence, without artificial irrigation, this region is not suitable for permanent agriculture.

In our paper, we propose the conceptual design of an automated drip irrigation system using various sensors like GPS, soil moisture, temperature and climate sensors to calculate site - specific, real-time irrigation requirement using Penman Monteith water demand model. This model has been selected because it closely approximates grass ETo at the location evaluated, is physically based, and explicitly incorporates both physiological and aerodynamic parameters. Moreover, procedures have been developed for estimating missing climatic parameters.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 2, pp 18-22, February-2022

https://doi.org/10.47001/IRJIET/2022.602004

Table 1: Annual Rainfall Details

	Winter	Pre-monsoon	Monsoon	Post-monsoon
North-West India	97.2 mm	110.9 mm	625.0 mm	72.7 mm
Central India	25.8 mm	30.1 mm	994.2 mm	89.6 mm
South-Peninsula	15.3 mm	103.2 mm	726.3 mm	273.7 mm
North-East India	55.5 mm	341.9 mm	1437.8 mm	171.2 mm
Country	40.9 mm	81.2 mm	887.0 mm	127.1 mm

II. IRRIGATION WATER DEMAND FOR COCONUT TREES

An advance in the sensor technology has made automation much simpler. Availability of various sensors for measuring the requirement of the irrigation of a crop has evolved with various site specific irrigation technologies. For the calculation of ETo rate on sites, we need climate and weather sensors and depending upon ETo we can adjust the drip irrigation rate automatically.

Generally, following steps are used to calculate drip irrigation water demand for any crop [4] (Richard at al., 1998).

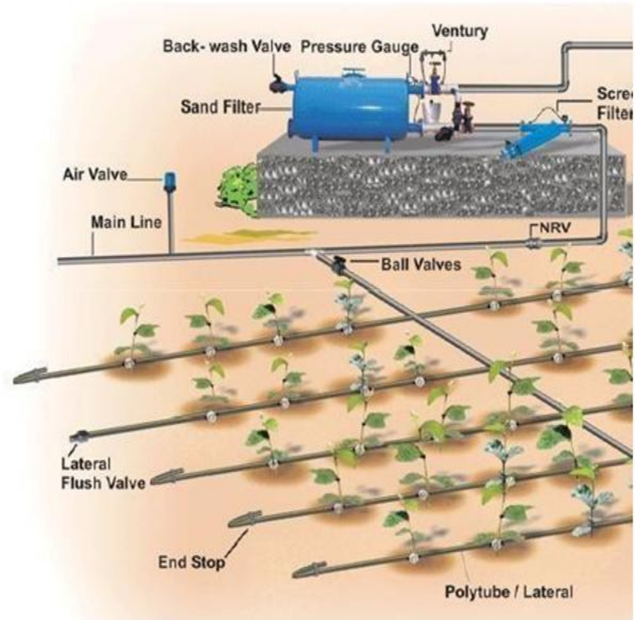
- Determine the reference crop evapotranspiration: ETo
- Determine the crop factors; K_c
- Calculate the crop water need: $ET_c = K_c$ ETo
- Determine the effective rainfall: Pe
- Calculate the irrigation water need : IN= ET crop- Pe

ETo can be calculated using various methods. One such method is discussed below. Solar radiation causes both evaporation and transpiration of soil moisture and crop moisture simultaneously. Evaporation and transpiration rate changes with growth of the crop. In initial growth of the crop, soil evaporation is more. As the crop growth is full transpiration becomes the main process especially, in coconut trees. The partitioning of ETo into evaporation and transpiration is plotted in correspondence to leaf area per unit surface of soil below it. The FAO Penman-Monteith method is recommended as the sole method for determining ETo.

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)}$$ ---------------(1)

Where,

ET_o reference evapotranspiration [mm day-1],
R_n net radiation at the crop surface [MJ m-2 day-1], soil heat flux density [MJ m-2 day-1]



T mean daily air temperature at 2 m height [°C],
u2 wind speed at 2 m height [m s-1],
e_s saturation vapour pressure [kPa],
e_a actual vapour pressure [kPa],
e_s - e_a saturation vapour pressure deficit [kPa],
D slope vapour pressure curve [kPa °C-1],
g psychrometric constant [kPa °C-1].

There is an alternative equation for ET_o when solar radiation data, relative humidity data and/or wind speed data are missing, they should be estimated using the procedures presented in equation 2. As an alternative, ET_o can be estimated using the Hargreaves ET_o equation where:

$$ETo = 0.0023(T_{mean} + 17.8)(T_{max} - T_{min})^{0.5} Ra$$ ------------(2)

Where,

R_a extraterrestrial radiation [MJ m-2 day-1],
T_{max} daily maximum air temperature,
T_{min} daily minimum air temperature,
T_{mean} daily mean air temperature.

ISSN (online): 2581-3048
Volume 6, Issue 2, pp 18-22, February-2022
https://doi.org/10.47001/IRJIET/2022.602004

M. K. V. Carr (2011) [5] has studied on Kerala where coconut tree has its roots extend to depths >2 m and laterally >3 m, the density of roots is greatest in the top 0 –1.0 m soil, and laterally within 1.0–1.5 m of the trunk. The best estimates of the actual water use (ETc) of mature palms indicate representative rates of about 3 mm d−1. Reported values for the crop coefficient (Kc) are variable but suggest that 0.7 is a reasonable estimate. Although the sensitivity of coconut to drought is well recognized, there is a limited amount of reliable data on actual yield responses to irrigation although annual yield increases (50%) of 20 –40 nuts palm−1 (4–12 kg copra, cultivar dependent) have been reported.

Irrigation increases female flower production and reduces premature nut fall. Basin irrigation, micro-sprinklers and drip irrigation are all suitable methods. M. K. V. Carr (2011) recommended methods of drought mitigation include the burial of husks in trenches adjacent to the plant, mulching and the application of common salt (chloride ions).

In M.Jayakumar at al., 1987 [6] consumptive water use of coconut was quantified by the use of volumetric lysimeters. The mean consumptive use of coconut palm (age 6 years) with a leaf area index of 2.4 during the observation period (November 1986 to May 1987) was of the order of 3.3 mm day−1 and ranged from 2.7 mm day−1 to 4.1 mm day−1. The crop coefficient values were 0.54, 0.73, 0.60 and 0.65 for the Penman, the Blaney -Criddle, the radiation and U.S. Class-A pan methods, respectively.

III. MATERIAL AND METHODS

In our conceptual design of an automated drip irrigation system we have predetermined node for a group of palm trees which gathers the climate and weather information through sensors and calculate ETo. All sensor nodes will send ETo wireless to central base station nodes which will calculate the water need and send signal to the irrigation module to irrigate the specific site. Design is as shown in Fig. 1. Similar method [7] (Mahir.D and Semih.O 2011) and [9] (Yunseop et al., 2008) describes an application of a wireless sensor network for low - cost wireless controlled irrigation solution and real time monitoring of water content of soil.

The wireless sensor module will be designed by us, that consists of climate, weather, soil moister and GPS sensors, 8-bit Microcontroller and 2.4 Ghz Zigbee for wireless transmission to a central base station. We have an Irrigation control module which consists of sinusoidal valve controller for the water tank and wireless Zigbee module for receiving commands from the central base station.

In general, square organization of planting with a spacing of 7.5m to 9 m is practiced. As a mono-crop Edward and Craig 2006 [8] suggest coconut trees can also be planted with a spacing of 9m in a triangular pattern. We are considering triangular pattern for more efficient design. By combining 6 equilateral triangles we can form a regular hexagonal where 7 trees can be planted. A low cost Zigbee series can cover Indoor/Urban range of 40m and outdoor/Line-of-sight 120m i.e., about ~60-70 trees can be covered within a multiple, honeycomb hexagonal structure, with at least 7 trees per hexagon as shown in Fig. 2. Advantage of using regular hexagon is that careful placement of Zigbee modules under line- of-sight will increase the number of trees coverage and hence reduces over all installation cost. For this design, star topology of sensors network is more suitable.

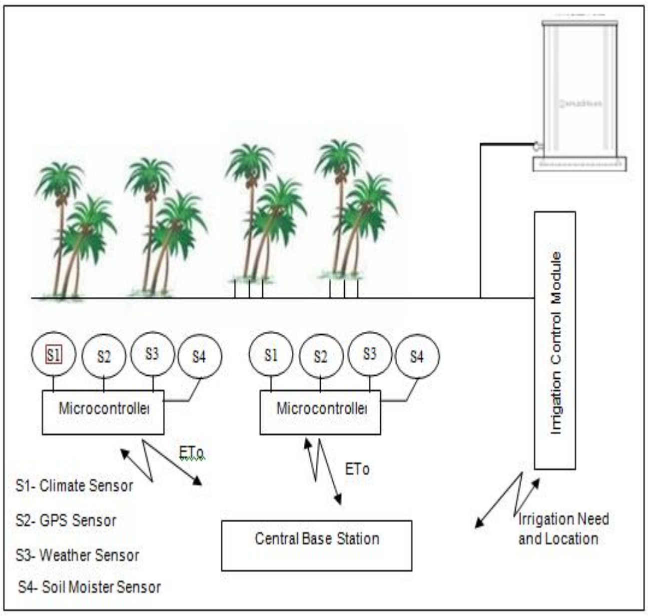


Figure 1: Conceptual Design of Automated Drip Irrigation

Coconuts have a very dense, fibrous root system that is mostly within 1.5 m of the soil surface. Clustered, deep drip irrigation below 1.5m of the soil is more appropriate which can also overcome surface evaporation. Soil sensors can also be integrated with in design, to measure soil nutrients, which is communicated to the base station for further data analysis to enable the timely and appropriate application of fertilizer

In this design, each wireless sensor node will gather the information from surroundings and calculate ETo and send it to the base station for water demand calculation. Here, GPS will help identifying the exact location, where irrigation demand is and this information is sent to the base station.

At base station, decision will be made for the need of irrigation and further communicated to irrigation control module, which controls the appropriate valve of the water tank for irrigating the cluster of coconut trees.

ISSN (online): 2581-3048
Volume 6, Issue 2, pp 18-22, February-2022
https://doi.org/10.47001/IRJIET/2022.602004

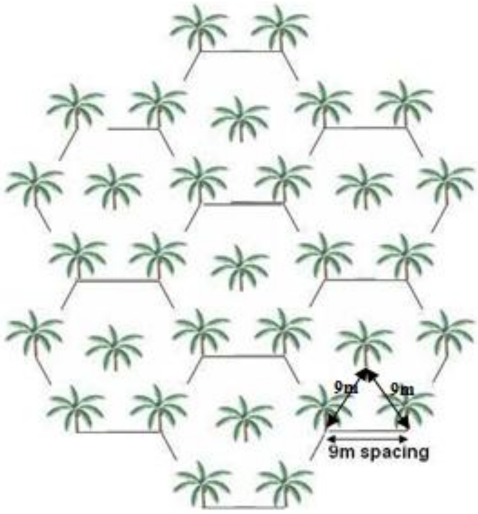


Figure 2: Honeycomb hexagonal structure

IV. RESULTS

A square spacing of 9m, which is generally practiced, can cover a total numbers of trees as NxM+Nx2 where, N is rows and M is columns in the square. In our design, we have considered regular hexagon which can cover a total no. of trees as shown by the below equation:

$$\text{Trees covered} = 7 + \sum_{i=0}^{i=N} (24 + 6x\ (N\text{-}i)\ x3)$$

Where, N is number of layers required for the coverage.

We have taken different range of Zigbee coverage and done analysis of total trees covered by square spacing and hexagonal spacing of 9m. Table 2 shows the difference in both spacing where as Fig. 3 shows the graphical analysis of these.

Table 2: Zigbee coverage under square and hexagonal spacing of 9m

Sr. No.	Zigbee Range in m	Total Coverage Area of Zigbee in m^2	Total No. of squares under Zigbee coverage	No. of trees covered under square spacing	Total No. of hexagons under Zigbee coverage	Total No. of trees covered under hexagon spacing
1	40	5027	55	71	23	87
2	90	25447	280	315	120	417
3	100	31416	388	429	149	529
4	120	45239	559	607	215	750

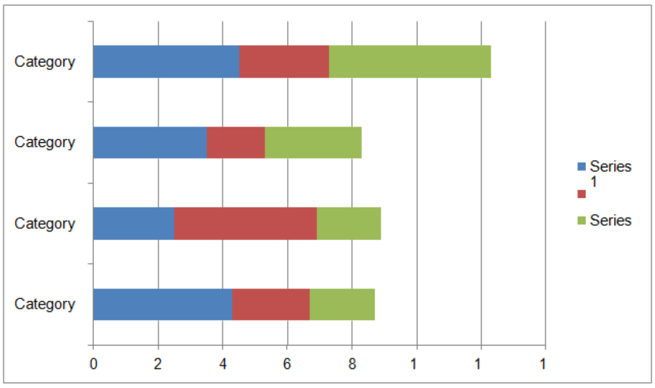


Figure 3: Analysis of Square and Hexagonal Spacing of trees

V. CONCLUSIONS

The present project work was aimed at finding suitable methods of irrigation using drip and surface and how it differs between both. Water and nutrients are delivered directly to the plant roots. Less water is required when irrigating with drip systems than with spray systems or other surface irrigation methods. Human contact and associated health risks are minimized. Earlier crop harvest is possible. Fewer odors, ponding, and runoff problems occur. Absorption of nitrogen by plants is increased and pollution of ground water is reduced because nitrogen is applied directly to the root zone. Pretreatment requirements are lower. Operation and maintenance requirements are reduced to reduce the overall cost of this automation, we have a honeycomb model which covers more clusters of trees per wireless sensor node and also covers maximum Zigbee range compared to square spacing of trees. Using climate, weather and soil moisture sensor information, the irrigation need is calculated and corresponding valve will be controlled for dripping. Only one time infrastructure is needed, as the lifetime of coconut trees varies from 40 to 80 years. Equipped with solar batteries, design is more cost effective and permanent with respect to sensor node lifetime. Noise sensor can also be integrated to detect the pest feed in palm trunk for appropriate measurement.

REFERENCES

[1] Department of Agriculture Karshika Keralam. Government of Kerala. India. (n.d.). "Coconut Cultivation". Retrieved 2009-12-06.

[2] Caviedes, C. N. (2001), El Niño in History: Storming Through the Ages (1st ed.), University Press of Florida (published 18 September 2001), ISBN 978-0813020990

[3] Indian Meteorological Department (Ministry of Earth Science, Government of India).

ISSN (online): 2581-3048
Volume 6, Issue 2, pp 18-22, February-2022
https://doi.org/10.47001/IRJIET/2022.602004

[4] Richard G.Allen, Luis S. Pereira, Dirk Raes, Martin Smith, Crop evapotranspiration - Guidelines for computing crop water requirements, FAO - Food and Agriculture Organization of the United Nations Rome, 1998

[5] M. K. V. Carr, The Water Relations and Irrigation Requirements of Coconut (Cocos Nucifera): A Review, Experimental Agriculture Journal, January 2011, 47 : pp 27-51

[6] M. Jayakumar, S.A. Saseendran, M. Hemaprabha, "Crop coefficient for coconut (Cocos nucifera L.): A lysimetric study", Centre for Water Resources Development and Management, Kunnamangalam P O, Calicut, Kerala India.

[7] Mahir Dursun and Semih Ozden; "A wireless application of drip irrigation automation supported by soil moisture sensors" in Academic Journals, 4 April, 2011; Scientific Research and Essays Vol. 6(7), pp. 1573-1582; ISSN 1992-2248 ©2011.

[8] Edward Chan and Craig R. Elevitch, Cocos nucifera (coconut), Species Profiles for Pacific Island Agroforestry, April 2006, ver. 2.1.

Citation of this Article:

Thennarasu. R, Fathima Bibi. S, "Wireless Sensor Network for Farm Field Automated Drip Irrigation for Coconut" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 2, pp 18-22, February 2022. Article DOI https://doi.org/10.47001/IRJIET/2022.602004

****