DESIGN OF AN APPROPRIATE IRRIGATION SYSTEMS FOR NON IRRIGATED AREAS OF KCAET FARM

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PROJECT REPORT

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Department of Irrigation and Drainage Engineering
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGYTAVANUR-679 573, MALAPPURAM
2013

DECLARATION

We hereby declare that this project report entitled "Design of an appropriate irrigation systems for non irrigated areas of KCAET farm" is a bonafide record of project work done by us during the course of project and the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowships or other similar title of any other university or society.

Jitha, K.J (2009-02-016)

Sumayya, A (2009-02-037)

Thulasi Mohan, P.U (2009-02-041)

Place: Tavanur

Date:

CERTIFICATE

Certified that this project report entitled "DESIGN OF AN APPROPRIATE IRRIGATION SYSTEMS FOR NON IRRIGATED AREAS OF KCAET FARM" is a record of project work done by Jitha, K.J., Sumayya, A., and Thulasi Mohan, P.U. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship/fellowship to them.

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Jitha, K. J

Sumayya, A

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Dedicated
to
Our loving parents
and
Profession of Agricultural Engineering

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SYMBOLS AND ABBREVIATION

ρ	Bulk density
ρ_d	Dry density
%	Percentage
µ	Micron
ω	Water content
cm	Centimeter
CPE	Cumulative pan evaporation
CV	Coefficient of variation
CWRDM	Central Water Resource Development and management
dS	Deciseimen
E_p	Pancoefficient
ETc	Crop evapotranspiration
ET	Evapotranspiration
FPME	Farm Power Machinery and Energy
gm	gram
g/cc	gram per cubic centimeter
g/cm^3	gram per cubic centimeter
gph	gallons per hour
GI	Galvanized iron
ha	hectare
hp	horse power
H_e	effective depth
IDE	Irrigation and Drainage Engineering

IAR	Instantaneous application rate
IW	Irrigation water requirement
IWUE	Irrigation water use efficiency
K_c	Crop coefficient
KPa	Kilo pascal
KTL	Kibena Tea Limited
LDPE	Low Density Poly Ethylene
lit	Litre
Lph	Litre per hour
lit/sec	Litre per second
lit/day/plant	Litre per day per plant
lit/hr/plant	Litre per hour per plant
m	Metre
mg	Milligram
mm	millimeter
m^2	square meter
m^3	cubic meter
mm	millimeter
mm/day	millimeter per day
ms^{-1}	meter per second
m^3/day/ plant	cubic meter per day per plant
M ha m	million hectare meter
MPa	Mega Pascal
N	Percentage finer
No	Number
PVC	Poly Vinyl Chloride

RF	Rainfall
Rs	Rupees
t ha^{-1}	Tonnes per hectare
WUE	Water Use Efficiency

CHAPTER 1

INTRODUCTION

Water is the basis of all forms of life. It supports life system not only to the plants but also to all other animals. Majority of the water requirement of the crop is met from different forms of precipitation. However, when the water requirement is not fully met from precipitation, then growth of the crop is affected. This results in reduction of yield of the crops. The reduction in yield depends on the amount of scarcity of water requirement of the crops.

Our water resources are limited and are often unevenly distributed. The demands placed on, the Nation's water resources by competing uses are increasing and the trend is expected to continue. Water withdrawal occurs when water is removed, from the ground or diverted from a surface source for use. Some of the water withdrawn is returned to the stream. Water consumption implies that the water is not available for reuse. Water demands for traditional uses (for example, agricultural, energy, domestic and industrial) are expected to increase as population grows, even though withdrawals declined slightly. Competition may also originate from two relatively new sources of water demand. First, growing awareness of environmental and recreational consequences of water diversions has increased the value of water remaining in rivers and streams. A second source of water competition is currently arising from outstanding Indian claims to reserved water rights. In many cases, increasing demands from traditional sources and new sources of demand conflict with existing appropriations among agriculture, urban, industrial or hydroelectric uses.

In world, 40% of area cultivated is under irrigation, gives food for 60% of population. Due to tremendous increase in population the per capita water availability came down from 5300 m^3 in 1960 to 2200 m^3 in early nineties against the world average of 7400 m^3 and asian average of 3240 m^3. The per capita water availability will be reduced to 1500 m^3 by the year of 2025 (Mahendran, 2004). Hence water is going to be the scarcest commodity; the demand for water in various fields is increasing drastically (Table 1.1) (Reddy, 2002).

Table 1.1 Past, present and future demand of water in India for various purposes (M ha m)

No	Purpose	Demand in years		
		1990	2000	2025
1	Irrigation	46	63	77
2	Drinking and livestock	2.5	3.3	5.2
3	Industrial use	1.5	3.0	12.0
4	Energy	1.9	2.7	7.1
5	Others	3.3	3.0	3.7
	Total	55.2	75.0	105.0

Groundwater constitutes the second major source of water supply, comprising 30% of total freshwater use from all sources. But the availability of ground water is also shrinking in many areas as water tables and well yields fall. The declining ground water tables, higher energy costs and increasing ground water contamination have diminished the availability and increased the cost of ground water. Efficient allocation and conservation can alleviate water scarcity. In the absence of supply expansion, efforts to resolve increasing competition for water resources must stress conservation and efficient allocation among competing uses. Agriculture is a likely target of efforts to more efficiently allocate water, since it is the largest consumer. With water supply development unlikely, higher water prices and less water for irrigated agriculture are inevitable. Although the mechanisms for more efficient water allocation are still evolving, water conservation through more efficient water use is the leading candidate for alleviating water scarcity. More efficient irrigation technology and new water management practices have the potential to conserve water with little or no loss in agricultural production.

Water conserving irrigation technology and water management practices are playing an important role in reducing both energy costs and water use. Not all of the water applied to the field is available for use by the plant, since some fraction is lost to evaporation, deep percolation or runoff. Irrigation technology and management practices by substituting more capital, labour and management skills reduce water loss through increased application efficiency with little or no loss in yields. However, the efficiency of an application system depends not only on the attributes of the irrigation system but also on the physical characteristics of the farm such as soil texture, topography and weather.

Water distribution systems available to early irrigators were limited to gravity flow systems such as simple stream diversions, flooding, ditch and siphon systems. Gravity flow systems use the force of gravity to distribute water across the surface of the field. Water is supplied to the upper end of a field by a ditch or pipe and then applied to the field through a siphon tube or gate. Since water percolates down below the root zone as it flows across the field, excess water must be applied to the upper end of the field to ensure that sufficient water reaches the lower end of the field. The gravity flow system is associated with a number of issues undermining productivity and environmental sustainability. Such as water logging, deep drainage and salinization. Primarily in response to increased costs of water and a greater interest in water conservation, irrigators recently have begun adopting advanced irrigation systems. Greater irrigation efficiencies associated with improved irrigation technology and advanced water management practices allow farmers to meet the water needs of the plant while applying less water.

Introduction of advanced irrigation system has acted as a prime mover to the agricultural development program by way of increasing and stabilizing the crop production. It has increased the cropping intensity and hence the total crop production and productivity of agricultural land. Drip irrigation is one of the latest innovations for applying water and it represents a definite advancement in irrigation technology. It was developed as sub irrigation about a century back. A significant step in the evolution of drip irrigation, occurred in Israel, in last 1950's, following the development of long path emitters. From 1960 onwards drip irrigation developed as an important new mode of irrigation. In India, the research work on drip irrigation system is done at few institutions and universities and has remained only at a laboratory or experimental stage. It is an efficient irrigation method, which is becoming increasingly popular in areas of water scarcity and poor quality irrigation water. There is considerable saving of labour in micro irrigation, presented in Table 1.2.

Table 1.2 Labour saving under micro irrigation (Jayakumar, 2002)

Crops	**No. of labours / acre / year**		
	Conventional irrigation	**Micro irrigation**	**Labour saving (%)**
Coconut	80	30	62.5
Arecanut	120	30	75.0
Rubber	120	30	75.0
Banana	160	60	62.5
Vegetables	100	30	70.0

In this system water is supplied directly to the root zone of the plant so as to maintain the soil moisture near the field capacity of soil for most of the time. Water is applied frequently to the soil through drippers attached to water delivery lateral line placed near the plant row. Very high water application efficiency (90-95%) can be obtained through drip irrigation method. In drip irrigation, water is applied at a slower rate to keep the moisture content most favorable to plant growth. Excess of water applied reduces plant growth as it displaces the air at the root zone, required for plant growth. Small but frequent application of water enables the plant to grow well without any ill effect of the water stress periods between consecutive irrigations.

Drip irrigation system can be used for all wide-spaced crops, as in orchards, plantation, row crops and others. Water is applied continuously over a long period through a network of small diameter plastic pipes and water delivering devices like drippers. Water conservation is the most obvious advantage of this system. Losses are almost fully eliminated. This system of irrigation ensures uniform application of water throughout the field which results in uniform plant growth and yield. Soil erosion is almost eliminated in steep hilly areas by the use of this method of irrigation. However, high initial cost of the system resulted in the reduced acceptance of drip irrigation in India.

Kerala, which lies in the humid subtropics, gets a rain of an average of 300 cm per year out of which almost 70% is received from the Southwest monsoon. Throughout Kerala, especially in northern regions, it is relatively dry during the periods from December to May. The amount and distribution of rainfall in many parts are not adequate to meet the total water requirement of crops. Kerala being dominated by plantation crops in two-third of the cropped area and due to uneven topography, drip irrigation is expected to have high demand. According to the latest data available 86.55 per cent of total cropped area is covered by plantation and horticultural crops. The contribution is being 50.9% by plantation crops, 12.16% by spices, 13.55% by fruits and10.14% by vegetables. Presently, the productivity of most of the plantation and horticulture crops in the state is far below the potential. Among other things, moisture stress during summer months is believed to be one of the reasons for this low productivity. The declining trend in the productivity of these crops which support vast majority of small and marginal farmers in the state is a matter of serious concern and could be addressed to a certain extent through adoption of better water management practices like micro irrigation. The average size of land holding in the state is 0.33 ha and the man to land ratio is declining fast. The per capita net zone area is 0.09 ha and gross cropped area is 0.11 ha. It is also reported that 85% of the coconut, 79% of arecanut, 76% of pepper, 60% of cashew, 55% of rubber, 45% of coffee and 86% of banana are grown in holdings less than 2 ha. The nature of farming therefore is homestead with a mixture of crops in each tiny holding except for crops like rubber, cardamom and tea. The irrigation system suitable for these crops in homestead condition is minor irrigation which emphasis on drip or micro sprinkler irrigation(CWRDM report, 2005).

More over the soils of Kerala State being good in infiltration with low water holding capacities, surface methods of irrigation are inefficient causing frequent irrigation and excess wetting of soils by wasting water. The adoption of sprinkler and drip irrigation in such conditions improve the irrigation efficiency considerably over the surface methods. The state water bodies, especially wells in the coastal regions have high salt content. Hence adoption of drip irrigation opens the chances of using the saline water for irrigating crops like coconut. In most of the homestead farms in Kerala, irrigation is well water based and the quality of water is excellent. This helps in reducing the problem of clogging. Hence there is ample scope for adoption of this advanced technique of irrigation in Kerala.

The total area of KCAET campus is 40.99 ha out of which total cropped area is 30.66 ha. Agro climatically the area falls within the border line of northern zone and central zone of Kerala. Major part of the rainfall in this region is obtained from southwest monsoon. The total water requirement of KCAET campus is 76100 m^3.

The water is required for various purposes such as drinking, cooking, washing, bathing and for irrigation purposes. Mainly these requirements are met by the water supply from wells present in the campus. There are 12 open wells, 6 filter point wells, 4 tube wells and 6 ponds. Here majority of water requirement for cropped field are met by surface method of irrigation like check basin, furrow and border strip irrigation. Also there are cropped areas in the farm requiring irrigation but are left unattended too, which if irrigated properly can give better yield. In the surface method of irrigation lot of water is wasted by evaporation. As in the current scenario water availability would be a serious problem because of higher demand of water for agriculture, industry etc. By keeping this condition in mind, it is urgent for finding a better and efficient method of irrigation system which can make the most judicious use of water. And it is essential to provide a relevant irrigation system to the area having no irrigation practice. Hence a study was made in this regard to find an appropriate irrigation system for KCAET farm with the following objectives

- To study the existing cropping pattern of KCAET farm and find out the constraints in the reduction of yield.
- To locate the available water resources in the farm and to analyze the water supply pattern.
- To formulate an appropriate irrigation systems for non irrigated area of KCAET farm.

CHAPTER II

REVIEW OF LITERATURE

Micro irrigation-led agriculture, armed with knowledge and technologies with farmer as centre point should be viewed as one of the eco-technological approaches to attain sustained and enhanced agricultural production and productivity. The technology is bound to maximize the synergistic interactions of improved seeds, water and fertilizer. Micro irrigation ensures the congruence of sustainability, productivity, profitability and equity. Since micro irrigation greatly enhances water, fertilizer and energy use efficiency and promotes precision agriculture, the sustainability in agriculture could be achieved without the burden of environmental degradation.

In this chapter, available literature relevant to the present study are reviewed and presented under the following subheads

2.1 Salt water utilization

Goldberge*et al*., (1976) defined drip irrigation as a new agro –technical approach for growing crops under highly controlled conditions of soil moisture, fertigation, pest control and salinity. It has significant response on crop yield and timing of harvest. A number of farmers have taken up this system for coconut gardens, orchards and vegetable crops. Cost of the system depends on spacing of crops, type of materials selected and source of water.

Guptha and Tyagi, (1984) studied effect of trickle irrigation and surface irrigation on the water use and salt accumulation. Compared with surface irrigation system, trickle irrigation results in 35% higher water use efficiency and 32% lower salt concentration.

Moollman *et al.*, (1988) studied the effects of special variability on estimation of soluble salt content in a drip irrigated saline loam soil. The salt content was found to increase exponentially with distance from the emitter

Shuqin *et.al*.,(2003) conducted a 3-year field experiment to investigate the effect of saline water on tomato yield and water use under mulched drip irrigation in North China Plain. Five treatments of irrigation water with average salinity levels of 1.1, 2.2, 2.9, 3.5 and 4.2 dS/m in 2003 and 2004, and 1.1, 2.2, 3.5, 4.2 and 4.9 dS/m in 2005 were designed. Throughout tomato growing season, the soil matric potentials at 0.2 m depth immediately under drip emitters of all treatments were kept higher than −20 kPa and saline water was applied about 30 days after transplant. Results showed that irrigation water salinity ranging 1.1–4.9 dS/m had few effects on tomato yield, but had some effects on tomato seasonal accumulative water use, water use efficiency (WUE) and irrigation water use efficiency (IWUE). With the increase of irrigation water salinity, tomato seasonal accumulative water use decreased, WUE and IWUE increased. After 3year irrigating with saline water, soil salinity in the 0–90 cm soil depths did not increase. So in North China Plain, or similar semi-humid area, when there were not enough fresh water for irrigation, saline water with salinity from 2.2 to 4.9 dS/m can be applied to irrigate field culture tomatoes after appropriate management strategies were adopted.

Shuhui *et al.,* (2011) conducted a field experiments to investigate water and salt management and its effects on Leymuschinensis growth under drip irrigation on saline-sodic soils of the Songnen Plain, China. The results provide theoretical and technological guidance for sustainable reclamation salt-affected soil and the quick restoration and reconstruction of saline-sodic grassland.

2.2 Increase of yield

Abrol and Dikshit, (1971) compared drip method with conventional basin method of irrigation in India for onions and okra. They found significant increase in yield and water use efficiency in the drip method.

Khader, (1982) obtaind significant yield increase in arecanut by adopting the drip irrigation method. The drip irrigated palms showed higher percentage of fruit set and good vigour and saving of more than 50percent of irrigation water compared to conventional method.

Russo, (1983) observed that for a given amount of irrigation water, yield of chilli obtained under daily irrigation was greater than the yield obtained under irrigation once in three days. Pampatiwar et al. (1986) showed that drip method saved water by 29 per cent along with an increase in yield of brinjal by 16 per cent. Seasonal net irrigation requirement was estimated to be 34.1 cm for winter and 35.2 cm for summer pepper.

Julius *et al.*, (2008) studied the effects of drip irrigation on the yield and crop water productivity responses of four tea clones in a large (9 ha) field experiment comprising of six drip irrigation treatments and four clones and planted at a spacing of 1.20 m × 0.60 m at Kibena Tea Limited (KTL), Njombe in the Southern Tanzania in a situation of limited water availability. Results showed that drip irrigation of tea not only increased yields but also gave water saving benefits of up to 50% from application of 50% less water to remove the cumulative soil water deficit (treatment I2), and with labour saving of 85% for irrigation.

Oner and Demet (2008) were conducted a study to determine the effect of drip line spacing, irrigation regimes and planting geometries of tomato on yield, irrigation water use efficiency (IWUE) and net return. The experiments were carried out in the conditions of Eskisehir in Central Anatolian part of Turkey, between 2003 and 2005, with cv. Dual Large F1 tomatoes (Lycopercionesculentum L). The maximum yield of 121.1 t ha−1 was obtained from the treatment in which both the lateral and row spacing were 1 m, and irrigated with water amount based on the percentage of canopy cover. The seasonal irrigation water amount of the treatment was 551 mm. Tomatoes yield of 109.9 t ha−1 was obtained under conditions of 491 mm seasonal irrigation water applied for the 2-m lateral spacing in which two plant rows (twin rows) were planted 0.35 m on either side of the lateral with a row spacing of 0.70 m across the drip lateral and 1.30 m in the inter row between each set of twin rows.

Takele *et al*.,(2009) conducted a field experiment to investigate the effects of different levels of drip irrigation and planting methods on yield and yield components (number of fruits per plant, number of primary and secondary branches per plant, and plant height) of green pepper (Capsicum annuum, L.) in Bako, Ethiopia. Three irrigation levels (50, 75 and 100% of ET_c) and two planting methods (normal and paired-row planting) were applied. The results revealed that full irrigation water supply under paired-row planting method could be used for the production of green pepper in an area with no water shortage.

2.3 Hydraulics of drip

Wu and Irudayaraj (1989) conducted sample size determination for evaluating drip irrigation systems. An equation was developed based on energy gradient and energy changes due to slope conditions. The result showed that the variation of calculated coefficient of variation of emitter flow using different sample sizes can be presented by statistical confidence limits for samples taken from normal distribution.

Bagerello *et al.* (1997) carried out an experimental investigation to deduce an evaluating procedure of local losses due to protrusion of emitter barb in to the flow in drip irrigation lines. Local losses corresponding to different pipe online emitter systems were measured for different Reynolds number values.

Atre *et al.* (1998) conducted experiments on hydraulics of drip tubing. The study includes pressure discharge relationships and values of friction factors for the design of drip irrigation system. The discharge studies at different operating heads in 20, 40 and 60 m drip tubing showed that pressure increases with increase in discharge. But the discharge decreased with increase in length of drip tubing as number of outlets increase with increase in length. The pressure discharge relationship was explained by power function. The discharge exponent ranged in between 0.46 to 0.64, indicating the emitters of drip tubing are partially pressure compensating. The various friction factors were evaluated. Hazen Williams's 'C' and Darcy-Weisbach friction factor, 'f' were found to be 112.8 and 0.593 respectively and Fanning's (F_f) and Blassius (F_b) friction factors were 0.0374 and 0.0367 respectively. The uniformity values were computed by Christiansen, Wilcox and Keller-Karmelli formulas. The values of emission uniformity computed by Keller- Karmelli were logical and ranged from 96 to 98%.

Srivastava and Upadhayaya (1998) studied the guidelines for deciding the economic threshold value of fixed cost of drip irrigation system for sugarcane crop. Nomographs have been developed to find the threshold value of economic fixed cost of drip irrigation system (exclusive of pumping unit) for a combination of variables, depth of water table, yield level under check basin irrigation, expected yield gain with adoption of drip system, irrigation requirement with check basin, and electricity charges. The perusal of nomographs shows that the factors influencing the economics of drip irrigation in order of importance are yield gain ratio, electricity charges, irrigation requirement and depth of ground water.

Jaiswal *et al*. (2001) conducted a study to determine the optimal length of lateral line for various discharge and emitter spacing .The results revealed that for a discharge of 4 lph emitter at 0.6, 1.2, 1.8 and 2.4 m emitter spacing, optimum lengths of lateral were 28.76, 59.7, 78.8 and 107.1 m respectively. At 10 % flow variation observed pressure variation for 0.6, 1.2, 1.8 and 2.4 m emitter spacing were 19.7, 22.89, 22.45 and 24.66 % respectively. For 8 lph emitter at 0.6, 1.2, 1.8 and 2.4 m emitter spacing optimum length of lateral were 20.2, 33.6, 49.8 and 63.8 m respectively. At 10% discharge variation pressure variation at 0.6, 1.2, 1.8 and 2.4 m emitter spacing were 22.6, 18.2, 14 and 17.3% respectively. It showed that flow and pressure variation along the lateral is directly proportional to number of emitter openings and emitter discharge rate.

Kirnak *et al*. (2004) conducted a study to determine the hydraulic performance of trickle irrigation emitters used in irrigation systems in the Harran Plain. In this study the discharge rates and coefficients of Manufacturing Variation values were compared with test results for various types of inline emitters. A total of 9 drip irrigation lines comprising 7 non-compensating and 2 compensating emitters were tested at 50, 100, 150 and 250 KPa pressures. Compensating emitter exponents ranged from 0.02 to 0.05 while non-compensating emitter values varied between 0.6 and 0.85.Test results showed that only 1 of the 7 compensating emitters and both compensating emitters had flow rates within $\pm 10\%$ of manufacture’s reported values.

Howell and Hiller (2005) reported that the flow conditions in the sub main and laterals of a drip irrigation system can be considered as steady and spatially varied with lateral outflows. The flow from the sub mains into the laterals or the outflow of each emitter from a lateral is controlled by the pressure distribution in the sub main and lateral lines. The variation of discharge from emitters along a lateral line is a function of the total length and inlet pressure, emitter spacing and total flow rate.

Kishor *et al*. (2005) tested the hydraulic performance of market available drippers. He used an automatic dripper testing set up for the study. The drippers were tested for pressure and discharge relation, pressure and coefficient of manufacturing variation, barb losses and uniformity coefficient. The pressure and discharge relations were developed for all drippers by fitting power equation to the data. The drippers had the CV less than 5% indicating the good performance, 5 to 10% indicating the average performance while CV more than 10% indicated the unacceptable range of performance. The uniformity coefficient of dripper was found to be more than 95 % at all operating pressure from 50 to 300 KPa.

Ibrahim *et al*., (2009) conducted a field measurement of soil hydraulic properties under two drip irrigation treatments, full (FT) and limited (LT). The objective was to identify the temporal variability of the hydraulic properties of field soil under high-frequency water application during a maize cropping season. Soil hydraulics was characterized using the Beerkan infiltration method. The results demonstrated that both soil porosity and hydraulic properties changed over time.

2.4 Field performance of drip

Phene *et al.* (1985) reported that the yield, quality and evapo transpiration of tomatoes are not affected by the depth of placement (surface Vs deep surface) of trickle laterals when irrigated volumes and frequencies were the same. The reported marketable yield of hand harvested tomatoes as 114,121 and 126 t/ha for low frequency surface drip, high frequency subsurface and high frequency surface drip respectively.

Gutal *et al.* (2005) in his study on scheduling of irrigation for strawberry through drip found that the amount of water to be applied at alternate day to strawberry crop through drip method of irrigation with 85% of 2 days pan evaporation gave higher water use efficiency and significant higher fruit yield over other treatment.

Low pressure drip irrigation is being promoted in Sub Saharan Africa as an alternative to traditional methods of small scale irrigation of vegetables. The experiment was performed on-station in Niger on three adjacent 500 m^2 plots in a sandy acid soil. It was found that improved crop management practices greatly enhance crop productivity over traditional methods at comparable production costs. This experiment showed the strong positive impact of drip irrigation and improved crop management practices on profits at minimal environmental costs, indicating that transformation of existing practices poses a considerable potential towards sustainable agricultural development (Lennart *et al*., 2011).

2.5 Water requirement of crops

Sivanappan *et al*. (1987) reported a drip system applying 32 cm of water giving a yield of 11,600 kg/ha of brinjal in addition to 10.0 cm rainfall. For the same experiment control plot required 90 cm of water besides 10.0 cm rainfall to give an yield of 10,690 kg/ha.

Locascio and Smajstria (1996) studied the effect of amount of water application and mulches for 3 years on irrigated tomatoes by applying water at 0.00, 0.25, 0.5, 0.75 and 1.00 times pan evaporation in one application per day. They found that fruit yield gets doubled with drip irrigation. The total yield was found highest with quantities of 0.75, 0.5 and 1.00 times pan evaporation and significantly lower with 0.25 and 0.5 times pan evaporation values.

2.6 Comparison of drip and basin irrigation methods

GilshaBhai (1997) conducted a study at KCAET, Tavanur to find out the effect of drip Irrigation along with two colours of plastic mulching on the growth and yield of Brinjal. Two types of irrigation methods: drip and surface, and two colors of plastic mulches, black and transparent, were used in the experiment. The yield obtained was maximum in the black mulched drip irrigated plants (13.9 t/ha) the yield from unmatched surface irrigated plot was 7.90 t/ha. Drip irrigation along with mulching in summer Vegetable can reduce the cost of cultivation through efficient water management.

C. Sunil Kumar and U. Jai Kumaram (2002) conducted a study at Agricultural Research Station, Mannuthy, Thrissur, to find the yield and yield attributes of bhindi as influenced by mulching and methods of irrigation. The ten treatments comprised of combinations of three irrigation systems (drip irrigation with and without mulch and furrow irrigation with mulch) and three irrigation levels (irrigation at soil moisture tensions of 0.04, 0.06, 0.08 MPa) plus furrow irrigation at 0.06 MPa without mulch as one control. The depth of irrigation was 30 mm. Black LDPE sheets of 200 gauges were used as mulch material. The crop received 254.6 mm rainfall during its growth in the field. There was no significant effect due to varying levels of irrigation once the crop was mulched. On an average, mulched and drip irrigated crop produced 22.70 tonnes fruits ha, whereas mulched and furrow irrigated crop, produced fruits 20.95 t/ha and the control crop produced12.86 t/ha.

2.7 Water saving

Cole (1971) reported that drip irrigation resulted in considerable increase in water use efficiency over furrow and sprinkler irrigation.

Sivanappan *et al.* (1972) reported that drip irrigation is suitable for fruits and vegetables and a saving of 80% in water use has been claimed under this system.

Bruce *et al*. (1976) conducted studies on economic comparison of trickle and sprinkler irrigation for six fruit crops. The trickle irrigation was shown to be economical and advantageous in 6 out of 8 cases. The trickle system used 54% less water and 74% less energy per year in supplying the same amount of water to desired plants.

Griffin (1977) reported that growers using drip irrigation method indicated 25 to 50% saving in water, saving in operational costs, 25% higher yield and better quality of crop as compared to sprinkler system.

Sivanappan (1977) conducted experiments to compare drip irrigation with conventional surface methods of irrigation and showed that drip irrigation save 80% of water, reduces weed growth and improves germination.

Sivanappan *et al*. (1983) reported that the economic advantages of the drip system are significantly impressive over the other methods if irrigation and water saved in the drip system can be profitably used for area expansion.

Mateos *et al*. (1991) reported a comparative study between drip and furrow irrigation for cotton. It was found that drip irrigation is advantageous under deficit irrigation conditions and water application efficiency was 30% higher in trickle irrigation system.

2.8 Drip irrigation for coconut

Nelliat and padmaja (1978) conducted systematic studies on climatic approach on irrigation requirements of West Coast Tal coconut palms. The response to three depths of irrigation water (IW) namely 20, 40 and 60mm at three frequencies based on IW/CPE ratios of 1.0, 0.75 and 0.5 reviled that irrigation at IW/CPE of 1.0 and 0.75 significantly increased leaf number, female flower production and yield over the IW/CPE ratio of 0.5

Negaraj *et al*, (1988) conducted study on economics of drip irrigation for coconut plantations. The study revealed that among several methods of irrigation, drip irrigation system is gaining importance especially for orchards and row crops, on account of the economics of water use.

Nair (1991) reported that drip irrigation is more suited for plantation crop like coconut and water can be saved up to 70%. The study also showed that the water requirement of coconut palm ranged between 30 to 50 L / day.

Njanadevan (1991) reported that drip irrigation is most suitable for growing coconut in water scarcity areas. Evaporation, percolation and nutrient losses are less compared to other methods. The drip irrigated coconut palm give more growth and early flowering.

RamaniGopalakrishnan (1991) reported that by adopting drip irrigation in coconut gardens water and energy can be saved up to 80%. Besides this, yield increase of 40 to 50% was observed.

Nambiar (1992) reported that drip irrigation is the best water application method for irrigating coconut field among the other irrigation methods. The main advantage of the system was saving of water up to 80% and maintenance of soil fertility without nutrient loss.

Yusuf and Vardan (1992) found that drip irrigation is most suitable for water scarcity areas. In littoral sandy soil at Kasargod, 32 litres/palm/day through drip produced 38% higher nuts than basin irrigation with 200liters/palm/four days.

Mathewkutty (1998) reported that the drip irrigation is more suitable in water scarcity areas. This method is profitable in soils having low water holding capacity and having mild slope.

Dhanpal *et al*, (1999) conducted studies in the coconut root absorption. The study indicated that 0.75 m to 1.25 m away from the bole is the active absorption zone and hence it is recommended to place the emitter or micro tubes in centre of that area. The water spread from a single point source revealed that at least four emitters are required for the laterite and red sandy loam soil, whereas for the sandy soil six emitters are required.

2.9 Soil moisture distribution pattern in different soil types

Remadevi and Michael (1983) conducted study on soil moisture distribution pattern with respect to different discharge rates and salinity levels from micro irrigation system. The profile of soil moisture front, wetting from the application of water at a point source was semi-elliptical in shape. The relationship between vertical and horizontal advance of soil moisture versus elapsed time was described by standard equations. The results were used in the design of optimum rate of water application with micro irrigation technique.

Padmakumari and Sivanappan (1988) carried out a study to identify how best to adjust the drip system to the soil hydraulic properties and crop requirements. The relationship identified that the saturation zone and discharge rate, can be used to design emittr spacing.

Fangmeir *et al*., (1989) irrigated cotton 2 to 3 times weekly using buried perforated tubing under each row. Water application rates were about 0.6, 1.0 and 1.3 times of estimated consumptive use. Significant differences in seasonal average crop water stress values, average soil moisture contents and yields were obtained for the three water treatments. The wettest treatment with average crop water stress index value near 0.1 gave the highest yield and highest soil water contents before irrigation. The yield increased nearly linearly with decrease in crop water stress.

Ahkoon *et al*., (1990) reported the influence of drip irrigation emission rate on distribution and drainage of water beneath a sugarcane and fallow plot. Soil hydraulic potential was measured intensively and regularly by a 3 dimensional array of tensiometers. The study investigated the effects of three emission rates (1,2 and 4 lph) using drip irrigation on the distribution and drainage of water beneath sugarcane crop and a fallow plot. The fastest rate of emission (4 lph) resulted in greatest lateral spread of water but emission rate did not affect the amount of drainage. More drainage occurred beneath the drip line than farthest from it and contrary to the expectation, maximum loss by drainage was found to be beneath the point half way between the emitters. This was interpreted as due to the overlapping pattern from adjacent emitters. The result also showed that adoption of emission rate of 4 lph and wider spacing between emitters (75 cm) allow the irrigation of a greater cane area.

Batchelor *et al*., (1990) studied the soil moisture conditions created under drip irrigation. The study describes a trial to determine the most appropriate combination of irrigation regime, drip line placement and row spacing for drip irrigated sugarcane grown under local conditions. The distributions of soil water potential on each 14 treatments were done using 2-dimensional array of tensiometers. The data of soil moisture potential were taken for each treatment. The data were used to explain differences between treatments in both cane growth and yield periods of over and under irrigation were identified.

Bell *et al*., (1990) conducted a study on soil water status, expressed in terms of soil water potential for soil water relations in drip irrigated sugarcane trials in Mauritius. The study revealed that unlike surface or overhead irrigation, soil water distribution resulting from drip irrigation is not one dimensional. Soil water potential data derived from vertical arrays of tensiometers set out across the crop row/drip line units were used to plot and quantify the soil water distributions resulting from many different treatments and regions.

Gregory (1990) conducted a study on soil physics and irrigation. Soil physical knowledge has contributed substantially to understand how water to apply to rewet the soil and how water is distributed away from points of application. The results showed that rooting depth and distribution of moisture contributed to the actual rate at which water was utilized and the preferential wetting of limited soil volume can modify this feature.

Hodnett *et al*., (1990) described a method for scheduling the drip irrigation for sugarcane using index tensiometers. Water was applied to a point in the profile near the drip line inorder to keep the root zone at constant soil moisture potential. The qualities of water to apply each day were estimated from the tensiometers readings using simple guidelines. A field trial was run to compare the index method of control with irrigation control. With the latter method of irrigation control treatment, the amount of water applied was (1.0 ET_c) or half of this (0.5 ET_c). the amount of water applied to the index treatments lay between that applied to treatments given 1.0 ET_c and that given to treatments receiving 0.5 ET_c. the result showed that yield obtained using index control were slightly better than with the irrigation control.

Abbott and Ahkoon (1992) reported the contrasting soil moisture environments in drip irrigated cane during day and night at two plots. Soil moisture environment under each treatment was monitored using two dimensional arrays of tensiometers across the middle of cane row. The data revealed a diurnal cycling of matric potential on both plots due to irrigation application and root water abstraction. Considerable difference in size and duration of wet bulb were also seen, showing that irrigation application has a significant effect on soil moisture.

Omary and Ligon (1992) developed a finite element for three dimensional movements of water and pesticide from trickle irrigation. The model considered unsaturated, non-steady flow in a multi layered soil, taking into account of reactive and degradable pesticide. Linear and first order equations were used to describe the adsorption and degradation of the pesticide. The finite element technique was used in solving the non-difference scheme to solve the time dependent part of the equations.

Phadtare *et al.*, (1992) conducted a field experiment to study the moisture distribution pattern of trickle irrigation in vertisol. Fixed quantity of water (12 litre) was applied during test from a single point source. The result showed that at the surface, radial spread of 31 cm and 26.25 cm were observed for lowest (2 lph) and highest (5 lph) discharge respectively. The vertical advances were 105.65 and 118.5 cm for 2 lph and 5 lph emitter discharges respectively.

Sarkar and Kar (1992) estimated the water uptake pattern of groundnut from different soil layers. The water uptake data were analyzed using one dimensional flow equation for water movement in the soil and treating the root system as distributed sink term. Sink term was determined by the evaluation of water content and soil water flux distribution as a function of depth and time. Root water uptake was higher in the near surface (0.3 - 0.7) as compared to very near the surface (0.0 - 0.3 m) and lower (0.7 - 1.0 m) layers. The zone of maximum uptake moves downward with time. In dry soil, water flux played the dominant role in controlling water extraction rate.

Vellidis and Smajstrla (1992) developed a mathematical model to simulate soil water infiltration, redistribution and extraction in a bedded soil profile overlying a shallow water table and irrigated by a line source drip irrigation system. The model was then used to simulate two dimensional soil water movement as observed in lysimeter study. A bedded and plastic mulched soil profile irrigated by a line source drip system influenced by a shallow water table was studied in the lysimeter. The model results were in good agreement with the lysimeter data collected.

Amir (1993) reported a study related to lateral and longitudinal wetting patterns of very low energy moving emitters. A set of experiments were conducted to investigate the wetting contours obtained under very low pressure (10-15 Kpa) moving emitters. 9 different instantaneous application rates (IAR) were applied by 2 water amounts. Result showed that high IAR increases uniformly of wetting pattern and its width and decreases the depth. But high IAR increases water ponding on soil surface, and consequently runoff. The results of wetting pattern under moving emitters are in good agreement with those for source- point stationary emitters.

Andreas *et al.* (1993) reported the soil water distributed under trickle source. Soil water distributions in homogenous soil profile of yolo clay loam and yolo sand irrigated from a circular source of water were measured at seven times after initiation of irrigation. The effect of trickle discharge rates and soil types on the locations of wetting front and soil water content distributions were determined. A finite element solution of the 2 dimensional transient soil water equation, the theory of time dependent, linearised infiltration from a circular source, the effective hemisphere model and generalized solution for axially symmetric flow were compared with experimental results. In general, computed vertical advances of the wetting front were closely related to those observed for both soils.

Carmi *et al*., (1993) conducted a study on effect of soil water distribution on cotton root growth. The study showed that capability of mature cotton plant roots to adjust their growth to large changes in water distribution in the soil is slow. This should be taken into account for determination of irrigation regime in which the depth of water application was changed during the growing season.

Clothier and Green (1994) reported the root zone processes and efficient use of irrigation water for kiwifruit vine. Time domain reflectometry observations of the changing soil water content in the root zone of the kiwifruit vine, and direct measurement of sap flow within the individual roots, both revealed that plants can rapidly change their spatial pattern of water uptake in response to the application of irrigation water.

Dahiwalkar *et al*., (1994) conducted a study on pressure discharge relationship and moisture distribution pattern of drip irrigation in sandy clay loam in pomegranate orchard. The results revealed that at low operating heads and at corresponding low discharges the vertical advance was higher. Similarly for high operating heads and at corresponding high discharges the horizontal advance was higher.

Shu-Jung (1994) reported green-ampt analysis of wetting patterns for surface emitters. A 3 dimensional green-ampt analysis was developed, and the infiltration capacity curve was applied to describe the wetting pattern of surface emitter with a constant discharge by matching the emitter discharge with average infiltration capacity curve.

Singh and Joseph (1994) conducted study on kinematic wave model for soil moisture movement in unsaturated soil with plants. The analytical solutions were derived which showed that the plant roots were assumed to extract soil moisture at constant rate and the upstream boundary condition was independent of time.

Coelho and Or (1996) conducted a study on flow and uptake patterns affecting soil water sensor placements, a key factor in the performance of soil water based drip irrigation scheduling schemes. The uncertainty in these sensor locations may be large due to the high sensitivity of such point measurements to minute variations in wetting and uptake patterns. A proper selection of sensor placement hinges on accurate description of soil water dynamics.

Friedman and Naftaliev (2012) extensively surveyed the soil aeration status in 35 commercial, drip-irrigated Israeli orchards. The main objective of the survey was to evaluate the extent and severity of soil hypoxia in drip-irrigated orchards. The survey involved measuring soil gaseous O_2 concentrations at depths of 0–60 cm, 20 cm to the side of the emitter. Oxygen concentrations at active root depths were usually higher than 15% and decreased approximately linearly with increasing depth. Low O_2 concentrations were mostly found in intensively irrigated, clayey soils.

2.10 Drip irrigation with fertigation

Loccasio (2000) reported that drip irrigation systems are generally costly and requires good management. Water application rate was reduced and the nutrient use efficiencies are increased with fertigation system. Loss of nutrients from the root zone was reduced in the fertigation system.

Singh (2001) conducted studies on the emerging scenario of micro irrigation in India and reported that drip system permits the use of fertilizers, pesticides and other soluble chemicals with the irrigation water. It has a potential for use as a major component in adoption of precision farming

Fertilizers supplied under traditional methods of irrigation are not effectively used by the crops. Through fertigation, water and fertilizers are efficiently used by the plant. Studies conducted in various commercial, horticultural and high value crops, revealed that adoption of this technology improves the yield and quality of crops. It is also highly beneficial to the farming community in reducing the cost of production. Further it helps in sustaining the soil health for better productivity and reducing environmental hazards (Manickasundaram, 2005).

CHAPTER III

MATERIALS AND METHODS

The materials used and methodology adopted for the study is presented in this chapter. The intention of the study is to design an appropriate irrigation system for non-irrigated fields in KCAET farm. The various laboratory experiments and testing procedures adopted for the design are listed as follows.

3.1 Location and climate

The design was carried for P and D blocks in the Instructional Farm, Kelappaji College of Agricultural Engineering and Technology, Tavanur. The field is situated at 10° 52’33” N latitude and 76° E longitudes with mean altitude of 914 m above mean sea level. The P block is of size 140 × 120 m and D block is having a size of 81 × 36 m. The climatological data of the KCAET farm is shown below.

- Mean maximum monthly temperature : 32.5°C
- Mean minimum monthly temperature : 22°C
- Average monthly relative humidity : 74.4%
- Average annual rainfall : 2300 mm
- Mean evaporation : 6 mm/day
- Mean sun shine hours : 5.8 hrs
- Mean wind speed : 3.51 km/hr

The total area of KCAET campus is spreads over an area of 40.99 ha, out of which total cropped area is 30.66 ha. Various irrigation practices are followed in the farm. The sites devoid of irrigation practices are selected for this project. The proposed sites were coconut farm of area of 1.06 ha area and mango orchard of 0.29 ha area.

3.2 Crop description

3.2.1 Coconut

Coconut requires an equatorial climate with high humidity. The ideal mean annual temperature is 27°C. Coconut is grown in different soil types such as laterite, coastal, sandy and alluvial soil. It tolerates salinity and wide range of pH (5 - 8). Spacing adopted for coconut is usually 7.6 to 9 m.

3.2.2 Mango

Mango is adaptable to a wide range of climatic and soil conditions and grows well about 1500 m above mean sea level. It withstands fairly dry condition and heavy rainfall.

3.3 Preliminary investigation

3.3.1 Cropping pattern

The existing cropping pattern in the farm has a variety of crops such as coconut, mango, arecanut, vegetables, cashew, jackfruit, pepper, suppota, paddy, pulses etc. Usually surface methods of irrigation like check basin, furrow irrigation and border strip irrigations are practised in this area. These methods are not feasible because more water is wasted by evaporation. Water saving methods like drip or sprinkler irrigation methods is not practised. Also there are cropped areas in the farm requiring irrigation but are left unattended. Coconut and mango orchards are such areas in the farm, which if irrigated effectively can give a better yield. Usually coconut fields in the farm are irrigated by means of hydrants. But the proposed site is at a higher elevation from the low lying source. Therefore it is unable to pump water to such an elevation, hence at present irrigation by means of hydrant is not possible to the proposed site.

Table 3.1 Land use pattern of KCAET instructional farm

Land use	Area(ha)
Wetland (Paddy,Pulses,Vegetable,Sesamum)	8
Coconut alone	15
Arecanut alone	0.6
Nursery area	0.5
Banana and Plantain	0.5
Experimental area	0.5
Vegetables	0.5
Cashew	1.0
Mango, Jack fruit,Tamarind,Gooseberry and Others	0.4
Uncultivable rock	2.0

3.3.2 Study of soil physical properties

3.3.2.1 Soil sampling procedure

The field tests were conducted for identification and characterization of soil properties. Both disturbed and undisturbed soil samples were collected from four different locations of study area. The selected locations were coconut field (P block) near the workshop and mango orchard (D block) near the river side boundary from which sample 1 and 2 were collected respectively. The field was divided into different homogenous units based on the visual observation. The surface litter was removed at the sampling spot. The auger was driven to a plough depth of 15 cm and the soil sample was drawn. Collect at least 10 to 15 samples from each sampling unit and place in a tray. A ‘V’ shaped cut to a depth of 15 cm in the sampling spot using a spade .Thick slices of soil was removed from top to bottom of exposed face of the ‘V’ shaped cut and place in a clean container.

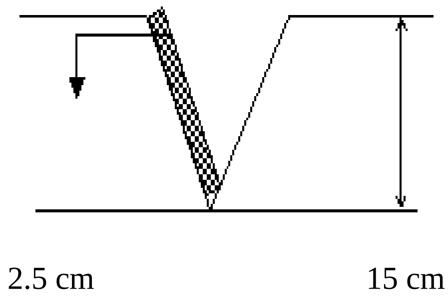

Fig.3.1 Dimension of the sampling pit

Laboratory testing of the collected soil samples were carried out to determine the moisture content, bulk density, dry density, grain size distribution, field capacity and permanent wilting

3.3.2.2 Determination of bulk density and dry density

Bulk density of a medium is defined as the total mass per unit total volume. The core cutter method was adopted to determine the bulk density. Soil sample was collected by using core sampler. The weight (W_2) and the volume (V_1) of the soil sample in the core cutter were noted. The sample was then oven dried and weighed again (W_3). Bulk density was calculated using the relation

$$\text{Bulk density} = W_3/V_1$$

Dry density of a medium is defined as the mass of solids per unit volume of the medium. The equation used

$$\rho_d = \frac{\rho}{1+\omega}$$

where ρ_d = dry density (g/cc)

ρ = bulk density (g/cc)

ω = water content

Plate 3.1 Sampling by core cutter

3.3.2.3 Determination of grain size distribution

The particle size analysis for finding out the percentage of various sizes of particles in a dry soil can be performed in two stages, sieve analysis for coarse grained fraction and sedimentation analysis for the fine grained fraction.

1. Sieve analysis

The soil was collected from the experimental field at a depth of 75 cm from the soil surface by using an auger. The soil sample obtained was then oven dried and passed through a set of IS sieves of size 4.75 mm, 2 mm, 1 mm, 600µm , 150µm and 75µm for sieve analysis. Sieving is done using sieve shaker. Weight of soil retained in each sieves were taken. The percentage finer was calculated on the basis of percentage of soil retained in each sieve. The gradation curve was plotted with particle size and cumulative percentage finer.

Plate 3.2 Sieve analysis set up

2. Hydrometer

For particles finer than 75 µ, sedimentation analysis was done using density. The calibration of hydrometer was done. 100 ml sodium hexametaphosphate solution was added to the dry soil sample passing through 2 mm IS sieve. It was then warmed for 10 minutes and was mixed thoroughly for 15 minutes. The soil suspension was then transferred to 75 µ IS sieve placed on a receiver and washed the soil on the sieve using jet of distilled water. The distilled water was added to the soil suspension to make the volume exactly to 1000 ml. a rubber bung was inserted on the top of 1000 ml measuring cylinder containing soil suspension and shaked it vigorously. The suspension was allowed to stand for some time. The cover of the cylinder was removed and stopwatch was started immediately. The hydrometer reading was taken after ½ minute by inserting the hydrometer in the solution. Similarly the readings were taken at1, 2, 4, 8, 16, 30, 60, 120, 240, 480, 960 and1920 minutes. Particle size was obtained for each hydrometer reading by using the formula

$$D= 10^{-5}F\sqrt{(H_e/t)}$$

D - Particle size (mm)

F - A factor which depends on the specific gravity of the soil and temperature of the solution

H_e - Effective depth obtained from calibration chart (cm)

t - Elapsed time (min)

The particle size curve was drawn with percentage finer 'N' as the ordinate and particle diameter (mm) as abscissa.

3.3.2.3 Determination of Soil moisture characteristics

Soil moisture potential is mostly determined by pressure membrane apparatus. The apparatus consists of ceramic pressure plates or membrane contained in airtight metallic chambers strong enough to withstand high pressure (15 bar or more).

The procedure for determining soil metric potential and water content relation involves in first saturating the porous plates and then the soil (undisturbed or disturbed) is placed on these plates. The soil samples were also saturated and then the plates were transferred to the metallic chambers. The chamber was closed with wrenches to tighten the nuts and bolts with the required torque for ceiling it. Pressure was applied from a compressor through control which helps in maintaining the desired two pressure 1/3 atm & 15 atm were applied to get field capacity and permanent wilting point. It was ensured that there was no leakage from the chamber. Water starts to flow out from saturated soil samples through outlet and continues to trickle till equilibrium against the applied pressure is achieved. After that the soil samples are taken out and oven dried for determining moisture content on volume basis (undisturbed soil). Similarly, the moisture content of the soil can be determined against other pressure values .The data are presented in result.

3.3.2.4 Determination of infiltration rate using double ring infiltrometer

Infiltration rate was measured using double ring infiltrometer. It consists of two 2 mm rolled steels cylinders of 25 cm depth. The cylinders were driven into the soil with the help of a hammer. The outer cylinder which is 60 cm in diameter is used to form a buffer pond to minimize the lateral spreading of water. The infiltration measurements were taken from inner cylinder of 30 cm diameter. A constant head was maintained by pouring water into the cylinders. The hook gauge measurements were taken at frequent intervals to determine the amount of water infiltrated during a particular interval. Water was added quickly after each measurement to maintain a constant average infiltration head. The readings were taken till a successive constant value was obtained. The test was replicated at different locations in the field. The average values of accumulated infiltration (Y) and infiltration rate were found. A functional relationship was developed by using the equation:

$$Y = at^{\alpha}+b$$

where

Y - Accumulated infiltration (cm)

t - Elapsed time (min)

a, α, b - Constants

The values of the constants a, α, b were found out.

3.3.3 Determination of pan evaporation using USWB class A pan evaporimeter

The standard US weather bureau class A pan is the most widely used evaporation pan. It is circular and is made of 22 gauge GI, 10.7 cm diameter and 25 cm deep. The pan is painted white. It is mounted on a wooden open frame which is 15 cm above the ground level. The open frame permits free movement of air beneath the pan. The pan is kept level. It is filled with clean water upto 5 cm below the rim of the pan. The water level is not allowed to drop more than 7.5 cm below the rim. The water in the pan is changed regularly. Water is added each day to bring the water level to a fixed point. The level of water in the pan is measured daily at a fixed time in the morning, using a hook gauge fixed over a cylindrical metallic stilling well, about 10 cm in diameter and 20 cm deep.

Plate 3.3 USWB Class A pan evaporimeter

3.3.4 Survey and mapping of the area

For the proper layout of pipe lines in a drip irrigation system, a cross staff survey of the area to be brought under irrigation was undertaken. The source of water, operational details of the pump, crop details and their spacing, and details of climate were included in the survey. Soil sample were collected and analysed for the physical property including soil texture and other properties.

3.3.4.1 Water resources

The various wells in the KCAET farm were identified and the exact location of well were marked on the topographic map of KCAET. Wells were categorized as open well, tube well and filter point well.

There are 12 open wells, 6 filter point well and 4 tube wells. Water from these wells are used for irrigating the fields. For the design of a proper irrigation system well, (W_5) was chosen as a source of water for irrigating the proposed site.

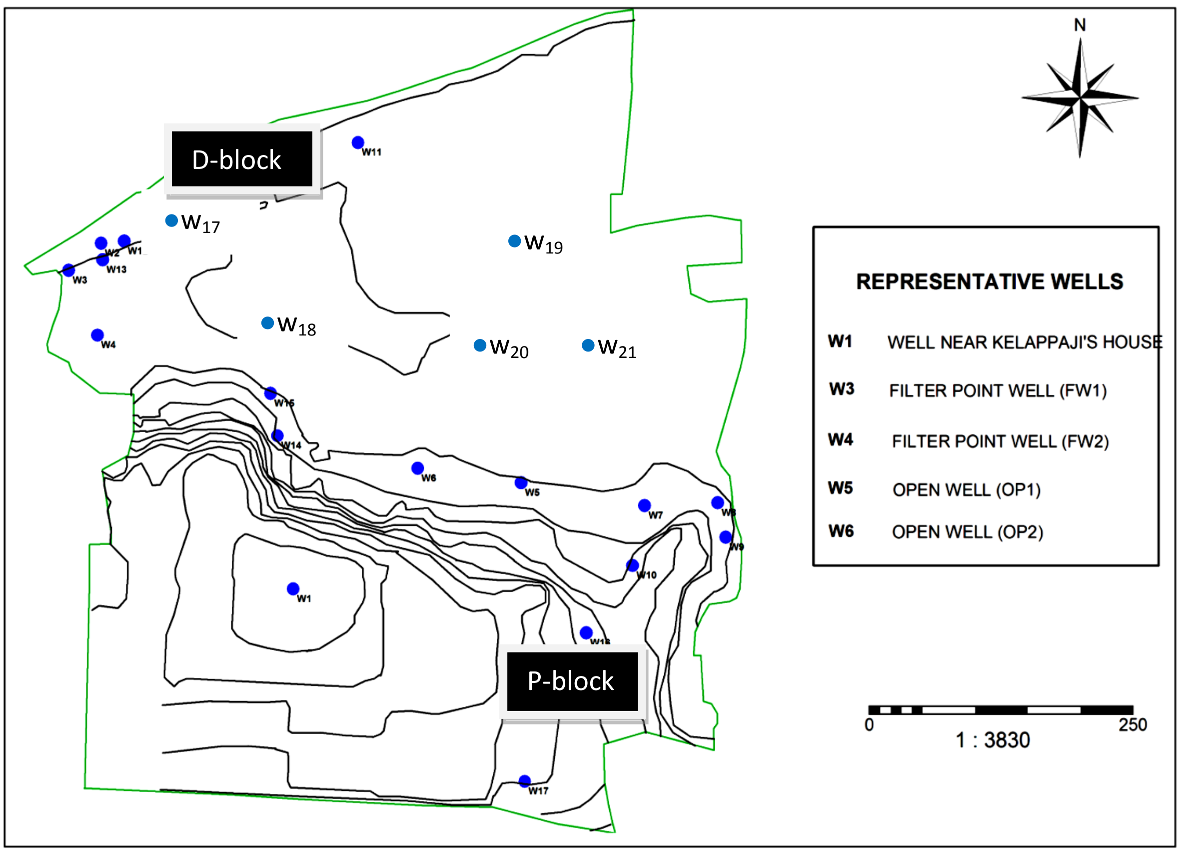

Fig 3.2. Location of wells

3.3.4.2 Pumping details

The pumping details of the wells were collected. The type of pump used in each wells, their capacity, HP, pumping rate and efficiency were noted. Those are listed in table given below.

Table 3.2 Pumping details of various wells

Well	Pump no	HP	Discharge(l/s)	Head(m)	Efficiency (%)
W1	P1	15	12.5	69	60
W7	P2	1	1.5	20	26
W20	P3	3	9.8	16	56
W21	P4	3	9.8	16	56
W19	P5	3	9.8	16	56
W12	P6	10	14		59
W4	P7	7.5	8.2	5.6	48
W3	P8	12.5	11	4	50

3.3.5 Design of irrigation systems

Plate 3.4 Coconut field in P block

Plate 3.5 Mango orchard in D block

3.3.5.1 Number of trees

Numbers of trees in the selected area were counted. Spacing between the trees is measured. The trees in the coconut field are irregularly spaced. For design consideration the spacing is taken as 7 x 7 m.

In the case of mango orchard trees are spaced uniformly and the spacing is taken as 9 x 9 m. Number of trees in the proposed site is calculated by dividing the area with the spacing.

3.3.5.2 Estimation of crop water requirement

Estimation of water requirement (WR) of crops is one of the basic needs for crop planting on the farm. Water requirement of crops may be defined as the quantity of water, regardless of its source, required by a crop in a given period of time for its normal growth under field condition at a particular place. Water requirements include the losses due to evapotranspiration (ET) plus the losses during the application of irrigation water and the quantity of water required for special operation such as land preparation, transplanting, leaching and unavoidable percolation losses.

The Irrigation water requirement of an area depends on the type of crop, weather data (class A pan evaporimeter), type of soil and area under cultivation. The monthly irrigation water requirement can be estimated on the basis of the monthly pan evaporation data and crop coefficient. The daily water requirement for fully grown plants can be calculated by the following steps

1. Calculation of evapotranspiration per day, ET_c

$$ET_c = k_c \times k_p \times E_p$$

where

K_c - crop coefficient

K_p - pan coefficient

E_p - pan evaporation (mm / day)

Table 3.3 Mean evaporation data obtained from pan evaporimeter

MEAN EVAPORATION (mm)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2011	5.8	5.7	5.7	4.7	4.0	2.8	2.5	3.0	3.2	3.5	3.8	4.9
2012	5.1	5.8	5.1	4.4	3.6	2.6	2.3	2.6	3.0	3.3	-	-

The values of crop coefficient K_c varies greatly with the stage of growth of the crop, as the crop develops the ground cover, crop height and leaf area change. The growth period of crop can be divided into four distinct stages, they are initial stage, crop development stage, mid-season stage and late season stage. The length of growth periods vary with the crop and its variety, the planting date and climate. The trends in the values of K_c at different growth stages of crops are given in figure below

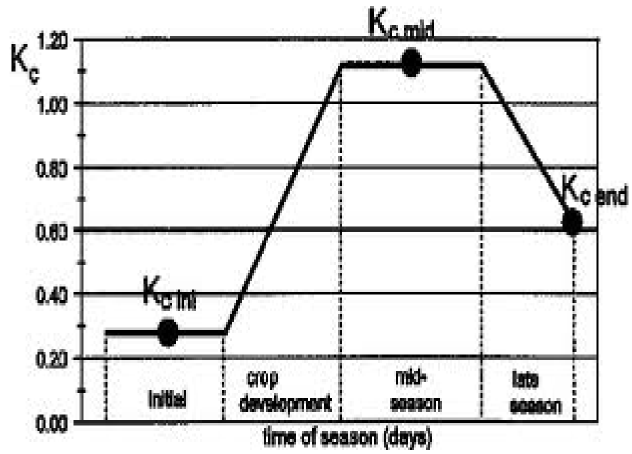

Fig.3.3. General trend in K_c values at different stages in the growth period of seasonal crops

2. Calculation of water requirement per tree, WR

$$WR = \pi \times R_w^2 \times ET_c$$

R_w - Wetting radius

3.3.5.3 Pumping rate

The drip irrigation system has to be designed for the maximum requirement of 40 litres per day per plant during the summer season. The average working hours of the pump set is 4 hours per day then the discharge required is calculated.

3.3.5.4 Selection of drippers

Emitter design and selection procedures require an estimation of discharge, spacing and the type of emitters to be used. The efficiency of drip irrigation system depends mainly on the selection of type of emitter and its design. The following are the major characteristics of the emitter that influence the efficiency of the irrigation system

- Discharge rate variations caused by emitter variations within manufacturing tolerance
- Closeness of discharge-pressure relationship to design specifications
- Possible range of suitable operating pressures
- Pressure loss on lateral lines caused by the connection of emitters to the lateral
- Susceptibility to clogging, siltation or built up of chemical deposits.

3.3.5.5 Number of drippers

Depending upon the type of dripper and discharge required the number can be estimated.

$$\text{No of drippers per plant} = \frac{rate\ of\ pumping\ per\ hour\ per\ plant}{average\ discharge\ of\ one\ dripper}$$

Then the total number of drippers per lateral would be calculated.

3.3.5.6 Design of main line

The main lines are mainly made of flexible materials such as PVC or plastics. The mainline is designed to carry the maximum discharge required for total number of plants in the plot. The design of mainline should be such that the friction head loss in the main line should not exceed 1 m/100 m length. The pipe diameter is selected from the smallest feasible size, going successively towards larger sizes. The size of main usually ranges from 4 cm to 11 cm in diameter. Then maximum discharge required is calculated as

Maximum discharge required = Number of plants × peak discharge per plant

The total head loss (friction losses in the pipe, emission devices and connectors) is calculated using standard tables. The friction loss is calculated by the equation

$$\text{Friction loss } (H_f) = \frac{4 \times f \times l \times v^2}{(2 \times g \times d)}$$

where

v - Velocity of flow in the pipe (m/s)

l - Length of pipe (m)

g - Acceleration of gravity (m/s^2)

d - Diameter of pipe (m)

f - Coefficient of friction

3.3.5.7 Design of laterals

Laterals convey water from main lines and sub-mains to the drippers or emission devices. Drip laterals are designed to maintain an acceptable variation in the discharge rates of drippers along their length. The main causes of the variation in the discharge of drippers along the lateral are the loss of pressure head due to friction in the pipe, minor losses, and changes of ground surface elevation in the irrigated field. The dripper flow variation caused by water pressure can be controlled by hydraulic design. Flow carried by each lateral line is calculated as

Flow carried by each lateral line = Discharge of dripper × No of drippers per plant × number of plants along each lateral

A lateral is so selected that the pressure difference from the proximate end to the last dripper does not exceed 10% of the normal operating head. The pressure loss due to fittings and connections will have to be added to obtain the total friction loss in the lateral pipe. Using diameter and the flow obtained the friction loss is noted from the table. Otherwise the friction loss in laterals is calculated by the equation

$$\text{Friction loss } (H_f) = \frac{4\times f\times l\times v^2}{(2\times g\times d)}$$

where

v - Velocity of flow in the pipe (m/s)

l - Length of pipe (m)

g - Acceleration due to gravity (m/s^2)

d - Diameter of pipe (m)

f - Coefficient of friction

3.3.5.8 Estimation of horse power of pumping unit

Power is required to pump the required irrigation water from the source and to develop sufficient pressure to operate the drippers effectively.

After finalization dimensions of mains and laterals consist of following steps

Total pressure head drop (m) due to friction, H_f =

Friction head loss in main + Friction head loss in lateral

Operating pressure head required at the dripper = H_e (m)

Total static head = H_s (m)

Total pumping head (m) = $H_f + H_e + H_s$

The HP of pump set required is based upon design discharge and total operating head. The size of pumping unit can be estimated using the following equation

$$\text{HP of pump set} = \frac{Q \times H}{75 \times e}$$

where,

Q - Discharge in l/s

H - Head in m

e - Pumping efficiency

CHAPTER IV

RESULT AND DISCUSSION

The present study was undertaken with the objective of designing an appropriate irrigation system for non-irrigated areas of KCAET farm. The result obtained from the study were analyzed and presented in this chapter

4.1 Climatic details

The table and graph showing rainfall characteristics, wind velocity, sunshine hours, relative humidity and evaporation are given in appendix I

4.2 Identification of the type of soil

The results of the soil textural analysis are shown in appendix II. The results of the mechanical analysis (both sieve and sedimentation) were plotted to get particle size distribution curve. In this curve, percentage finer “N’ was taken as ordinate and particle diameter (mm) as the abscissa on logarithmic scale. As per the USDA classification chart, the textural class of the soil obtained from the sieve analysis was found that the coarse fraction was 85% and the rest was a mixture of silt and clay. From this inference it is concluded that the soil in the mango orchard is sandy loam and laterite in coconut field.

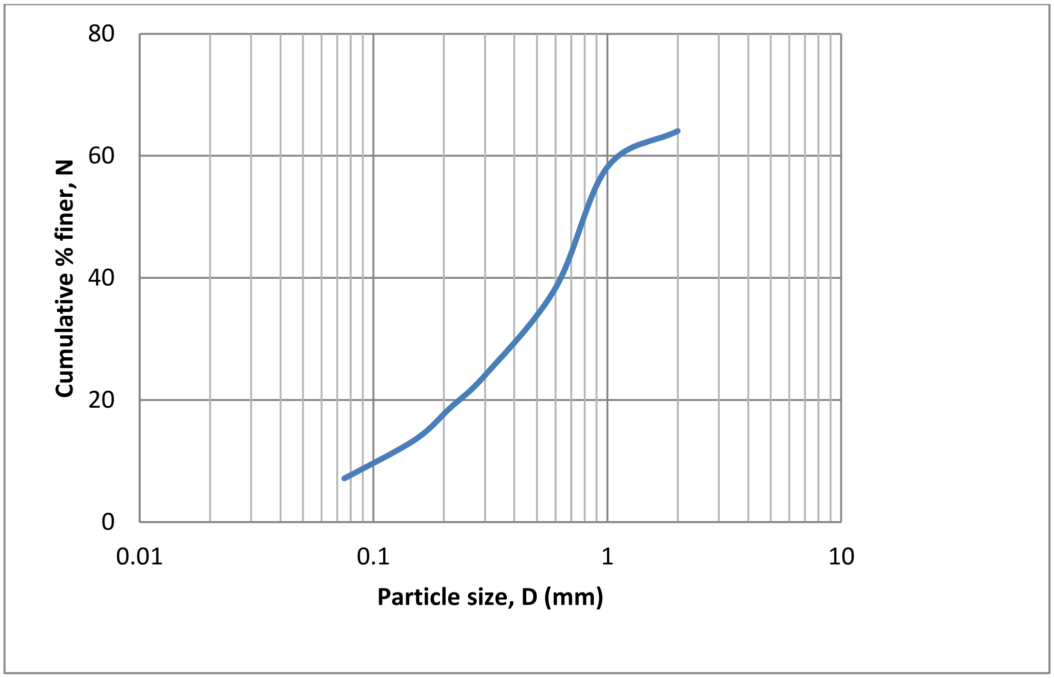

Fig.4.1. Gradation curve for the soil sample from coconut field

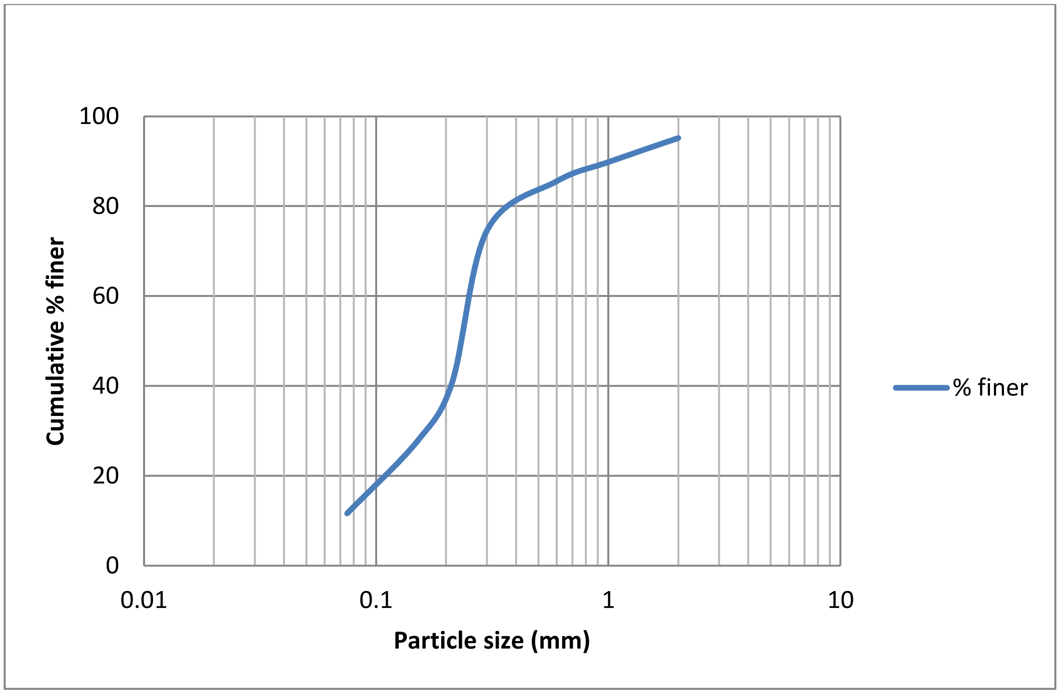

Fig. 4.2.Gradation curve for the soil sample from mango field

4.2.1 Bulk density and dry density

The determined values of bulk density and dry density are shown in the Table 4.1. The measurements from core cutter and gravimetric method were given in appendix III. The mean bulk density of soil in the P block and D block having values 1.8 and 1.85 g/cm^3.

Table 4.1. Bulk density and dry density of the samples

	Coconut field(g/cm^3)	Mango orchard (g/cm^3)
Bulk density	1.8	1.85
Dry density	1.55	1.55

4.2.2 Field capacity and permanent wilting point

Soil samples were taken for determining the field capacity using pressure plate apparatus. The field capacity was determined as 9.52% for the soil in the D block, and 13.5% for P block and the value is within the standard limit of 3 to 15% for sandy loam soil. The average wilting point of the soil is 7.5% for D block and 11.54% for P block which is in conformity with the standard range of 3 to 8% for sandy loam soil. The result obtained from the pressure plate apparatus is given in the Appendix IV.

4.2.3 Infiltration Rate

A double ring cylinder infiltrometer test was conducted to determine the infiltration rate of the soil as the performance of the system was influenced by the infiltration properties of the soil. The field data on cylinder infiltrometer is given in Appendix V. The functional relationship between accumulated infiltration and time was fitted as

$$y = 0.42\, t^{0.79} + 0.54$$

The basic infiltration rate of sandy loam soil ranges between 6.5 to 12.5 cm/hr. The average basic infiltration rate of the soil was found to be 8.1 cm/hr.

4.3 Water resources

From the investigation it is found that the campus has got abundant water supply resources as open wells, tube wells, filter point wells and ponds. Most of the wells have less storage capacity and are usually dry during summer season. Most of the open wells being left as such and no further conservation steps are taken. Well (W_5) is selected as water source for irrigating the fields. The locations of various wells in the campus are given in Appendix VI. Also the well selected as a source is marked in the map.

4.3.1 Pumping details

Only few of the pumps that are available in the farm are in working condition. For design purpose the well W_5 is selected as a source and is having a motor of 15 hp pump for pumping. Due to the higher elevation of the proposed site it is unable to pump water using this capacity pump. Hence a high capacity pump or another alternative source is required to pump water to the selected field.

4.4 Design of irrigation system

4.4.1 Site 1 (coconut field)

The length of main is 140 m and that of lateral is 70 m. The total area of the field is 1.06 ha. Spacing between the trees is 7 × 7 m.

4.4.1.1 Number of trees

The number of trees in the coconut field is 198. By using the equation it is calculated as approximately 200

$$\text{Number of tree} = \frac{140 \times 70}{7 \times 7} = 200 \text{ plant}$$

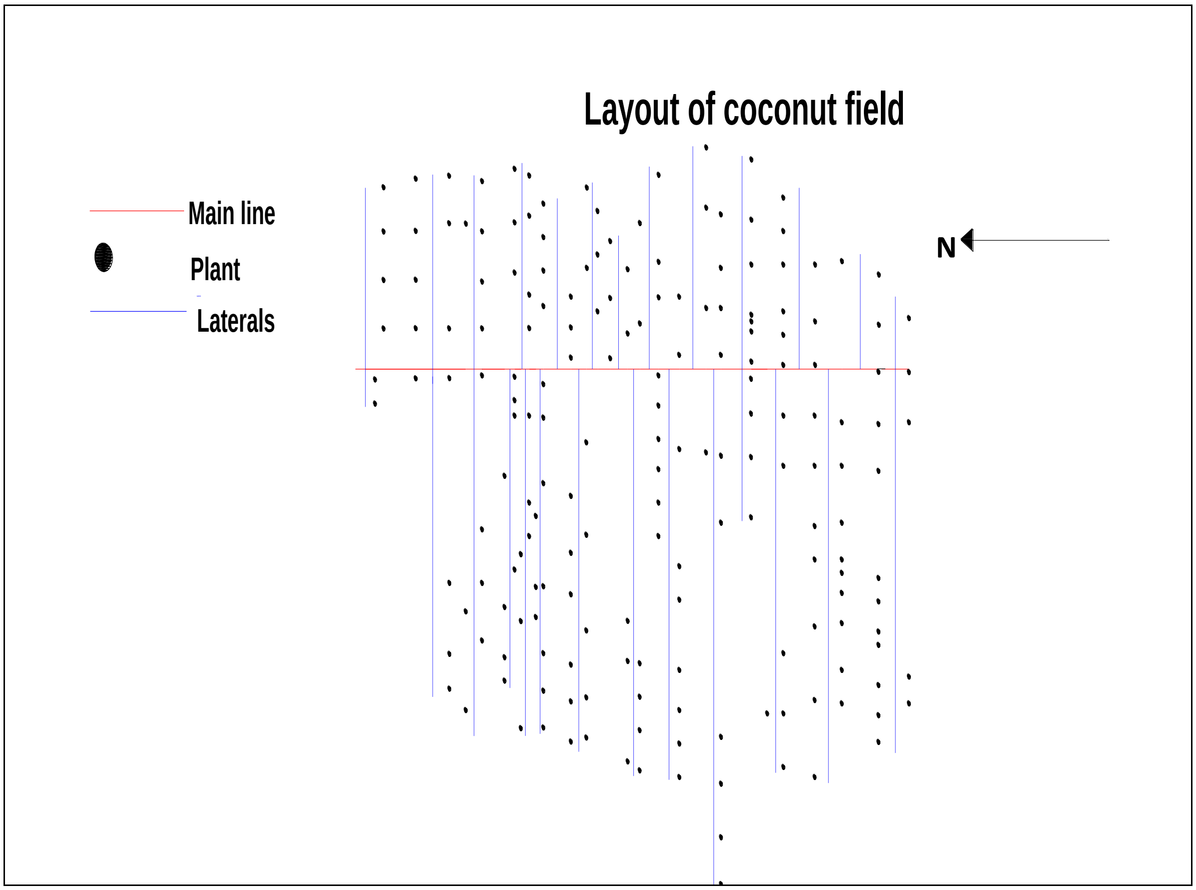

Fig . 4.3 layout of coconut field

4.4.1.2 Calculation of water requirement

The K_c value of coconut is 0.75.The K_c values of different crops are given in Appendix VII. The pan coefficient is 0.7. Pan evaporation data obtained is 6 mm per day. Then

$$ET_c = 6 \times 0.75 \times 0.7$$

$$= 3.15 \text{ mm/day}$$

Assume the effective wetting radius as 1.4

$$WR = 3.14 \times 1.4^2 \times 3.15$$

$$= 19.38 \text{ litres}$$

The value obtained is too less. This calculated quantity of water is not sufficient to meet the requirement of coconut. Therefore as per POP the water requirement of the coconut is taken as 40 lit/day/plant.

4.4.1.3 Pumping rate

The drip irrigation system has to be designed for the maximum requirement of 40 lit/ day/ plant during the summer season. For this the water requirement works out to 8 m^3/day/ha. The average working hours of pump set is 4 hrs per day then the discharge required is given as

$$\text{Pumping rate per ha} = 8 \text{ m}^3\text{/ day /ha}$$

$$= 2 \text{ m}^3 \text{ / hr / da}$$

$$= 10 \text{ lit / hr / plant}$$

$$= 0.5 \text{ lit / sec}$$

Alternatively, a tank of 8 m^3 capacity can be provided so that uninterrupted irrigation may continue for 4 hrs.

4.4.1.4 Selection of drippers

An emitter is designed to provide a specific flow rate. Most commonly, there is a choice between 0.5, 1.0, 1.5, or 2.0 gallons per hour. The 1.0 gph emitter is recommended to avoid excessive pipe friction problems. Pressure compensating emitter is not 100 percent effective, but does suppress major flow fluctuations as compared to the non-compensating emitter. Pressure compensating emitters try to provide a constant flow rate, through a diaphragm embedded into the emitter, under varying pressure. A pressure compensating emitter with a self-flushing capability is recommended. This type of emitter will not clog as often as other types. In orchards multiple outlet emitters are preferred.

For a pressure head of 10 m and discharge of 4 lit/ hr the numbers of drippers required are

$$\text{Number of drippers per plant} = \frac{10}{4}$$

$$= 2.5 \cong 3.0$$

For main line is having 140 m and lateral of 70 m length. A total of 26 laterals are required. Each lateral should serve approximately 12 plants and there would be 3 drippers per plant.

$$\text{Thus the total number of drippers per lateral} = 12 \times 3$$

$$= 36$$

4.4.1.5 Design of main line

The main line is designed to convey the water from the source to irrigating field. The diameter of the main line is taken as 40 mm.

The maximum discharge required = 200 × 10

= 2000 lit/hr

= 0.5 lit/sec

Friction head loss in the pipe

Total length of the line = 140 m

In addition to 140 m length of main there is additional loss due to connectors. This is generally taken as 0.1 to 1.0 m (on an average of 0.5)

Equivalent length of 26 straight connection = 13

Equivalent length of tee bends = 6

Total length = 159 ≅ 160 m

From table given in Appendix VIII it is seen that for a discharge of 0.5 lit/hr through pipe of 40 mm diameter, the friction head loss is 0.56 m per 100 m length of 0.896 for 160 m length.

Friction head loss = 0.896 × 0.88

= 0.788 ≅ 0.79m

where 0.88 is the conversion factor

As the proposed system uses multiple openings, then

Friction head loss $= \frac{1}{3} \times 0.79$

= 0.26 m

Thus the loss in mainline is within 1 m / 100m and a pipe of 40 mm diameter will be ideal in the layout.

4.4.1.6 Design of lateral

Assume the diameter of lateral as 13.9 mm

The pressure difference from the proximate end to the last dripper = $10 \times \frac{10}{100}$

ie,1 for lateral of 70 m length. The land slope is 0.5 m / 70 m length.

Total friction loss available = 1 + 0.5

= 1.5 m

In addition to 70 m length of laterals there is additional loss due to connectors. This is generally taken as 0.5m of the equivalent length of a dripper.

The equivalent length of 36 drippers = 36 × 0.5

= 18m

Total equivalent length of lateral = 70 + 18

= 88 m

Total flow in lateral = 4 × 3 × 12

= 144 lit /hr

= 200 lit/ hr

For a flow of 200 lit/ hr the friction loss in 13.9 mm diameter pipe would be 1.7 m per 100 m length. It is obtained from table given in Appendix IX. Therefore, for 88 m length it would be 1.49 m. It is general practice that the friction losses are taken at 1/3 of the total equivalent length of pipes with multiple drippers/connections.

Thus the friction loss = 1/3 × 1.49

= 0.49 m

This is within the maximum permissible limit. 14 mm pipe is not available in the market, therefore 16 mm pipe can be selected as the lateral.

4.4.1.7 Estimation of horse power of pumping unit

The total operating head is the sum of total static head and friction losses in the system.

Static head

The total static head is the sum total of the following

a) Depth of water = 15 m
b) Drawdown = 3 m
c) Outlet level above ground level = 1 m
d) Friction losses in pipes, bends foot valves etc. = 2 m

Total = 21 m

Frictional losses in the drip unit

a) Friction loss in the main pipe = 0.26 m
b) Friction loss in lateral = 0.49 m
c) Minimum head required over drippers = 10 m

Total = 10.75 m

Total head = 21 + 10.75

= 31.75

= 32

HP of the pump set $= \frac{0.5 \times 32}{75 \times 0.6}$

= 0.35 hp

Power requirement for pumping activity were found to be 0.35 hp. But due to unavailability of such a small capacity motor 0.5 hp is suggested. This is the smallest of available capacity.

4.4.1.8 Cost estimation

Cost of different components of drip system are as follows;

- ❖ Cost of half HP electric motor and pump = Rs. 3500
- ❖ Cost of 140 m PVC pipe(40mmф) @ Rs30/m = Rs. 4200
- ❖ Total length of lateral = 70 ×26 =1820 m
- ❖ Cost of lateral(16mm ф) @ Rs 8/m = Rs.14560
- ❖ No of pressure compensating drippers = 200×3= 600 m
- ❖ Cost of drippers @ Rs 7/ piece = Rs.4200
- ❖ Cost of suction pipe, foot valve, gate valve, tees, bends,endcaps and other plumping accessories = Rs.2000
- ❖ Ventury and manifold = Rs 1100
- ❖ Screen filter = Rs 2500
- ❖ Total material cost = Rs.32060
- ❖ Installation cost = Rs.3000
- ❖ Total cost = Rs.35060

4.4.2 Site 2 (Mango orchard)

The length of main is 81 m and that of lateral is 36 m. The total area of the field is 0.29 ha. Spacing between the trees is 9 × 9 m.

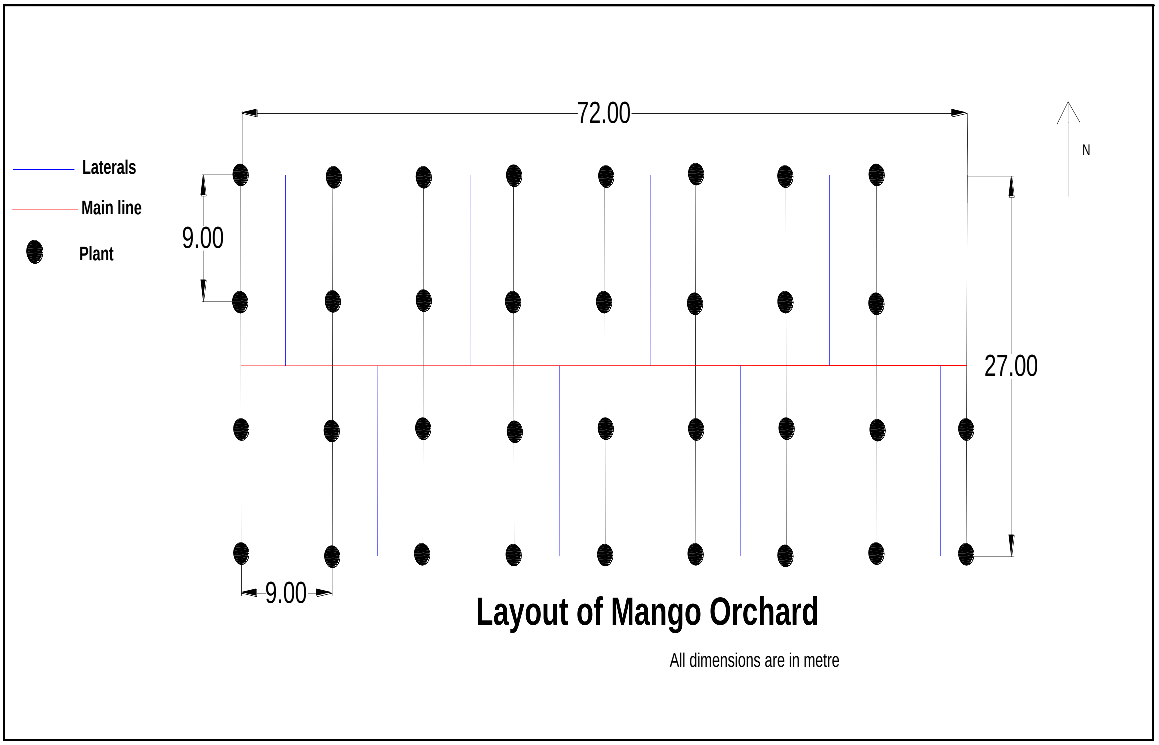

Fig. 4.4 Layout of mango orchard

4.4.2.1 Number of trees

The number of trees in the mango orchard is 34. By using the equation it is calculated as approximately 36

$$\text{Number of trees} = \frac{81 \times 36}{9 \times 9}$$

$$= 36 \text{ plants}$$

4.4.2.1 Calculation of water requirement

The K_c value of mango is 0.8.The K_c values of different crops are given in Appendix VII. The pan coefficient is 0.7. Pan evaporation data obtained is 6 mm per day. Then

$$ET_c = 6 \times 0.8 \times 0.7$$

$$= 3.36 \text{ mm/day}$$

Take the effective wetting radius as 1.6

$$WR = 3.14 \times 1.6^2 \times 3.36$$

$$= 27 \text{ lit /day / plant}$$

Take the water requirement of the mango as 30 lit/day/plant.

4.4.2.2 Pumping rate

The drip irrigation system has to be designed for the maximum requirement of 30 lit/ day/ plant during the summer season. For this the water requirement works out to 1.08 m^3/day/ha. The average working hour of pump set is 4 hr per day, the discharge required is given as

$$\text{Pumping rate per ha} = 1.08 \text{ m}^3\text{/ day /ha}$$

$$= 0.27 \text{ m}^3 \text{ / hr / day}$$

$$= 7.5 \text{ lit / hr / plant}$$

$$\cong 8 \text{ lit / hr / plant}$$

$$= 0.08 \text{ lit / sec}$$

4.4.2.3 Selection of drippers

For a pressure head of 10 m and discharge at 4 lit/ hr the number of drippers required is,

Number of drippers per plant $= \frac{8}{4}$

$= 2.0$

For main line is having 81m and lateral of 36m length. A total of 9 laterals is required. Each lateral should serve approximately 4 plants and there would be 2 drippers per plant.

The total number of drippers per lateral $= 4 \times 2$

$= 8$

4.4.2.4 Design of mainline

Assume the diameter of the main line as 40 mm.

The maximum discharge required $= 36 \times 8$

= 288 lit/hr

= 0.08 lit/sec

Friction head loss in the pipe

Total length of the line = 81 m

In addition to 81 m length of main there is additional loss due to connectors. This is generally taken as 0.1 to 1.0 m (on an average of 0.5)

Equivalent length of 9 straight connection = 4.5

Equivalent length of tee bends = 6

Total length = 91.5 ≅ 100 m

From table given in Appendix VIII it would be seen that for a discharge of 0.5 lit/hr through the pipe of 40 mm diameter the friction head loss is 0.56 m per100 m.

Friction head loss = 0.56 × 0.88

= 0.49m

Where 0.88 is the conversion factor

As the proposed system uses multiple openings, then

Friction head loss $= \frac{1}{3} \times 0.49$

= 0.16 m

Thus the loss in mainline is within 1 m/ 100m, and a pipe of 40 mm diameter will be ideal in the layout.

4.4.2.5 Design of lateral

Assume the diameter of lateral as 13.9 mm

The pressure difference from the proximate end to the last dripper = 10 × $\frac{10}{100}$

ie,1 for lateral of 36 m length. The land slope is 0.5 m / 36 m length.

Total friction loss available = 1 + 0.5

= 1.5 m

In addition to 36 m length of laterals there is additional loss due to connectors. This is generally taken as 0.5m of the equivalent length of a dripper.

The equivalent length of 8 drippers = 8×0.5

= 4 m

Total equivalent length of lateral = 36 + 4 m

= 40 m

Total flow in lateral = $4 \times 2 \times 4$

= 32 lit /hr

The flow through the lateral was found to be 32 lit / hr. As the flow through the lateral is too low the head loss corresponding to the flow is not available in the standard table. Hence the head loss corresponding to minimum flow was chosen. The minimum flow in the standard table is 200 lit/hr.

For a flow of 200 lit/ hr the friction loss in 13.9 mm diameter pipe would be 1.7 m per 100 m length. It is obtained from the table given in appendix IX. Therefore, in 41 m length it would be 0.72 m. It is general practice that the friction losses are taken at 1/3 of the total equivalent length of pipes with multiple drippers/connections.

Thus the friction loss = $1/3 \times 0.72$

= 0.24 m

This is within the maximum permissible limit. 14 mm pipe is not available in the market; therefore 16 mm pipe is selected as the lateral.

4.4.2.6 Estimation of horse power of pumping unit

The total operating head is the sum of total static head and friction losses in the system.

Static head

The total static head is the sum total of the following

e) Depth of water = 15 m

f) Drawdown = 3 m

g) Outlet level above ground level = 1 m

h) Friction losses in pipes, bends foot valve etc. = 2 m

Total = 21 m

Frictional losses in the drip unit

d) Friction loss in the main pipe = 0.16 m

e) Friction loss in lateral = 0.24 m

f) Minimum head required over drippers =10 m

Total = 10.4 m

Total head = 21 + 10.4

= 31.4 m

= 32 m

HP of the pump set $= \frac{0.08 \times 32}{75 \times 0.6}$

= 0.056

= 0.05 hp

Power requirement for pumping activity were found to be 0.05 hp. But due to unavailability of such a small capacity motor 0.5 hp is suggested. This is the smallest of available capacity.

4.4.2.7 Cost estimation

Costs of different components of drip system are as follows

- Cost of half HP electric motor and pump = Rs. 3500
- Cost of 81 m PVC pipe(40mmф) @ Rs30/m = Rs. 2430
- Total length of lateral = 9 ×36 = 324 m
- Cost of lateral(16mm ф) @ Rs 8/m = Rs.2592
- No of pressure compensating drippers = 36 ×2= 72 m
- Cost of drippers @ Rs 7/ piece = Rs.504
- Cost of suction pipe, foot valve, gate valve,tees, bends,endcaps and other plumping accessories = Rs.2000
- Ventury and manifold = Rs 1100
- Screen filter = Rs 2500
- Total material cost = Rs.14626
- Installation cost = Rs.3000
- Total cost = Rs.17626

CHAPTER V

SUMMARY AND CONCLUSION

The study entitled design of an appropriate irrigation system for KCAET farm was aimed to design an irrigation system to area having no irrigation practice which could bring a better yield if irrigation is practiced. The details about cropping pattern and the irrigation method adopted in the farm were collected to design an appropriate irrigation system. The design was carried in the D and P blocks of KCAET Tavanur.

Drip irrigation method is suggested for non-irrigated areas. The drip irrigated system is more efficient which provide better yield and saves water. Water requirement of mango and coconut was estimated as 40 and 30 litre per day per plant respectively. A pipe of 40 mm diameter was chosen as a main pipe that is sufficient to ensure the conveyance of water as per the water requirement of both plants. The yield of coconut and mango will be increases by providing the drip irrigated system.

The discharge required for total number of plants in the mango and coconut field were found to be 0.5 and 0.08 litre per second respectively. Use of 40 mm diameter pipe for main line can meet the discharge requirement. The provision of main line at the center of field can minimize the friction loss and which can supply water to the extreme ends at required discharge.

Well W_5 having pump of 15 hp was selected as a source for irrigating both fields. Through calculation it was found that a pump of 0.35 hp and 0.05 hp was best suited to irrigate mango orchard and coconut field respectively. As the size of the pump required is too small, the next available size 0.5 hp pump is selected.

The hydrants were provided at the coconut field for irrigation of plants but as the field is at higher elevation the water does not reach at the hydrant. This problem can be solved by providing a separate valve in the system for adjusting the discharge to required level. Another option is the provision of an intermediate storage tank in which water can be collected and stored. The cost estimation for installing drip irrigation in mango and coconut was conducted and the costs were calculated to be Rs 17626 and Rs 35060 respectively.

It can be concluded from the study that

- By drip irrigation the water required for crop is less than surface methods like check basin and furrow irrigation.
- The yield obtained from crops that are drip irrigated is more than that compared from surface irrigated crops.
- By providing fertigation in drip irrigation system the yield can be considerably increased.

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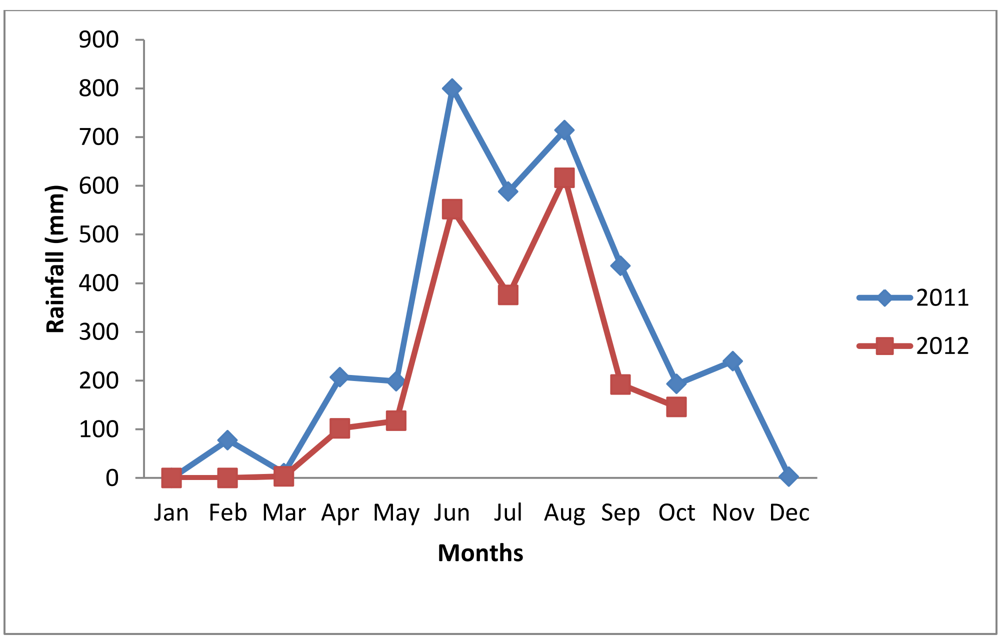
Appendix I

Climatological data

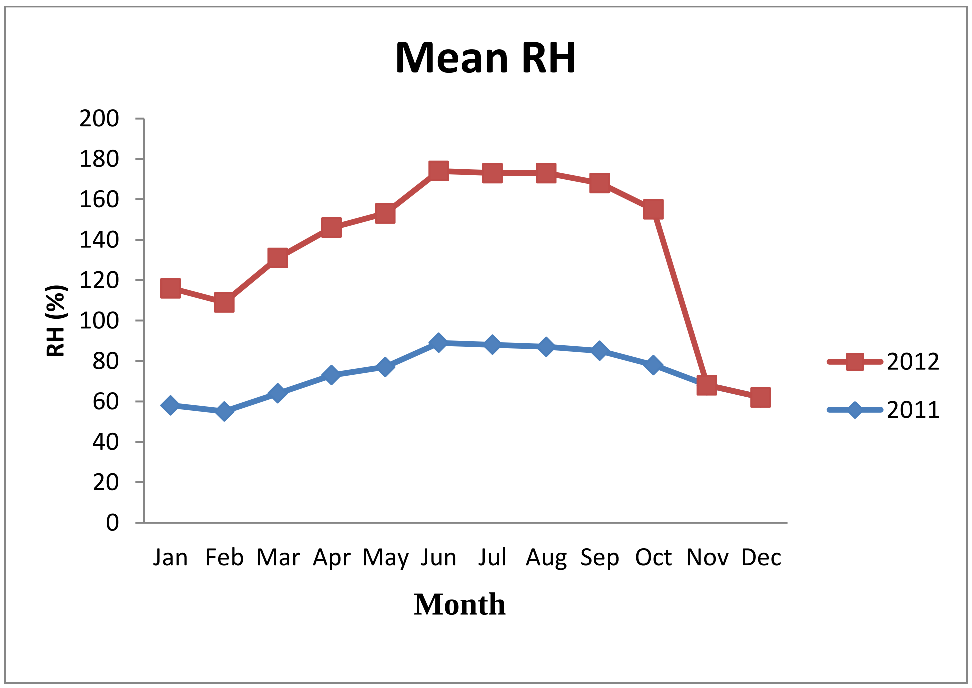
Rainfall (mm)

Month	2011	2012
Jan	0.0	0.0
Feb	77.5	0.0
Mar	10	3.5
Apr	207.1	101.9
May	198.5	117.3
Jun	799.6	551.5
July	588.2	375.8
Aug	713.8	616.5
Sept	435.2	191.8
Oct	193.0	145.6
Nov	240	223
Dec	240	47



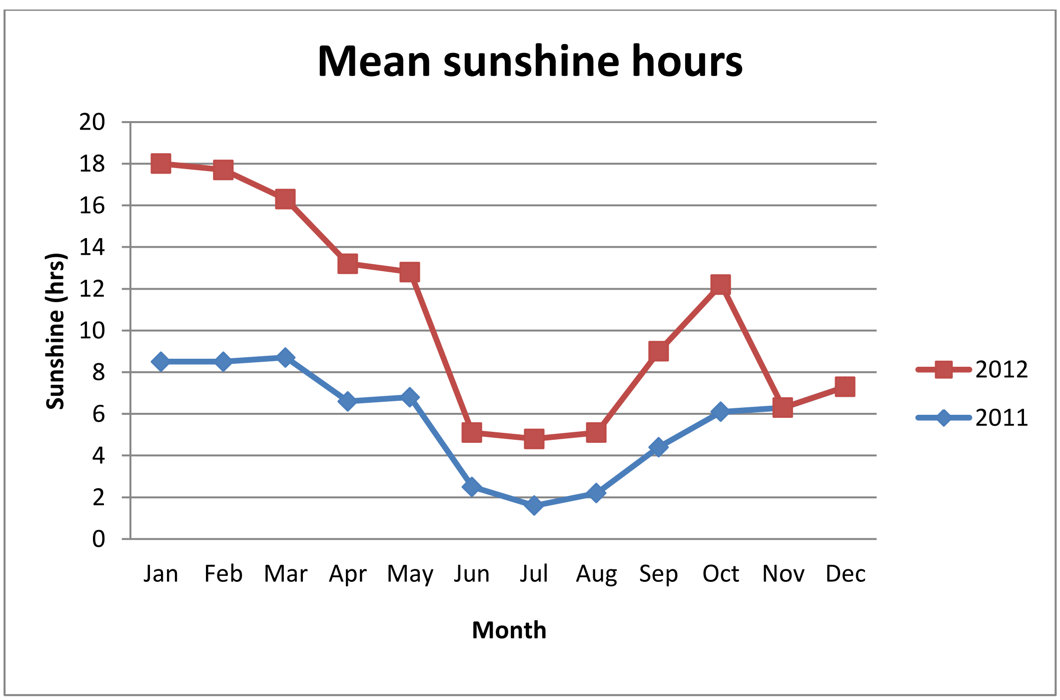
Mean relative humidity

Month	2011	2012
Jan	58	58
Feb	55	54
Mar	64	67
Apr	73	73
May	77	76
Jun	89	85
July	88	85
Aug	87	86
Sept	85	83
Oct	78	77
Nov	68	58
Dec	62	58



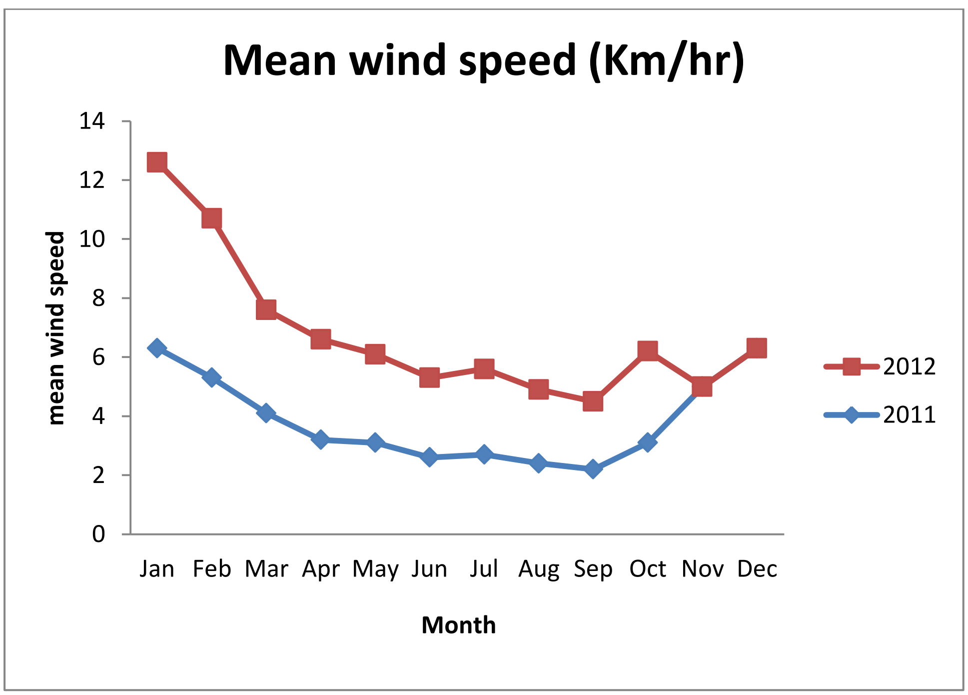
Mean sunshine hours

Month	2011	2012
Jan	263	294
Feb	239.1	265.4
Mar	268.9	234.7
Apr	199.2	199.2
May	211.7	185.5
Jun	74.1	78.4
July	50.9	99.5
Aug	68.7	90.7
Sept	139.9	137.4
Oct	190.4	192.1
Nov	188.9	270
Dec	226.6	288.3



Mean wind speed (km / hr)

Month	2011	2012
Jan	6.3	6.3
Feb	5.3	5.4
Mar	4.1	3.5
Apr	3.2	3.4
May	3.1	3
Jun	2.6	2.7
July	2.7	2.9
Aug	2.4	2.5
Sept	2.2	2.3
Oct	3.1	3.1
Nov	5	
Dec	6.3	



Appendix II

Grain size distribution of the samples (sieve analysis)

Sample soil from coconut plot

Sl no	IS sieve	Particle size	Mass retained	% Retained	Cumulative % retained	Cumulative % finer
1	4.75	4.750	-	-	-	100
2	2.00	2.000	179.5	35.09	35.09	64.91
3	1.00	1.000	77	15.05	50.14	49.86
4	600	0.600	59	11.53	61.67	38.33
5	300	0.300	68.5	13.39	75.06	24.94
6	212	0.212	59	11.53	86.59	13.41
7	150	0.150	12.5	2.44	89.03	10.97
8	75	0.075	30.5	5.962	94.99	5.01

Soil sample from mango orchard plot

Sl no	IS sieve	Particle size	Mass retained	% Retained	Cumulative % retained	Cumulative % finer
1	4.75	4.750	-	-	-	100
2	2.00	2.000	29	4.84	4.84	95.16
3	1.00	1.000	32	5.34	10.18	89.82
4	600	0.600	43.5	7.25	17.43	82.57
5	300	0.300	48	8	25.43	74.57
6	212	0.212	215.5	35.94	61.37	38.63
7	150	0.150	36	6	67.37	32.63
8	75	0.075	150	25.02	92.39	7.61

Appendix III

Determination of dry density, bulk density and moisture content of samples

Sl no	Particulars	units	Sample1	Sample2
1	Mass of container + wet sample (M_1)	g	64.5	72
2	Mass of container (M_2)	g	23	23
3	Mass of wet sample (M_3)	g	41.5	47
4	Moisture content	%	19	20.5
5	Bulk density	g/cc	1.85	1.8
6	Dry density	g/cc	1.55	1.55

Appendix IV

Field capacity of soil samples			
Soil type	**Initial weight (gm)**	**Final weight (gm)**	**Field capacity (%)**
Soil sample1 (Coconut field)	21	18.5	13.5
Soil sample 2 (Mango orchard)	23	21	9.52

Wilting point			
Soil type	**Initial weight (gm)**	**Final weight(gm)**	**Wilting point (%)**
Soil sample1 (Coconut field)	14.5	13	11.54
Soil sample 2 (Mango orchard)	21.5	20	7.5

Available water content			
Soil type	**Field capacity**	**Wilting point**	**Available water content (%)**
Soil sample1 (Coconut field)	13.5	11.54	1.96
Soil sample 2 (Mango orchard)	9.52	7.5	2.02

Appendix V

Observations on cylinder infiltrometer

Elapsed time (min)	Interval (min)	Distance of water surface from reference point			Infiltration during period	
		Initial depth(cm)	Final depth(cm)	Decrease in water level(cm)	Average rate (cm/hr)	Accumulated infiltration(cm)
-	-	11.0	-	-	-	-
5	5	11.0	9.10	1.90	22.80	1.90
10	5	11.0	9.40	1.60	19.20	3.50
15	5	11.0	10.20	0.80	9.60	4.30
25	5	11.0	9.50	1.50	18.00	5.80
45	20	11.0	8.11	2.89	8.67	8.69
60	15	11.0	9.00	2.00	8.00	10.69
75	15	11.0	9.00	2.00	8.00	12.69
90	15	11.0	8.30	2.70	10.8	15.39
110	20	11.0	8.30	2.70	8.10	18.09
130	20	11.0	8.30	2.70	8.10	20.79

Appendix VI

Location of wells in KCAET campus

Well Number	Type of well	Location
W1	Open well	Near kelappaji's house
W2	Open well	North west corner of boundary
W3	Filter point	North west corner of boundary
W4	Filter point	Near coconut farm
W5	Open well	Near farm building
W6	Open well	Near coconut farm
W7	Open well	Near Dairy farm
W8	Open well	Near east corner of boundary
W9	Open well	Near east corner of boundary
W10	Open well	Near farm garden
W11	Open well	Near mango orchard
W12	Tube well	North west corner of boundary
W13	Tube well	North west corner of boundary
W14	Open well	Near temple
W15	Open well	Near temple
W16	Open well	
W17	Open well	
W18	Filter point well	Near mango orchard
W19	Filter point well	Near poly house
W20	Filter point well	In paddy field
W21	Filter point well	In paddy field
W22	Filter point well	Near rain water harvesting pond

Appendix VII

Crop coefficient (K_c) for major crops of Kerala

Crop	**K_c**
Vegetables	1.0
Pulses	1.0
Tapioca	0.4
Banana	0.4-0.85
Coconut	0.75
Cardamom	1.0
Tea	1.0
Mango	0.8
cocoa	1.0

Appendix VIII

Friction losses for flow of water (m/ 100m) in smooth pipes

Discharge (lit/sec)	**Bore diameter (mm)**									
	20	**25**	**32**	**40**	**50**	**65**	**80**	**100**	**125**	**150**
0.5	16.4	5.5	1.66	0.56						
1.0		10.0	6.00	2.00	0.68					
1.5			12.70	4.30	1.45	0.40				
2.0			16.00	7.30	2.50	0.68	0.25			
3.0				15.50	5.20	1.45	0.53			
4.0				26.40	8.90	2.50	0.90	0.30		
5.0					13.40	3.80	1.36	0.46		
6.0					18.80	5.20	1.90	0.64	0.22	
7.0						6.90	2.50	0.84	0.29	
8.0						8.90	3.20	1.10	0.37	0.1
9.0						11.10	4.00	1.36	0.46	0.19
10.0						13.40	4.90	1.66	0.55	0.32

Appendix IX

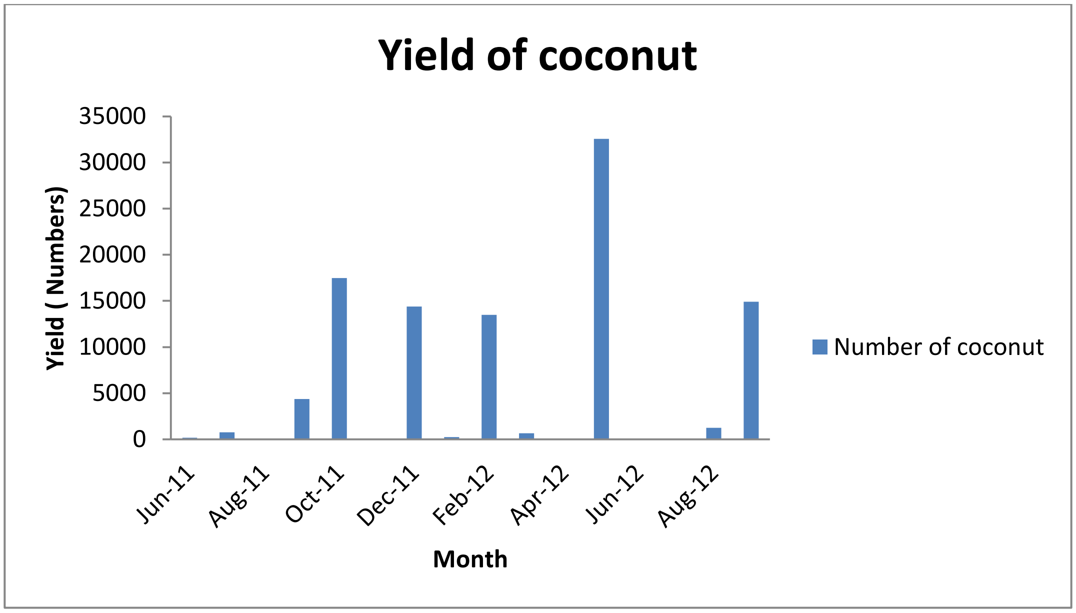
Friction head loss in meters per 100 m pipe length

Discharge (lit/sec)	Inside diameter (mm)						
	9.2	**11.7**	**12.7**	**13.9**	**15.8**	**18.0**	**19.0**
200	10.2	5.2	2.5	1.7	0.8	0.4	0.3
400	39.0	18.0	8.6	5.7	2.7	1.6	1.1
600		39.0	18.0	13.0	5.9	3.2	2.5
800			30.0	21.0	10.0	5.5	4.1
1000			45.0	30.0	16.0	8.3	6.2
1200			42.0	21.0	11.0	8.8	
1400				56.0	28.0	16.0	11.0
1600					36.0	20.0	15.0
1800					45.0	25.0	19.0
2000					54.0	30.0	23.0

Appendix X

Yield of coconut from 2011 July- 2012 September

Month	2011
Jun-11	175
Jul-11	750
Aug-11	
Sep-11	4362
Oct-11	17470
Nov-11	
Dec-11	14387
Jan-12	238
Feb-12	13500
Mar-12	650
Apr-12	
May-12	32545
Jun-12	
Jul-12	
Aug-12	1235
Sep-12	14925


Yield of coconut
Yield (Numbers)
35000
30000
25000
20000
15000
10000
5000
0
Jun-11
Aug-11
Oct-11
Dec-11
Feb-12
Apr-12
Jun-12
Aug-12
Month
Number of coconut

DESIGN OF AN APPROPRIATE IRRIGATION SYSTEM FOR KCAET FARM

By

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THULASI MOHAN, P.U

PROJECT REPORT

Submitted for the partial fulfillment of the requirement for the degree

Bachelor of Technology
In
Agricultural Engineering

Faculty of Agricultural Engineering and Technology
Kerala Agricultural University

Department of Irrigation and Drainage Engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR-679 573, MALAPPURAM
2013

ABSTRACT

As in the current scenario water availability is a serious problem because of higher demand of water for agriculture, industry etc.The present study was aimed to design an appropriate irrigation system for non irrigated areas of KCAET farm. The campus is spread over an area of 40.99 ha out of which cropped area is 30.66 ha. Majority of water requirement of cropped field is met by surface methods of irrigation like check basin, furrow and border strip irrigation. In the surface method of irrigation lot of water is wasted by evaporation

Since the water availability for irrigation purpose is diminishing day by day. Improved irrigation technology offers an opportunity for agriculture to alleviate water scarcity and more effectively allocate water resources. The system design start with selection of suitable emitters depending on type of crop, water requirement, operating type, soil type, water quality etc. The length and size of lateral is determined by surveying the field. Main line is provided at the centre of field so that friction head loss is within the limit and total pressure required for the system is within the pump or water source capacity. The total quantity of components were estimated so as to compute or calculate the total cost of irrigation system.