Standardization of Irrigation Requirement of Cowpea under Naturally Ventilated Poly House

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled **“Standardization of Irrigation Requirement of Cowpea under Naturally Ventilated Poly House”** is a bonafide record of research work done by us during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Place: Tavanur

Date: 07.02.2015

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CERTIFICATE

Certified that this project report entitled, **“Standardization of Irrigation Requirement of Cowpea under Naturally Ventilated Poly House”** is a record of project work done jointly by Arunya S. Kumar, Athulya, T.K., Sahla, N. under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

Place: Tavanur
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DEDICATED TO

AGRICULTURAL

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SYMBOLS AND ABBREVATIONS

Cm	Centimetre
CWR	Crop Water Requirement
et al.	Others
etc	etcetera
ET	Evapotranspiration
ET_c	Crop evapotranspiration
ET_o	Reference crop evapotranspiration
FAO	Food and Agricultural Organization
g	Gram
g/l	Gram per litre
hp	Horse power
hr	hour
IWUE	Irrigation Water Use Efficiency
K	Potassium
K_c	Crop coefficient
KAU	Kerala Agricultural University
KCAET	Kelappagi College of Agricultural Engineering and Technology
kg	Kilogram
kg/day	Kilogram per day
kg/h	Kilogram per hour

kg/h-mm	Kilogram per hour millimetre
km/day	Kilo meter per day
L	Litre
m	Meter
m^2	Square meter
m^3	Cubic meter
min	minute
$MJ/m^2/day$	Mega joules per square meter per day
ml	millilitre
mm	millimetre
mm/day	millimetre per day
mm/dec	millimetre per decade
N	Nitrogen
P	Phosphorous
PAR	Photosynthetically Active Radiation
PFDC	Precision Farming Development Centre
PVC	Poly Vinyl Chloride
viz	that is
^oC	Degree Celsius

INTRODUCTION

CHAPTER 1

INTRODUCTION

Water is essential for human civilisation, living organisms and natural habitat. It is used for drinking, cleaning, agriculture, transportation, industry, recreation, animal husbandry and for producing electricity for domestic, industrial and commercial use. Due to its multiple benefits and the problems created by its excesses, shortages and quality deterioration, water as a resource requires special attention. On a global scale, total quantity of water available is about 1600 million cubic kilometres. The hydrologic cycle circulates enormous quantity of water around the globe. However, much of the world's water has little potential for human use because 97.5% of the water on earth is saline. Out of the remaining 2.5% fresh water, most of which lies deep and frozen in Antarctica and Greenland, only about 0.26% in rivers, lakes and in the soils and shallow aquifers which are readily available for mankind. Land occupies nearly 20 percent of the earth surface, covering around 13000 million hectares of the total area.

Agricultural production system is the outcome of a complex interaction of seed, soil, water and agro-chemicals (including fertilizers). Therefore, judicious management of all the inputs is essential for the sustainability of such a complex system. The focus on enhancing the productivity during the Green Revolution coupled with total disregard of proper management of inputs without considering the ecological impacts, has resulted into environmental degradation. The only alternative left to enhance productivity in a sustainable manner from the limited natural resources at the disposal, without any adverse consequences, is by maximizing the resource input use efficiency.

Agricultural intensification is commonly attained through irrigation and fertigation coupled with protected cultivation. With drip fertigation, nutrient use efficiency can be increased and the loss of nutrients to the ground water is reduced. The use of drip irrigation saves water and gives better plant yield and quality as it reduces the humidity build up inside greenhouse after irrigation due to precise application of water to the root zone of the crop. Successful fertigation requires precise calculation of injection rates, knowledge regarding solubility of different nutrients in water and knowledge on how to apply it with different fertigation equipments. Since the volume of root medium under greenhouse cultivation is relatively smaller compared to the volume under open conditions, frequent replenishment with balanced amount of plant nutrients is very crucial. Air in the vicinity of greenhouse crops is generally more humid compared to the crop in the open fields, because the greenhouse air does not get mixed with open air. Humidity inside the greenhouse keeps on increasing due to evapotranspiration. The productivity of crop is based on effective utilization of water and fertilizer, along with other agricultural inputs. Fertigation provides flexibility of fertilizer application, which enables three specific nutritional requirement of the crop to be met at different stages of its growth. Micro climate inside poly house is maintained at favourable conditions for plant growth and yield. Cultivation of crops under this condition and varying irrigation and fertigation levels show some significant effect on performance of crop which is becoming popular among Indian farmers. Climate that can be optimized by different ways is a beneficial impact of structure over open field cultivation.

Precision farming is generally defined as information and technology based farm management system to identify, analyse and manage variability within fields for optimum profitability, sustainability and protection of the land resources. In this mode of farming, new information technologies can be used to make better decisions about many aspects of crop production. Precision farming is helping many farmers worldwide to maximize the effectiveness of crop inputs. Precision agriculture often referred to as GPS (Global Positioning System) agriculture or variable rate farming. The potential of precision farming for economical and environmental benefits could be visualized through reduced use of water, fertilizers, herbicides and pesticides besides the farm equipments. Instead of managing an entire field based upon some hypothetical average condition, which may not exist anywhere in the field, a precision farming approach recognizes site-specific differences within field and adjusts management actions accordingly. Farmers usually are aware that their fields have variable yields across the landscape. These variations can be traced to management practices, soil practices and environmentalcharacteristics.Soil characteristics that affect yields include texture, structure, moisture, organic matter, nutrient status and landscape position. Environmental characteristics include weather, weeds, insects and diseases.

In India traditional farming is prevalent but now new farming technology like poly house farming provides better income in a short period of time with less labour. Poly house farming is an alternative new technique in agriculture gaining foot hold in rural India. It reduces dependency on rainfall and makes the optimum use of land and water resources. Poly house cultivation is known as isolated, intensive and protective cultivation, which results in a quality crop produce, which has a high demand in local and overseas market. Normally the people can recover the investment within 2 ½ - 3 years. Poly house farming also promises to extent the harvest life of vegetables like cowpea by one to one-and-a-half months. Capsicum, salad cucumber, tomatoes and cowpeas have been great success in the poly houses in Kerala and the number is expected to go up to more than a 1,000 this financial year.

Advantages of poly house:

- Protection from rain and wind.
- Climate can be controlled.
- Minimum labour required.
- Better control over pests and diseases.
- Maximum yield per unit area.
- Good market value due to high quality crops.

Poly house farming process requires expertise in three areas such as construction of the structure, cultivation techniques and marketing. It entails construction of a metal structure covered by polythene sheet. Parameters such as moisture, soil nutrients and temperature in the poly house are controlled to ensure timely and abundant yields.

CROPWAT is a DOS or WINDOWS based decision support system designed as a tool to help agro-meteorologists, agronomists and irrigation engineers to carry out standard calculations for evapotranspiration and crop water use studies, particularly the design and management of irrigation schemes. It allows the development of recommendations for improved irrigation practices, planning of irrigation schedules under varying water supply conditions and the assessment of production under rainfed conditions or deficit irrigation. It is used as a tool for testing the efficiency of different irrigation strategies (irrigation scheduling, improved irrigation efficiency) under climate change. CROPWAT does not have the capacity of simulating the direct effects of rising atmospheric carbon dioxide concentration on crop water use. Inorder for CROPWAT to provide efficient and correct data, the user needs to insert data about the evapotranspiration process, i.e. the quantity of water evaporated from the soil and eliminated by plants into the atmosphere. The data can be entered manually by filling in the forms provided by the inlays from the left side of the main window. Therefore, users will have to observe weather changes and have access to information regarding the climate (temperature, humidity, wind, sun, etc.), as well as other parameters such as the monthly throughfall quantities and soil characteristics. To sum up, CROPWAT is a valuable application for farmers or crop and soil specialists that can supply detailed data about the necessary quantity of water necessary to obtain maximum crop yields.

Irrigation scheduling, or irrigation water management, ensures that water is consistently available to the plant and that it is applied according to crop requirements.

Proper irrigation scheduling will improve profitability and water use efficiency by

1. Maximizing crop yield and quality;
2. Decreasing water lost through deep percolation and runoff; and
3. Optimizing pumping costs.

To effectively schedule irrigation applications, four key pieces of information need to be known:

1. Soil texture;
2. Water holding capacity of the soil;
3. Soil moisture content; and
4. Crop water use at the specific development stage.

Another factor that should be considered within a scheduling program knows the allowable depletion of the crop that is how much water can be removed from the soil profile prior to stressing the crop. The limitations of an irrigation system can impact a scheduling program, so it is necessary to be aware of how much water can be applied efficiently to the crop and the time duration required applying a specific amount of irrigation. This work is intended to provide the irrigators information needed to properly schedule irrigation on their farms.

` In India, the irrigated area consists of about 36 per cent of the net sown area. Presently, the agricultural sector accounts for about 83 per cent of all water uses. The remaining uses include 5, 3, 6 and 3 per cent respectively, by domestic, industrial and energy sectors and other consumers. Increasing competition with the other water users in the future would limit the water availability for expanding irrigated area. In traditional surface irrigation methods, the losses of water during conveyance and application are large. These losses can be considerably reduced by adopting micro irrigation methods (drip irrigation). The term micro irrigation describes a family of irrigation systems that apply water through small devices. These devices deliver water to the soil surface directly into the plant root zone. In India, efforts were made to introduce micro irrigation system at farmer's level from around 1980. Micro irrigation conserves irrigation water easily, doubling the command area of a water resource, with a yield increase of up to 50 per cent. Growers, producers and landscapers have adapted micro irrigation systems to suit their needs for precision water application. Micro-irrigation systems are immensely popular not only in arid regions and urban settings but also in sub humid and humid tropical zones where water supplies are limited. In irrigated agriculture, micro-irrigation is used extensively for row crops, mulched crops, orchards, gardens, greenhouses and nurseries. In urban landscapes, micro-irrigation is widely used with ornamental plantings.

Advantages of micro irrigation are:

Water saving: Conveyance loss is minimum and evaporation, runoff and deep percolation are reduced as compared to other traditional irrigation systems. A water supply source with limited flow rates such as small wells or city/rural water can be used.

Energy saving: Power consumption is less compared to other systems and every drop of water saved is equivalent to energy saved.

Weed and disease reduction: Because of limited wetting area of micro irrigation, weed growth is inhibited and disease incidences reduced.

Automation and fertigation facility: Fertilizers and chemicals can be applied with water through the irrigation system. Micro irrigation systems can be automated which reduces labour requirements.

Improved production on marginal line: In hilly terrain, micro irrigation systems can operate without runoff and any interference due to wind. The field levelling is not required.

Among all the irrigation methods, drip irrigation is the most efficient and can be practised in a large variety of crops, especially in vegetables, orchard crops, flowers and plantation crops. Drip irrigation, also known as trickle irrigation or localized irrigation, is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. It is done through narrow tubes that deliver water directly to the base of the plant, at a low rate varying from 2 to 20 lit res per hour. The soil moisture is kept at an optimum level with frequent irrigations. Drip irrigation results in a very high water application efficiency of about 90-95 per cent.

The main objective of the present study is to standardise the irrigation requirement of cowpea under naturally ventilated poly house and the specific objectives of the study are:

1. Determination of the water requirement of the cowpea using CROPWAT.
2. Preparation of irrigation schedule for cowpea under naturally ventilated poly house.

REVIEW
OF
LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

This chapter includes the previous researches related to the present study which gives general information about poly house, CROPWAT software, irrigation inside the poly house and its effects on yield of crop.

2.1 Poly House Farming

Morphological development like plant height, number of branches per tomato plant, leaf area expansion rate and leaf area index were positively favoured due to the warmer environment inside the poly house (Duhr and Dubas, 1990; Miah 2001; Pandey *et al*., 2004) inspite of lower amount of PAR.

Ganesan (1999) conducted a study to define the effect of changes in microclimate produced by poly greenhouse conditions on plant growth characteristics and fruit yield of tomato. The UV stabilized plastic film covered greenhouse recorded higher day temperature than the open environment but relative humidity at 8 AM was lower inside the green house except from May to August. The light intensity inside the green house was lower than in the open. Height of the plant, number of nodes, internodal length, total dry matter production and average fruit weight increased under green house conditions as compared to open field condition. The fruit yield inside the green house was nearly two times more than in the open field condition.

Von Zabeltitz (1999) reported that the main advantage with green house farming is that the production can be got throughout the year, which is not possible in the open field farming due to heavy rainfall and wind, especially in tropical regions.

Harmanto (2002) evaluated the water requirement for the tomatoes grown under drip fertigation system in tropical greenhouse conditions. The specific objectives of the study were to: (1) determine the optimum water requirement of drip irrigated tomato plants, (2) compare the evapotranspiration estimated from microclimate inside and outside the greenhouse and (3) assess the drip system performance under greenhouse condition. They reported that an average irrigation rate of 0.5 l /plant/day was found to be optimum amount of water for maximizing the tomato yield. The application of irrigation at lower amount (deficit irrigation) of the water requirement gave lower yield. But increasing the irrigation water over a certain level (over irrigation) did not increase the tomato yield above maximum yield. So, the irrigation should be given as precise as possible to the plant close to the optimum. The optimum amount of irrigation was very close to the crop evapotranspiration which was calculated from the dynamic microclimate inside the greenhouse during the experiment.

Montero and Anton (2003) reported that the lower amount of incident PAR under poly house as compared to the open field was due to the greater inference of the roof of poly house against the incoming solar radiation. Although poly house permits easy entrance of short wave radiation, it traps the outgoing long wave radiation. As a result the air temperature inside the poly house gradually increases due to the green house effect. The warm air inside the poly house induces soil warming. Therefore, soil temperature was also higher under poly house than open field.

Willits (2003) reported that cooling has always been an important problem for poly house operators in warm climates, potentially limiting production and constraining profits. Poly house cooling is typically accomplished by ventilation, either mechanically via exhaust fans or naturally via wind.

Early maturity is one of the important aspects for harvesting of fruit earlier. Total fruit bearing period was also prolonged under poly house. For that reason 13 total number of fruit harvests were more in poly house than open field (Pandey *et a*l., 2004).

An optimum day temperature of 28 ºC is required for better production of tomato (Sato *et al.*, 2006 and Adil *et al*., 2004) which remained in the poly house during December to February whereas the ambient temperature was far below than the optimum which affected the growth, development and ultimately yield of tomato.

Neha and Anirudha (2009) reported that the typical poly houses are from 500 square meters to 10,000 square meters, which makes them suitable for farmers with small land holding. The poly house also differ in terms of cost. Government of India gives 50% subsidy for low cost poly houses, 2 % for medium cost poly houses and 10% for high cost poly houses as an incentive. Information for the installation of the Poly house is provided by various agriculture universities, District Central Nurseries and also by private consultants. Currently, farmers from the states of Himachal Pradesh, Punjab and Maharashtra are taking interest in poly house farming.

Parvej *et al.* (2010) conducted an experiment in a covered poly house along with open field planting to compare the phenological development and production potentials of two tomato varieties viz. BARI Tomato-3 and Ratan under poly house and open field conditions. Photosynthetically active radiation inside the poly house was reduced by about 40% compared to the outside (i.e. open field) while air and soil temperatures always remained higher. Relative humidity had opposite trends with that of air temperature i.e. it was lower inside the poly house as compared to open field. The above microclimatic variability inside poly house favoured the growth and development of tomato plant through increased plant height, number of branches/plant, rate of leaf area expansion and leaf area index over the plants grown in open field. Poly housed plants had higher number of flower clusters/plant, flowers/cluster, flowers/plant, fruit clusters/plant, fruits/cluster, fruits/plant, fruit length, fruit diameter, individual fruit weight, fruit weight/plant and fruit yield over open field condition.

Prathiba and Sivaji (2013) suggested that by using polythene sheets poly houses are constructed to provide secured and controlled environment for the proper growth of the plant. As the plants grow in a controlled environment inside a poly house gives the advantage of high yield irrespective of environmental changes, climatic changes and also location. Also it provides suitable environment for the growth of the plant and protect the plants growing inside the poly house from abnormal weather conditions and from different plant diseases. The required environment for plants growth and increased productivity can be met by adopting poly house cultivation method.

Rajasekar *et al. (2013)* took up studies to screen ten vegetables for cultivation under shade net house (33% shade) and open field for year round production of vegetables. Tomato, egg plant, chilli, cucumber, cluster bean, radish, amaranthus, coriander and capsicum were grown in the summer and winter. The influence of environmental variables temperature, relative humidity and light intensity were studied. Relative humidity was always higher under shade net house than in open field during both seasons. Light intensity in the shade net house was lower than in the open field. Mean weekly temperature during summer and winter were higher under open field conditions than in the shade net house. Lower temperature caused plant height, number of branches, inter-nodal length, average fruit weight and yield per plant to be higher in the shade net house than in the open field.

2.2 Water Requirement

Bithell and Smith (2011) reported that the method to estimate crop irrigation water volumes for the Tindall Limestone Aquifer, Katherine, Water Allocation Plan. Estimates of volumes are needed for water allocation planning. An assessment is also given of the method’s usefulness in estimating crop irrigation volumes elsewhere for water allocation plans. Such information will be of interest to water allocation planners, water users and irrigators.

Raihan (2013) focussed on analyzing the irrigation water requirement of Wheat in Barind area of Bangladesh. The study was carried out from 2002 to 2011 in nine upazillas of Barind area under Rajshahi district. Reference Evapotranspiration was estimated using FAO Penman-Monteith method. Reference Evapotranspiration and crop coefficient of selected crops were used for estimating crop water requirement. By using estimated effective rainfall and crop water requirement, the irrigation water requirement was determined. The maximum evapotranspiration was estimated in 2004 and minimum was estimated in 2011 during the period of 2002-2011. The irrigation water requirement for Wheat was higher in the vegetative and mid-season stage from December to January and comparatively less irrigation water was required in initial and maturity stage. IWR decreases in the month of March as wheat was in maturity stage. It was also found that irrigation water requirement was less in the maturity stage as compared to the initial stage.

2.2.1 Water Requirement inside Poly House

Allen *et al.* (1998) suggested that K_c values results to vary by crop, development stage and management.

Fernandez (2000) directed towards studying both the water use and development of the crop coefficients for crops grown in greenhouse. In Mediterranean areas, the seasonal ET of greenhouse horticultural crops is quite low when compared to that of irrigated crops outdoors. This is due, firstly, to a lower evaporative demand inside a plastic greenhouse, which is 30-40% lower than outdoors throughout the entire greenhouse cropping season.

Baille (2001) found that by applying a dense white paint to glass, a reduction of about 50% on solar radiation resulted. This drastic change in the greenhouse radiation load led to indirect modifications of other microclimatic variables such as air temperature and vapour pressure deficit, through the microclimate interactions.

Orgaz *et al.*, (2005) conducted an experiment to determine K_c for horticultural crops under greenhouse (melon and watermelon). The K_c values were found to be similar to those under field conditions.

Neelam and Rajput (2011) suggested that poly house cultivation gives higher yield, higher productivity, better quality produce and production throughout the year. Capsicum (*Capsicum annum L.)* is a valuable vegetable crop with excellent prospect both for the domestic and export market. To ensure its regular and off-season supply, technology for growing of capsicum under protected conditions needs to be standardized. Irrigation is one of the most important inputs, which affects the yield and quality of agricultural produce from poly house. Efficient irrigation in poly house can be achieved by accurate estimates of evapotranspiration. The important factors to control the poly house evapotranspiration are solar radiation, air temperature, relative humidity and wind speed. Control and monitoring of environmental parameters inside a Poly house, so as to ensure continuous maintenance of favourable crop atmosphere is the objective of the work presented in this paper. The objective is achieved through the use of internet based technology.

2.3 CROPWAT

During nineties, CROPWAT, a computer program for irrigation planning and management developed by FAO (Smith, 1992), had been getting particular importance among irrigation engineers.

The field experimental data from the Hsueh Chia Experimental Station of Chia Nan Irrigation Association in Taiwan were collected and analyzed then input the results to the CROPWAT irrigation management model that was developed by the Food Agricultural Organization (FAO). The results from CROPWAT model show that the annual potential evapotranspiration and effective rainfall in Hsueh Chia area are 1444 mm and 897 mm, respectively. In the paddy fields, the crop water requirements and deep percolation are respectively 962 mm and 295 mm for the first rice crop and 1114 mm and 296 mm for the second rice crop. The research shows that the irrigation management model can effectively and efficiently estimate the crop water requirements (Kuo, 2001).

Nazeer (2009) conducted a study on CROPWAT simulation under irrigated and rain fed conditions for maize crop, in order to provide information necessary in taking decisions on irrigation management. Simulation results analysis suggests that areas, where the maize water requirements exceeds the water supply, by application of adequate irrigation scheduling the yield losses can be significantly reduced.

Adeniran *et al.* (2010) carried out a study to determine the crop water requirement of some selected crops for the area around Kampe (Omi) Dam Irrigation Project. Crop water requirement for each of the crops was determined by using 25 year climatic data in CROPWAT. The study shows that the dam can conveniently supply the water required for irrigation in the area used at present and also in the entire land area.

The assessment of irrigation water needs at Muda Irrigation Scheme, Kedah, Malaysia due to climate change can lead to better irrigation water management for the operating systems of Pedu-Muda Reservoir in the future. Nurul and Sobri (2012) conducted a study with the objective of measuring irrigation water requirement of Pedu-muda reservoir for paddy plantation (two seasons) using two different methods, (Blaney-Criddle method and CROPWAT model) to compare the capability of both methods and to evaluate the reliability of CROPWAT version 8.0 model in predicting future trend of irrigation water. In this study, the SDSM tool was used to simulate future climate trend from the year 2010 to 2099 and revealed that the temperature and rainfall are estimated to increase in the future year. In effort to measure the irrigation needed at the region, CROPWAT model was found to be more reliable and capable compared to the Blaney-Criddle method. From year 2010 to 2099, the annual irrigation requirement is estimated to slightly decrease at every interval year even though the ET_{crop} is expected to increase due to the effect of rising temperature in the future.

Sudip *et al*. (2012) carried out a study to assess the impact of climate change on crop water requirement. In this study, potato was taken as the reference crop for its growing period and its high response to irrigation. The ET values from the potato field were measured using field water balance method and the data was used to validate the CROPWAT model. After proper validation of CROPWAT model, the model was used to determine the irrigation requirement of potato using current and future (prediction years: 2020 and 2050) weather data. It was observed that irrigation water requirement will be increased by 7 to 8% during 2020, while it may increase about 14 to 15% during 2050.

Megha and Sabeena (2013) conducted a study to determine the crop water requirement and irrigation schedule of eleven major crops. In the study CROPWAT model was used to estimate the CWR and irrigation scheduling using climate data obtained from the nearby Meteorological station located at RARS, Pattambi. Crop data required for the software were taken from FAO 56 and 24, 1996. The soil data obtained from the results of various experiments conducted in the KCAET laboratory were also used as input to the model. The crop water requirement of eleven crops viz. amaranthus, snake gourd, cowpea, cucumber, water melon, pumpkin, bhindi, ashgourd, sesamum, banana and rice were calculated and the results were 187.7 mm, 341.5 mm, 405.9 mm, 418,2 mm, 381.7 mm, 375.5 mm, 398.2 mm, 486.4 mm, 56.7 mm ,118.2 mm and 430.1 mm respectively. From the study it was clear that the computation of total CWR became effortless, less time consuming and more accurate.

2.4 Drip Irrigation

Sivanappan *et al.* (1977) conducted experiments to compare drip irrigation with other methods and showed that farmers saves up to 80% water, reduces weed growth, improves germination and gives the same or sometimes more yield.

Mane *et al.* (1987) conducted an experiment on comparative study of drip and furrow method of irrigation for bindhi crop and revealed that drip irrigation method of irrigation recorded maximum yield of bindhi (17.72 t-ha^{-1}). Drip method increased the yield by 16.14 per cent with water saving of 39.6 per cent when compared with conventional furrow method. The water use efficiency in case of drip method was 5.46q/ha/cmwhich was nearly twice the furrow method.

According to Sheela (1988) average conveyance loss of water in the basin method while irrigating 1 ha of land was 27.7 % where as these losses were found to be considerably less under trickle irrigation system.

Anitha *et al*. (1990) conducted a study to design and develop an automatic drip irrigation system. The study showed that labour cost and operational costs could be reduced by this system thereby achieving a highly economic and efficient irrigation application.

Singh *et al.* (2000) made an attempt to study the effect of drip irrigation compared to conventional irrigation on growth and yield of apricot, to work out its irrigation requirement. Drip irrigation at 80 per cent evapotranspiration of water gave significantly higher growth and fruit yield of 8.6 tonnes per hectare compared to that surface irrigation. Plastic mulch plus drip irrigation further raised the fruit yield to 10.9 tonnes per hectare. Drip irrigation besides giving a saving of 98 percent irrigation resulted in 3.3 metric tonnes per hectare higher fruit yield.

Jain *et al.* (2001) conducted experiments on the response of potato under drip irrigation and plastic mulching. The highest water use efficiency was found to be 3.24t/ha-cm for the treatment irrigated with drip system at 80 per centlevel with mulch as compared with to 2.17 t/ha-cm control treatment.

Singh *et al.* (2001) conducted studies on drip irrigation resulted in significant increase in production and water use efficiency of potato. At Udaipur it was reported that besides saving in water, the yield of potato tubers was high and weed growth was least in drip irrigation compared to surface irrigation.

Micro irrigation systems save irrigation water by 40% and fertilizer by 25%, enhances yield up to 50%, improves water use efficiency by 2 to 4 times with benefit cost ratio of 2.77 (without subsidy) and 3.5 on subsidized cost. Through the good management of micro irrigation systems, the root zone water content can be maintained near field capacity throughout the season providing a level of water and air balance close to optimum for plant growth. In addition, nutrient levels that are applied with water through the system (fertigation) can be controlled precisely (Samra, 2005).

Yuan *et al., (2006)* studied the effects of different amount of irrigation water on the growth and yield of cucumber under a rain shelter for two seasons in Yamaguchi University, Japan. For spring experiment, the amount of irrigation water applied was 0.50, 0.75, and 1.00 times of water surface evaporation (Ep) and regimes were denoted as Ep0.50, Ep0.75, and Ep1.00. Same method for autumn experiment, regimes were denoted as Ep0.75, Ep1.00, Ep1.25, Ep1.50, and Ep1.75. The results showed that amount of irrigation water significantly affected plant growth and fruit production. Plant height and biomass increased, but specific leaf weight (SLW, g/m^2) decreased with increasing amount of irrigation water.

Schwankl *et al*. (2007) defined drip irrigation as an irrigation method that transverse the water under a definite pressure, after filtering, through pipe network into the soil surrounding the root system of plants in drops slowly and uniformly. The emitters are to drip the pressured water in the pipeline to the root of the crops evenly and steadily, so as to guarantee the water demand for crop growth. The quality of the emitter has an important effect on the reliability, life span of the drip irrigation system and quality.

Deepa *et al.* (2010*)* conducted a study to standardize the irrigation requirement of salad cucumber grown in poly house. The experiment had five irrigation treatments with six replications. Two types of irrigation basin and drip were practiced. The irrigation treatments include drip irrigation with 1, 1.5, 2 and 2.5 lit/day of water. From the study it was found that drip irrigation has a positive effect on growth and yield of crop. Crops drip irrigated with 1.5 l/plant/day performed well with a water use efficiency of 121. Drip irrigation in comparison with the surface irrigation has given higher yield throughout the crop period. And also drip irrigation has shown larger soil moisture content a day after irrigation, while the conventional surface irrigation has least soil moisture content.

MATERIALS AND METHODS

CHAPTER 3
MATERIALS AND METHODS

3.1 Location

The experiment was conducted during the wet seasons of 2014 under the naturally ventilated poly house (292 m^2) of PFDC, KCAET, Tavanur, Kerala using cowpea. The soil type of the experimental plot was sandy loam.

3.2 Water requirement

The water requirement of cowpea was determined using CROPWAT. The CROPWAT is used for testing the efficiency of different irrigation strategies (irrigation scheduling, improved irrigation efficiency) under climatic change.The key to effectiveness of irrigation water management lies in proper estimation of crop water requirements, which are primarily based on cropping pattern, rainfall in the area and other climatic factors. Computer model simulation is an emerging trend in the field of water management. CROPWAT is one of the models extensively used in the field of water management throughout the world. CROPWAT facilitates the estimation of the crop evapotranspiration, irrigation schedule and agricultural water requirements with different cropping patterns for irrigation planning.

CROPWAT for Windows uses the FAO Penman-Monteith method for calculation of reference crop evapotranspiration (Allen *et al.,* 1998). The development of irrigation schedules and evaluation of rain fed and irrigation practices are based on a daily soil-moisture balance using various options for water supply and irrigation management conditions. Scheme water supply is calculated according to the cropping pattern provided in the program (Clarke *et al*., 1998). Studies have shown that the Penman-Monteith method is more reliable than methods that use less climatic data (Jensen *et al.*, 1990).

$$ET_0 = \frac{0.408\,\Delta\,(\mathrm{R_n} - \mathrm{G}) + \gamma\,\frac{900}{\mathrm{T}+273}\,\mathrm{U_2}(\mathrm{e_s} - \mathrm{e_a})}{\Delta + \gamma\,(1 + 0.34\,\mathrm{U_2})}$$

Where,

ET_0 = Reference evapotranspiration (mm/day)

R_n = Net radiation (MJ/ (m^2 day))

G = Soil heat flux density (MJ/ (m2 day))

U_2 = Wind speed at a height of 2 m (m/s)

e_s = Saturated vapour pressure (kPa)

e_a = Actual vapour pressure of the air at standard screen height (kPa)

γ = Psychrometer constant (kPa/°C)

Δ = Slope of the saturation vapour pressure curve between the average air temperature and dew point (kPa/°C)

T = Mean daily air temperature (°C)

$ET_C = ET_0$ * Crop coefficient

ETc is termed as the crop water requirement (CWR) in mm/day, which is defined as the depth of water needed to meet the water loss through evapotranspiration of a disease free crop, growing in fields under non-restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment (Doorenbos and Pruitt, 1977; Doorenbos and Kassam, 1979.)

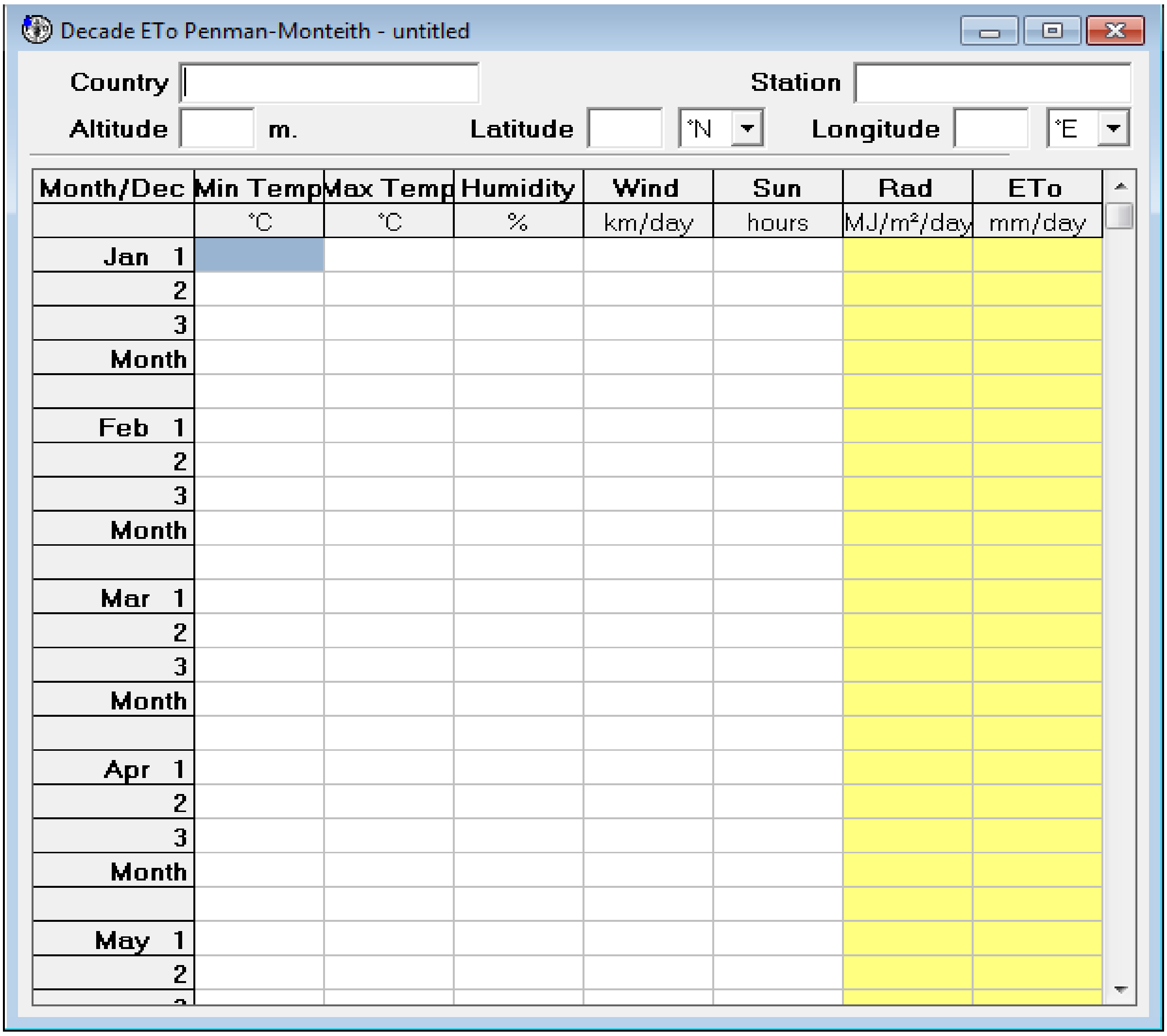

Fig. 3.1 CROPWAT window

The climatic data required for CROPWAT calculations are,

- Solar radiations
- Relative humidity
- Sunshine hours
- Maximum air temperature
- Minimum air temperature
- Wind speed

These data were collected from previous studies. Fig. 3.1 shows the CROPWAT window.

Water requirement of cowpea varies according to the growth stages, since the crop coefficient changes. Table 3.1 shows the crop coefficient of cowpea in each stage.

Table 3.1 Crop coefficient of cowpea at different growth stages

Growth stages	**Crop coefficient**
Initial stage	0.45
Crop development stage	0.80
Final stage	1.05

3.3 Data Collection

3.3.1 Climate Data

Inorder to calculate ET_0, the previous data including daily solar radiation, precipitation, relative humidity, sunshine hours, minimum and maximum air temperature and wind speed of the year 2012 were collected.

3.3.2 Soil Parameters

Soil analysis for grain size distribution was done by sieving. Dry sieve analysis was carried out using 4.75mm, 2mm, 1mm, 600µm, 425µm, 300µm, 212µm, 150µm, and 75µm size sieves. Sieving was done using sieve shaker. Weight of soil retained in each sieves were taken (Appendix I).

3.3.3 Soil Testing

Soil testing is a scientific tool to assess nutrient composition of soil. Soil collected from the poly house was analyzed for the nutrient composition (N, P and K) and pH. (Appendix II).

3.4 Field Experiment

3.4.1 Land Preparation

The land was ploughed thoroughly using mini tiller**.** The soil type of the experiment field was sandy loam. The field was left idle for one week after lime application. Farm yard manure was added to the field and dolomite applied in the rate of 435 kg/ha. The layout of the experimental plot is shown in Fig. 3.2.

The manure used was:

Neem cake - 1 sack of 25 kg

Tricoderma - 1 pack of 250g in 50 l water

Cow dung - 4 kg

3.4.2 Bed Preparation

Four beds of dimension 16m length and 0.7m width were prepared. Area of each bed is 11.2m². Each bed contains single row of cowpea. Every single bed contains 32 plants at a spacing of 50cm. The plate 3.1 shows the experimental plot after bed preparation.

3.4.3 Crop Variety

Cowpea (Vellayani Jyothika) which is of trailing type was used for the trial. Sowing was done on 27.8.2014. The seeds were sown at a depth of 2 cm from ground level.Laterals with inline drippers lay on each bed providing water and fertilizer effectively up to root zone depth.

3.4.4 Inter Cultural Operation and Weeding

Manual weeding was done in a periodic manner. Drip irrigation control the growth of weeds as it gives only sufficient amount of water to each plant.

3.4.5 Plant Growth Regulators and Protection Measures

Plant protection measures were adopted for incidents of pest and disease attacks using recommended dose of chemicals on time.

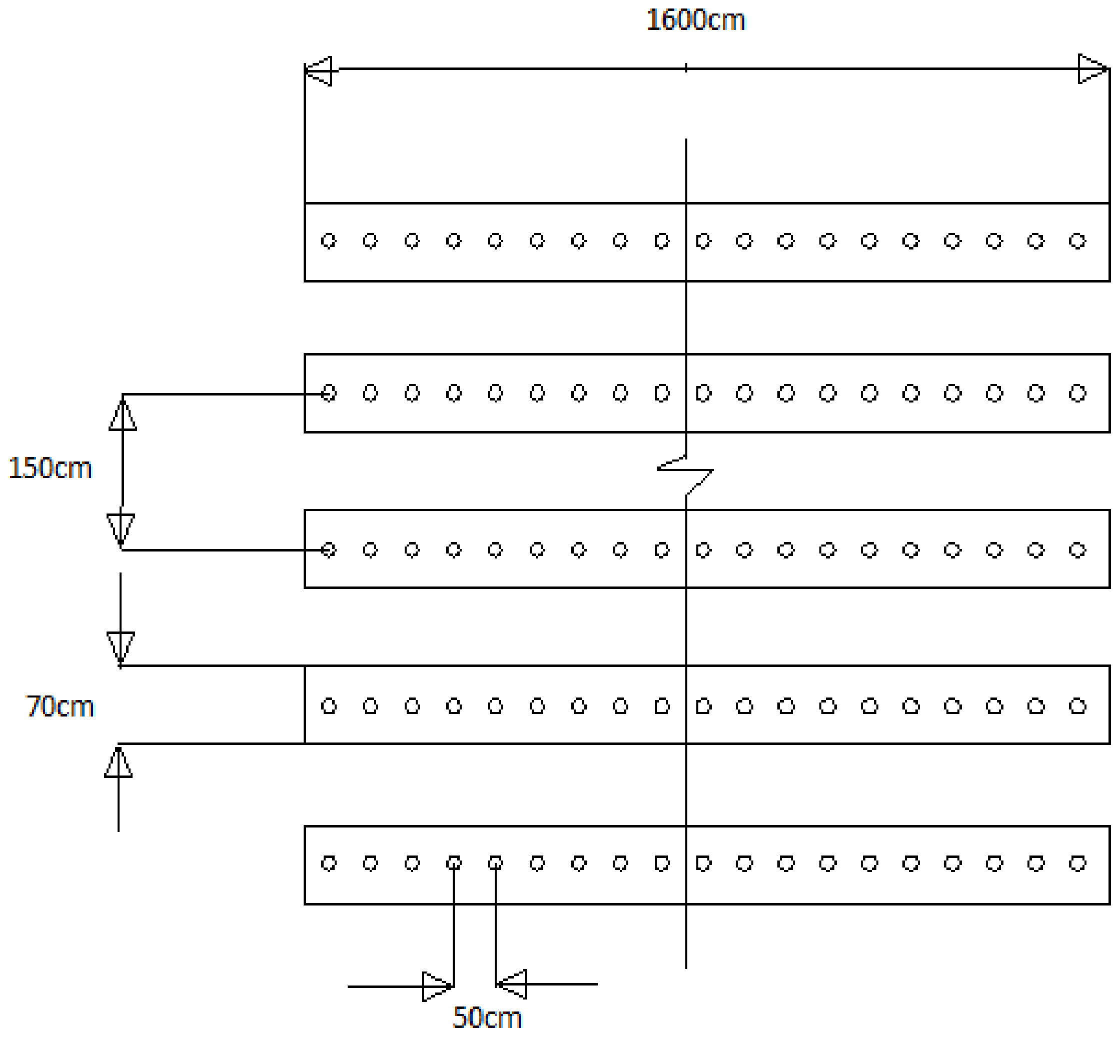

Fig. 3.2 Layout of the experimental plot

3.4.6 Experimental Details

The field experiment using cowpea mainly involves the standardization of the rate of irrigation water. The irrigation treatments were formulated for different levels of water requirement of the crop. The crop water requirement of cowpea was computed using the CROPWAT model. The fertigation treatment was fixed based on the adhoc recommendation of KAU. The irrigation trial was conducted during 13th September to 28th December. The objective was to standardize the irrigation requirement of cowpea grown in a naturally ventilated poly house. The soil in the field plot was well drained sandy loam. In these experiments, the land under the poly house was levelled and beds were raised. The plot was divided into five rectangular beds having five treatments. Plate 3.2 shows the plot with emerging plants.

Plate 3.1 Experimental plot after bed preparation

Table 3.2 Details of application of fungicides and pesticides

Name of fungicides/ pesticides	Amount used
Pseudomonas	1 spoon with irrigation water
Acetaf insecticide	2g per litre
Bavestin	2g per litre
Corragen	2ml

3.4.7 Irrigation Scheduling

Irrigation schedule was planned to provide the estimated water requirement of the crop. Water requirement of cowpea varies according to the growth stages. In order to determine the optimum water requirement of the crops, five irrigation levels were adopted which were 80, 90, 100, 110 and 120percent of water requirement ofcowpea.Table3.3 shows the time of irrigation in each treatment. In this experiment, fertilizers were applied as per adhoc recommendations with different rate of irrigation. The details of irrigation treatments are given below.

I_1: 80% of the estimated irrigation requirement from CROPWAT

I_2: 90% of the estimated irrigation requirement from CROPWAT

I_3: 100% of the estimated irrigation requirement from CROPWAT

I_4: 110% of the estimated irrigation requirement from CROPWAT

I_5: 120% of the estimated irrigation requirement from CROPWAT

Plate 3.2 Plot with emerging plants

3.4.8 Installation of Drip System and Fertigation Units

Irrigation water was pumped using 5 HP, 2 x ½ monoblock pump set and conveyed through the main line of 50mm diameter PVC pipes after filtering through the screen filter. The installation of the irrigation line was on 20-08-2014. From the main pipe, sub main of PVC pipes were installed. From the sub mains, laterals were installed. Each lateral was provided with individual control for improving irrigation. Inline drippers at spacing of 50cm were used for irrigation. The number of laterals installed was based on the number of rows of crops grown. The discharge rate of single dripper is 4lph.Venturifertigation unit was installed along with irrigation unit. Control valves regulate the flow through each line.

Table 3.3 Time of irrigation in each treatment

Date	Treatments	Time required for irrigation (min)
28-08-2014 to 13-09-2014 (Initial stage)	I_1	8.0
	I_2	9.0
	I_3	10.0
	I_4	11.0
	I_5	12.0
	I_1	14.3
	I_2	16.1
	I_3	17.89
	I_4	19.68
	I_5	21.47
20-10-2014 to 28-12-1014 (Final stage)	I_1	19
	I_2	21
	I_3	23
	I_4	26
	I_5	28

3.5 Collection of Experimental Data

3.5.1 Meteorological Data

3.5.1.1 Temperature and Humidity

Temperature and humidity measurements inside and outside the poly house are taken using digital thermo hygrometer (Thermo-hygroclock). Thermo hygrometer: Thermo hygroclock are useful for measurement of humidity. Humidity is a representation of the concentration of water vapour in the air where value is shown as a percent. Thermo hygroclock have sensors which measure humidity and temperature of the air. Both values will be shown as a digital representation and converted in to the desired unit. A comparison in variation of temperature and relative humidity inside and outside were also done. For this measurements outside the poly house were noted for the corresponding days.

3.5.2 Biometric Observation

For analyzing the growth patterns of the crop, five plants were selected randomly from each bedand were tagged to record the various observations. The main crop growth parameters like height / length of main vine, and number of leaves per plant were measured. Also date of first flowering is noted.

3.5.2.1 Height / Length of Main Vine

The average height of the randomly selected plants grown under each treatment was taken. The measurement was taken from the ground surface to the vine tip for the selected plants.

3.5.3 Yield (kg/ha)

Harvesting of the crops was done treatment wise after attaining maturity. After the first harvest, other harvests were done at an interval of 3-5 days. The first yield was taken one and half month after planting the cowpea. The total of 11 harvests gave the total yield. Bean weight in each treatment was taken. Plate 3.3 shows the harvested cowpea.

Plate 3.3 Harvested cowpea

3.5.3.1 Bean Characteristics

The bean characteristics such as number of beans per bed and bean length of every tagged plant in every harvest were observed. And the effect of different treatments on these parameters was studied.

3.5.4 Determination of Irrigation Water Use Efficiency

The bean yield obtained for each treatment was divided by the quantity of water used consumptively for the respective treatments by this method. Water use efficiency was worked out and expressed in kg/ha and the total water utilized in mm.

$$\text{IWUE} = \frac{\text{Yield (kg/ha)}}{\text{Total amount of water applied (mm)}}$$

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

Field study was conducted to evaluate the performance of cowpea under different irrigation levels inside the poly house. The study was undertaken with the objectives to determine the water requirement of the cowpea using CROPWAT and to standardise the irrigation schedule for cowpea grown under naturally ventilated poly house. Weather parameters such as temperature and humidity inside the poly house were recorded to compare the effect of different irrigation treatments on the yield and growth parameters of cowpea under poly house. The experiment was conducted during August 2014 to December 2014. The results obtained and the discussions on the results obtained from the study are analysed and are presented in this chapter.

4.1 Crop Water Requirement

The details of climate, soil and the crop which is related to the study were fed to the CROPWAT model to estimate the crop water requirement. The crop data, soil data and crop water requirement of the crop are shown in the following tables 4.1, 4.2, 4.3 and 4.4.

Table 4.1 Input and output climatic data

Country: India Year: 2012							Station: Pattambi
Decade / Month	**Min Temp ºC**	**Max Temp ºC**	**Humidity %**	**Wind km/day**	**Sun hours**	**Rad MJ/m²/day**	**ETo mm/day**
Jan 1	20.4	34.3	61	168	8.7	19.6	4.93
2	19.9	33.3	61	146	8.8	20.1	4.74
3	19.8	33.9	60	139	8.8	20.5	4.86
Month	20.0	33.8	61	151	8.8	20.1	4.84
Feb 1	20.5	34.2	60	134	8.9	20.2	5.00
2	20.7	35.0	61	113	9.3	22.3	5.10
3	21.1	35.4	62	110	9.0	22.3	5.15
Month	20.8	34.9	61	119	9.1	21.9	5.08

Mar 1	21.7	36.4	60	106	9.1	22.9	5.38
2	22.7	36.4	64	106	8.8	22.8	5.38
3	25.5	35.9	67	106	8.3	22.2	5.33
Month	23.3	36.2	64	106	8.7	22.6	5.36
Apr 1	23.9	35.6	69	101	8.0	21.9	5.15
2	24.2	35.2	70	101	8.1	22.0	5.14
3	24.4	35.1	70	103	8.1	22.0	5.14
Month	24.2	35.3	70	102	8.1	22.0	5.14
May 1	24.4	34.2	73	103	7.7	21.2	4.89
2	24.4	33.8	74	108	7.5	20.7	4.78
3	23.9	32.9	76	98	6.9	19.6	4.43
Month	24.2	33.6	74	103	7.4	20.5	4.70
June 1	23.2	31.4	81	86	5.3	17.1	3.77
2	22.9	29.8	85	84	3.5	14.4	3.15
3	22.9	29.7	86	82	3.7	14.7	3.17
Month	23.0	30.3	84	84	4.2	15.4	3.36
July 1	22.6	29.4	85	84	3.6	14.6	3.15
2	22.6	29.3	86	89	3.5	14.5	3.12
3	22.8	29.0	85	91	3.3	14.3	3.1
Month	22.7	29.2	85	88	3.5	14.4	3.12
Aug 1	24.0	29.3	85	118	4.1	15.6	3.39
2	22.9	30.9	86	142	5.3	17.5	3.78
3	23.8	29.8	82	158	8.1	21.8	4.54
Month	23.6	30.0	84	139	5.8	18.3	3.90
Sep 1	23.0	30.3	82	94	5.6	17.9	3.82
2	23.0	30.8	80	86	6.7	19.5	4.11
3	22.9	31.0	80	74	6.0	18.3	3.86
Month	23.0	30.7	81	85	6.1	18.6	3.93
Oct 1	22.8	30.9	81	62	6.1	18.1	3.77
2	23.0	31.3	81	58	5.6	17.0	3.58
3	22.8	31.3	80	60	5.9	17.1	3.56
Month	22.9	31.2	81	60	5.9	17.4	3.63
Nov 1	23.5	31.5	78	62	6.3	17.2	3.60

2	22.1	31.9	74	79	6.9	17.7	3.70
3	21.7	32.2	71	98	7.7	18.4	3.96
Month	22.4	31.9	74	80	7.0	17.8	3.75
Dec 1	20.9	32.1	67	134	8.2	18.9	4.24
2	20.5	32.1	64	144	7.9	18.3	4.29
3	20.2	32.3	66	144	8.6	19.3	4.37
Month	20.5	32.2	66	141	8.2	18.8	4.30
Average	22.5	32.4	74	105	6.9	19.0	4.26

Table 4.2 Crop data

	Crop Name: Cowpea			**Planting Date:**27-08-2014	
Stages	Initial	Crop develop	Mid-season	Final	Total
Length (days)	18	36	30	36	120
K_c values	o.45	0.8		1.05	
Rooting depth (m)	0.3			0.6	
Crop height (m)		0.4			

Table 4.3 Soil data

Soil: Sandy Loam	
Total available soil moisture (FC-WP)	37 mm/m
Maximum rain infiltration rate	95 mm/day
Maximum rooting depth	150 cm
Initial soil moisture depletion (%TAM)	50%
Initial available soil moisture	18.5 mm/m

Table 4.4 Estimation of crop water requirement

ET_0 station: Pattambi		**Crop:** Cowpea **Planting date:** 27-08-2014	
Growth stage	**ET_0 (mm/day)**	**Crop coefficient**	**ET_c (mm/day)**
Initial	4.26	0.45	1.917
Crop develop	4.26	0.8	3.408
Final	4.26	1.05	4.473

4.2 Climatic Condition Inside and Outside the Poly House

The climatic parameters viz. maximum and minimum temperature and relative humidity were observed both inside and outside the poly house. Based on the climatic data, a graph is plotted. Fig. 4.1, 4.2, 4.3 and 4.4 shows the variation of climatic data during morning and evening both inside and outside the poly house. (Appendix III & IV).

Fig. 4.1 shows variation of maximum and minimum temperature inside the poly house during crop period. The maximum temperature ranges from 28.5 to 34^{o}C and the maximum value recorded during the last days of production period of crop. The minimum temperature inside the naturally ventilated poly house ranges from 26.6 to 27.5^{o}C. The least value of minimum temperature recorded is 21^{o}C during the early stages of crop development. The atmospheric temperature inside the poly house is slightly higher than outside. The rise in atmospheric temperature inside the poly house ranges from 0.5°C to 3.0°C.Similar readings were reported by Farguesa et al. (2005). It indicates that there is considerable increase in the inside temperature of the poly house. The temperature shows lower value at high rainfall and a high temperature is observed at minimum rainfall.

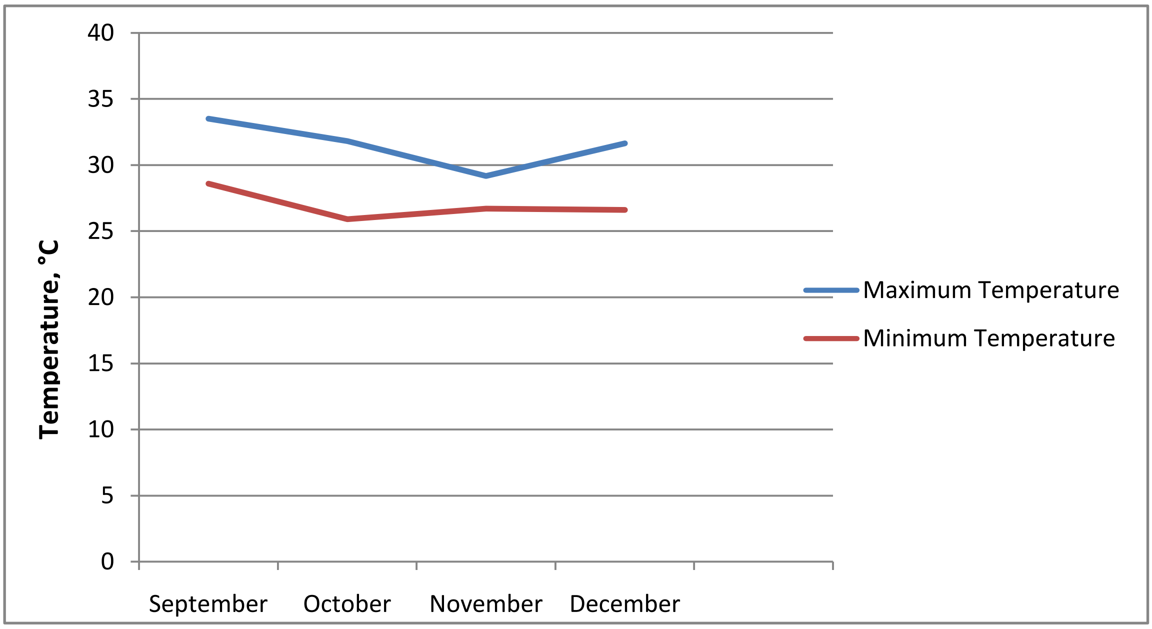

Fig. 4.1 Variation of maximum and minimum temperatures inside the poly house during morning

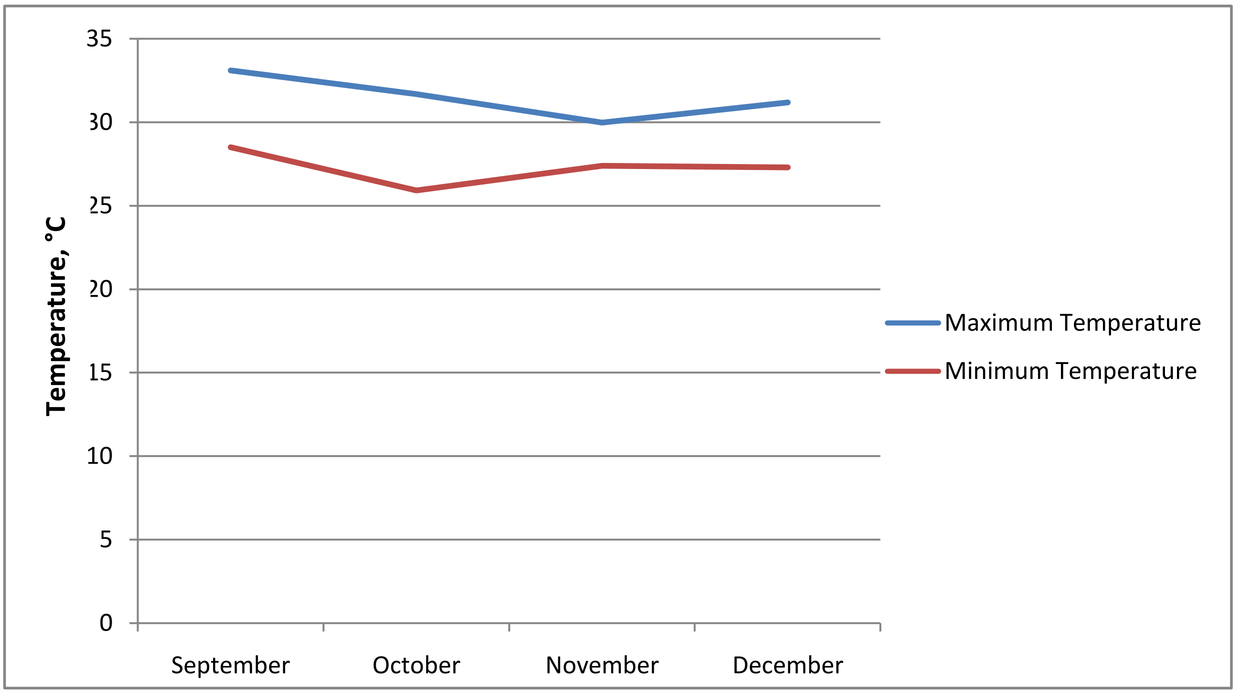

Fig. 4.2 Variation of maximum and minimum temperatures inside the poly house during evening

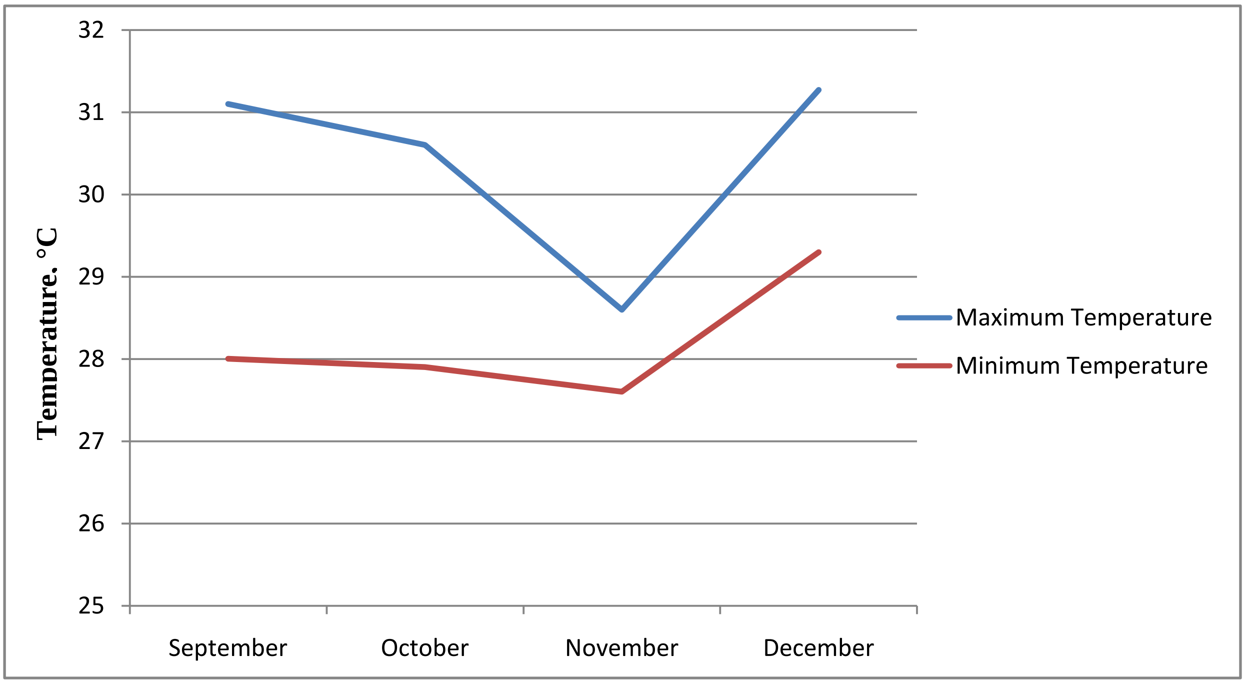

Fig. 4.3 Variation of maximum and minimum temperatures outside the poly house during morning

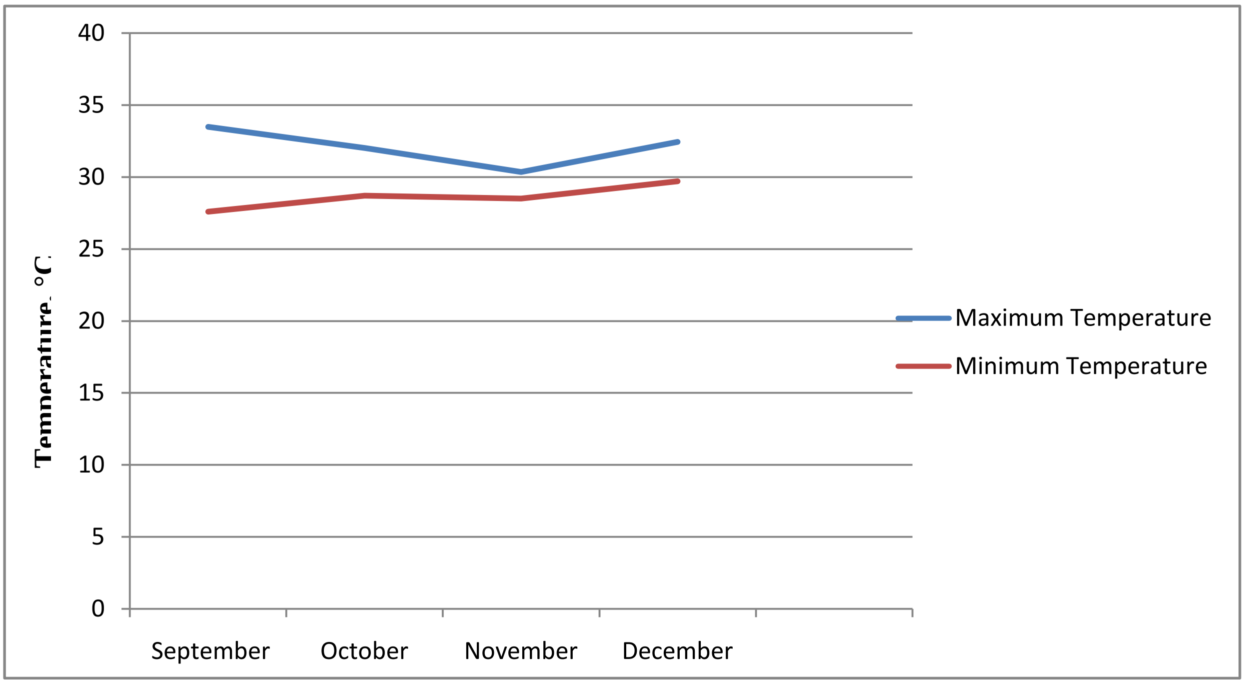

Fig. 4.4 Variation of maximum and minimum temperatures ouside the poly house during evening

4.2.1 Variation of Temperature and Relative Humidity

Readings of temperature and humidity variations are represented graphically. Generally outside temperature seems to be lower than inside the poly house, due to the greenhouse effect. Also the relative humidity is more than inside value. Fig. 4.5, 4.6, 4.7 and 4.8 compare the variation of temperature and relative humidity inside and outside the poly house.

The climatological data observations indicate the variation of increased temperature and effect of humidity have significant role in growth and performance of cowpea. Yield data shows that the increased production as compared to open field may be due to the improvement in microclimate provided inside the poly house. This is agreement with M.R Parvej *et al.* (2010) in which it was reported that from December to February the mid-day air temperature under poly house and open field varied from 31.8 to 39.1ºC and 23.3 to 31.1ºC, respectively indicating about 8ºC higher air temperature inside poly house and during that time the average air temperature inside poly house was about 28ºC which was optimum for the growth and development of tomato plants. The above microclimatic variabilities inside poly house favoured the growth and yield of tomato.

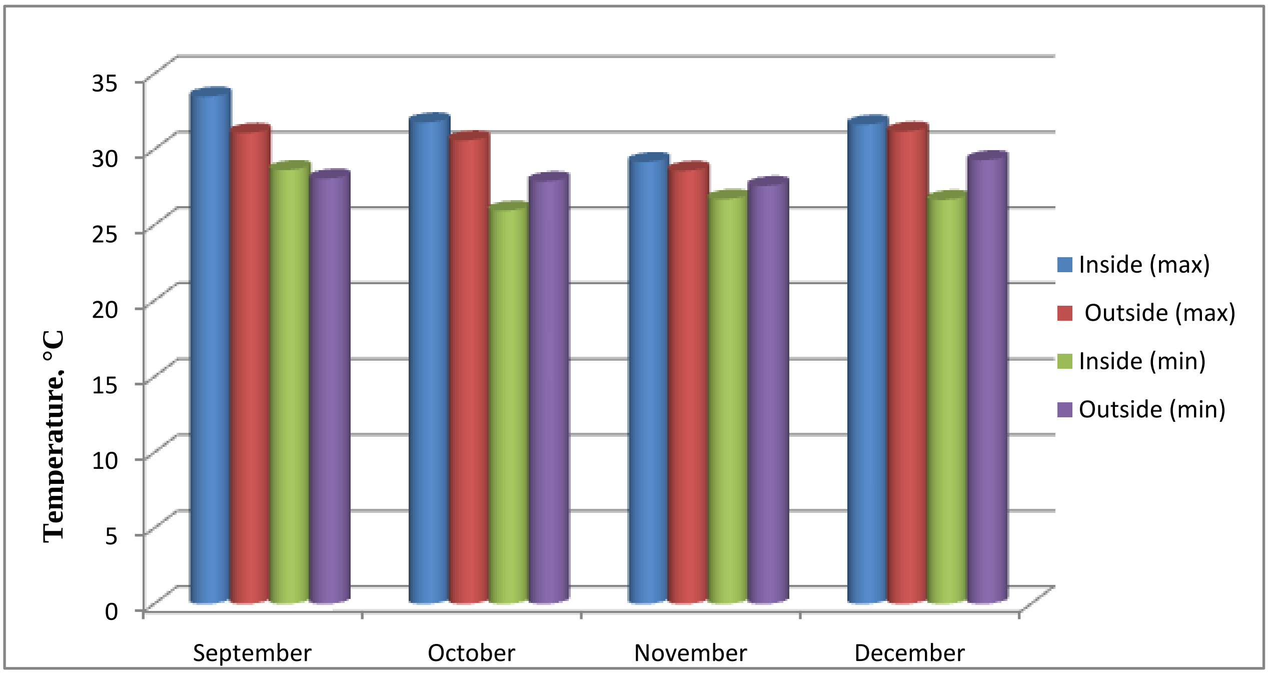

Fig. 4.5 Maximum and minimum temperature variation inside and outside poly house during morning

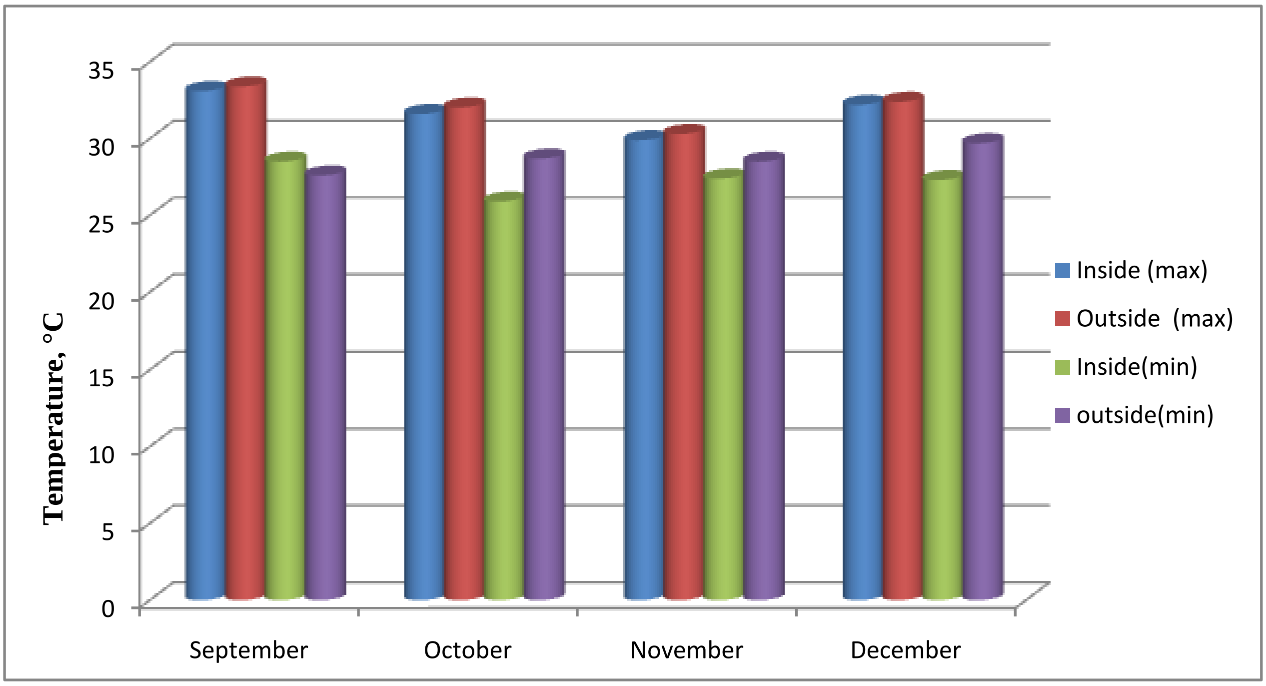

Fig. 4.6 Maximum and minimum temperature variation inside and outside poly house during evening

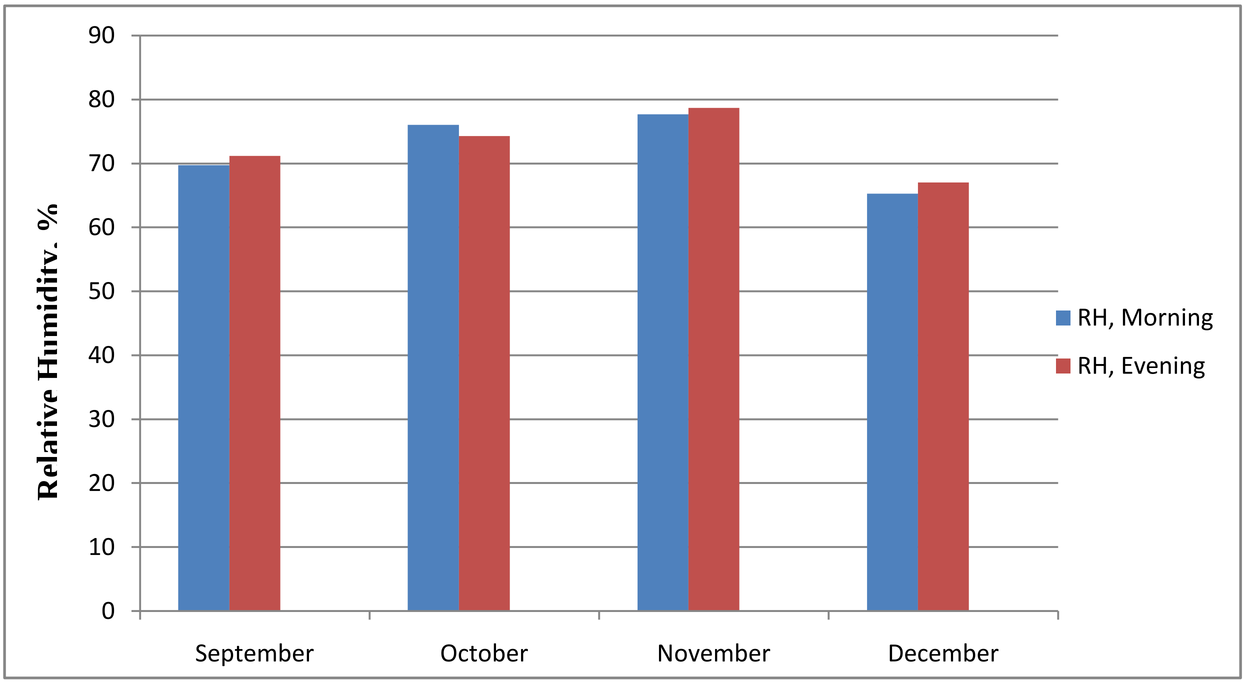

Fig. 4.7 Variation of relative humidity inside the poly house during morning and evening

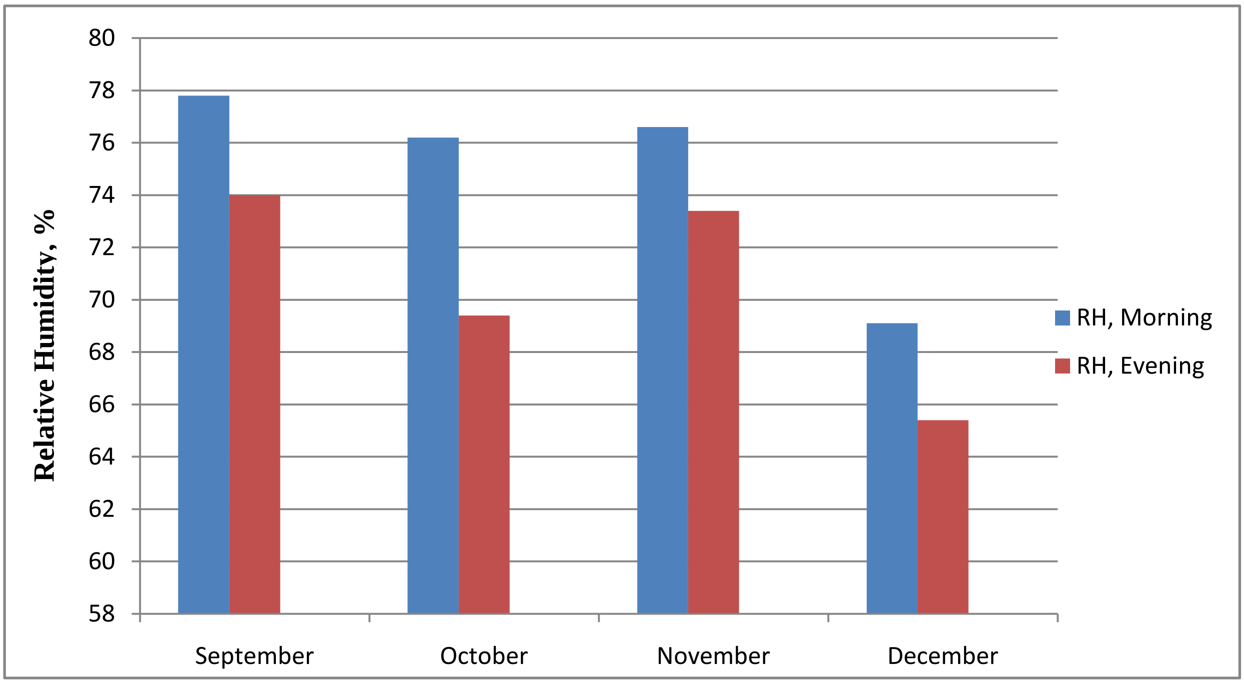

Fig. 4.8 Variation of relative humidity outside the poly house during morning and evening

Fig. 4.7 shows variation of relative humidity during the crop period. Figure revealed that the maximum humidity recorded was 80% and the minimum humidity recorded was 65%.

4.3 Biometric Observation

4.3.1 Flower Initiation

The first flowering was observed 5-10-2014 days after sowing in bed 2 (B2). The early flowering in B2 indicates level of irrigation effect on plant.

4.3.2 Growth Parameters

Crop growth parameters such as date of germination, length of wine and number of leaves of each tagged plant were observed during different stages of crop growth. The influence of irrigation on these crop growth parameters are discussed below.

4.3.2.1 Date of Germination

The date of first germination was observed on 29-09-2014 (Two days after sowing). The percentage germination was 75% and 40 plants were transplanted.

4.3.2.2 Length of Main Wine

The data on length of main wine at different stages of crop growth after planting as influenced by different irrigation treatments are presented in the Tables 4.5.

4.3.2.3 Number of Branches

The data on number of branching as influenced by different irrigation treatments are presented in the Tables 4.5. Data on length of main wine were recorded at two week interval from the day of sowing. As shown in Table 4.5, it is seen that average lengths of wine were increased with crop growth and reached a maximum value of 440cm in the irrigation trial during the growth stage. Wine lengths changed minimally at the final stage because irrigation did not affect wine elongation any longer. The statistical results indicate that the length of main wine of cowpea plant at different growth stages did not differ considerably with respect to irrigation. The data reveals that the number of branches were increased with crop growth and reached a maximum value of 16 at the crop growth stage. From the tables it is seen that number of leaves did not differ considerably with respect to irrigation levels.

Table 4.5 Length of main wine and number of branches as influenced by different irrigation levels

Date: 30-08-2014										
Bed	**P_1**		**P_2**		**P_3**		**P_4**		**P_5**	
	H (cm)	**B**	**H (cm)**	**B**	**H (cm)**	**B**	**H (cm)**	**B**	**H (cm)**	**B**
B1	8.0	0	8.4	0	8.2	0	9.0	0	7.8	0
B2	9.0	0	9.1	0	8.9	0	8.8	0	9.2	0
B3	7.2	0	8.5	0	8.1	0	8.0	0	7.3	0
B4	8.2	0	8.9	0	8.0	0	7.9	0	7.7	0
B5	7.9	0	8.0	0	5.6	0	6.8	0	8.7	0

Date: 12-09-2014										
Bed	**P_1**		**P_2**		**P_3**		**P_4**		**P_5**	
	H (cm)	**B**	**H (cm)**	**B**	**H (cm)**	**B**	**H (cm)**	**B**	**H (cm)**	**B**
B1	99.0	3	88.6	2	95.2	2	98.1	3	90.0	2
B2	100.0	4	103.9	5	99.7	3	89.1	2	82.6	1
B3	83.3	2	78.9	1	77.7	2	93.1	3	88.7	2
B4	72.3	2	81.9	2	63.8	1	94.5	3	70.0	2
B5	71.1	2	82.0	3	92.3	3	70.0	2	84.1	2

Date: 26-09-2014										
Bed	**P_1**		**P_2**		**P_3**		**P_4**		**P_5**	
	H (cm)	**B**	**H (cm)**	**B**	**H (cm)**	**B**	**H (cm)**	**B**	**H (cm)**	**B**
B1	360	15	420	19	360	13	350	14	275	11
B2	355	16	340	18	365	14	440	17	355	14
B3	310	14	315	13	275	9	360	18	300	11
B4	215	9	211	7	250	9	178	7	213	8
B5	260	7	174	7	216	8	190	7	218	8

4.4 Yield

4.4.1 Bean Characteristics

4.4.1.1 Average Length of Bean (cm)

Bean length is one of the external quality parameter which influences market value. The data on average length of cowpea after 45days of planting are presented in the Table 4.6. The maximum length of cowpea was found in the treatment I_1 (68cm). The minimum length was found in treatment I_2 (42cm). The data did not differ significantly either due to the levels of irrigation. The results indicate that the treatments did not influence the length of cowpea.

4.4.1.2 Average Weight of Bean (g)

The data on average weight of individual bean are shown in the Table 4.6. The maximum weight of individual bean was obtained in treatment I_1 which was 43.92g. The minimum weight of individual cowpea was obtained in treatment I_2, it was 12.10g. The data did not differ considerably in the case of average weight of individual cowpea. Biometric observations on the basis of length and average weight were tabulated.

Table 4.6 Average length and weight of individual bean for different treatments

	I_1	**I_2**	**I_3**	**I_4**	**I_5**
Average Length (cm)	50	49	48	47	45
Average Weight (g)	21	21	19	22	19

4.4.1.3 Bean Number

The number of beans per plant is an important factor in the yield of cowpea. Variation in number of bean with different treatments of irrigation is shown in the Table 4.7. From the observations, treatment I_5 shows the least no of beans and I_2 shows the maximum number of beans. The detailed comparison among the treatments shows that the treatment with 120% of irrigation requirement (I_5) gives the least number of beans and treatment I_2 gives more number of beans.

Table 4.7 Variation in number of bean with different treatments

	I_1	I_2	I_3	I_4	I_5
No. of Beans	187	193	157	160	119

4.4.2 Yield Data (kg/ha)

Crop yield is always an important effective and economic index consideration in the crop development. The aim of planting any crop is to get the highest yield of good quality beans. The first yield was obtained 51days after sowing and continued up for 120th day. Yield was influenced by different treatments of irrigation. The yield obtained from each treatment is shown in table 4.8.

Table 4.8 Yield obtained from each treatment

Treatment	I_1	I_2	I_3	I_4	I_5
Yield (kg/ha)	25389	29620	20771	19462	13673

The irrigation trial was carried out with five levels of irrigation such as 80, 90, 100, 110 and 120 % of daily irrigation requirement, with the same fertilizer amount.The maximum yield was observed for the treatment I_2 and the minimum yield was seen for the treatment I_5. The treatment I_1 was on par with treatment I_2. Fig. 4.9 shows the significance of irrigation level on yield obtained. This is in agreement with the experiment done by Harmanto *et al.,* (2004). They reported that an average irrigation rate of 0.5 l /plant/day was found to be optimum amount of water for maximizing the tomato yield. The application of irrigation at lower amount (deficit irrigation) of the water requirement gave lower yield. But increasing the irrigation water over a certain level (over irrigation) did not increase the tomato yield above maximum yield. So, the irrigation should be given as precise as possible to the plant close to the optimum. The optimum amount of irrigation was very close to the crop evapotranspiration which was calculated from the dynamic microclimate inside the greenhouse during the experiment.

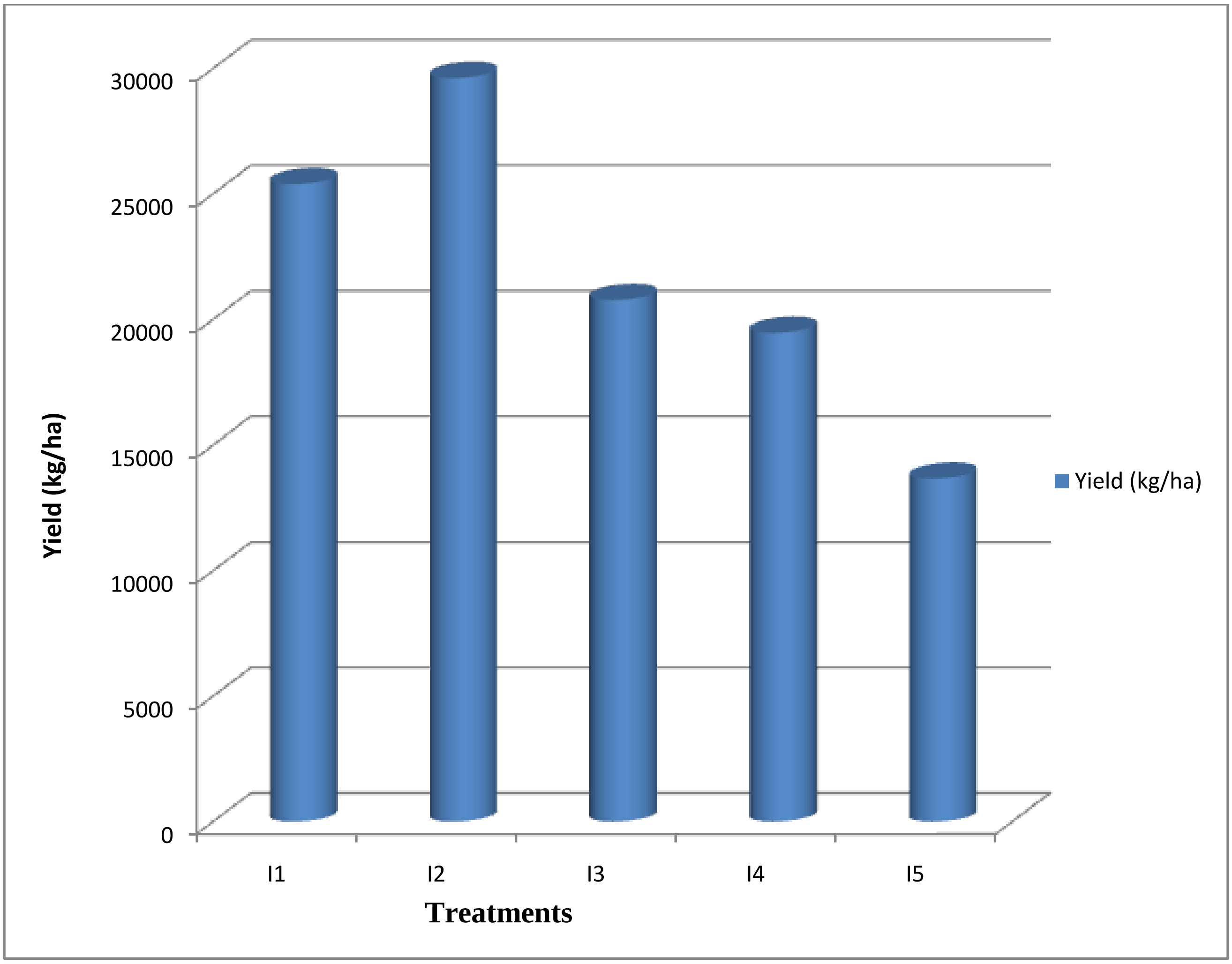

Fig. 4.9 Yield obtained from each treatment in kg/ha

4.4.3 Irrigation Water Use Efficiency

The term water use efficiency (WUE) denotes the production (of crops) per unit of water applied. It is expressed as the weight of the crop produced per unit depth of water over a unit area (kg/mm/hectare). Table 4.9 shows the water use efficiency for different irrigation treatments.

Table 4.9 Water use efficiency of various irrigation treatments

Treatments	Average yield (kg/ha)	Water used (mm)	Water use efficiency (kg/ha/mm)
I_1	25389	362	70
I_2	29620	407	73
I_3	20771	452	46
I_4	19462	497	39
I_5	13673	542	25

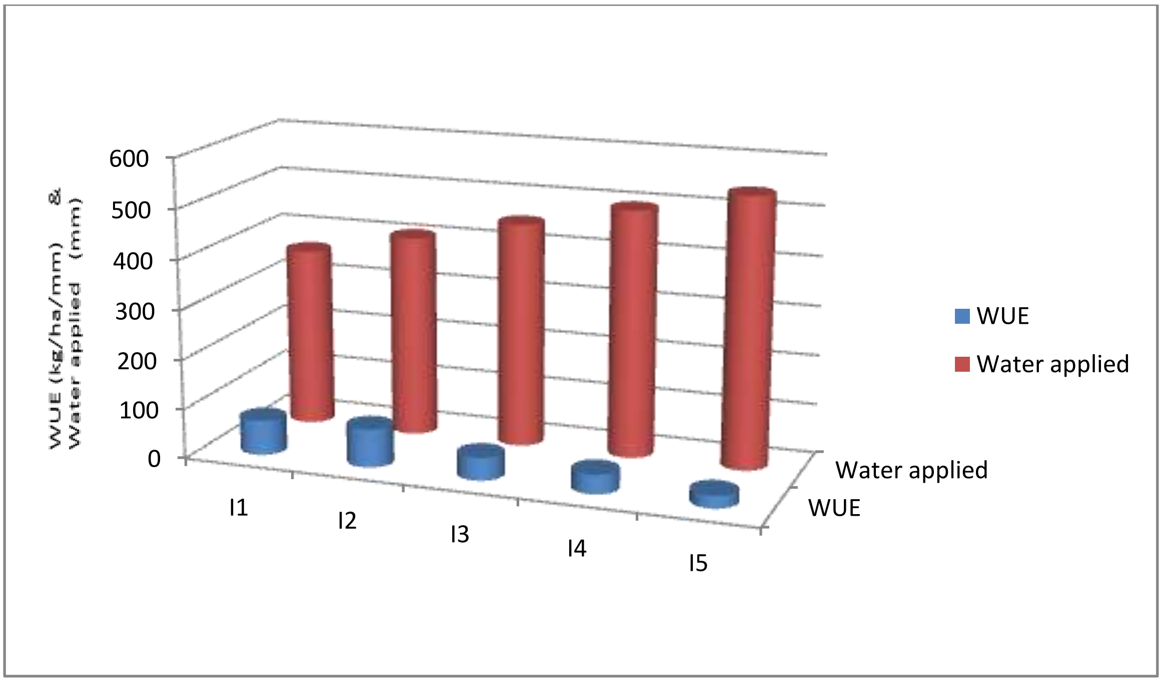

Fig. 4.10 IWUE influenced by different irrigation level

From Fig. 4.10 it can be seen that irrigation rate significantly affected irrigation water use efficiency (IWUE). IWUE ranged from 25 kg/ha mm in I_5to73 kg/ha mm in I_2 (Table 4.9).

SUMMARY AND CONCLUSIONS

CHAPTER 5

SUMMARY AND CONCLUSION

The present study was undertaken with the objective to determine the effect of different irrigation levels on yield of cowpea under naturally ventilated poly house. It was conducted at the experimental plot of PFDC farm, KCAET, Tavanur.

Crop water requirement of cowpea was determined using the irrigation management and planning model CROPWAT. The details of climate, soil and the crop were fed to the CROPWAT model to estimate the crop water requirement. The value of reference crop evapotranspiration obtained was 4.26 mm/day.

The weather parameters such as maximum and minimum temperature and relative humidity inside and outside the poly house during the entire crop period were recorded. From the study it was seen that temperature inside the poly house is always higher than the outside temperature. The rise in temperature inside the poly house ranges from 0.5°C to 3.0°C. The crop water requirement depends on the rate of evaporation and thereby temperature.The maximum and minimum humidity recorded inside the poly house were 80 and 65% respectively.

The pest and disease infestation in the poly house was controlled by adopting appropriate control measures.

The irrigation trial was carried out using five levels of irrigation viz. 80, 90, 100, 110 and 120% of daily irrigation requirement of crop. Crop growth parameters such as length of wine, number of branches and date of flowering for each treatment were observed during various crop growth stages. The results indicated that the different treatments of irrigation did not influence length of wine, number of branches and number of flowers after sowing.

The yield obtained from the irrigation treatments was analysed. The five treatments showed significant difference in the case of average yield (kg/ha). The maximum yield was observed for the treatment I_2 (29620kg/ha). The minimum yield was observed in the case of treatment I_5 (13673kg/ha). With respect to average yield, the different levels of irrigation showed significant difference. Compared to I_2, the yield from other treatments I_1, I_3, I_4, and I_5 were less by 14, 30, 34 and 54%. The study revealed that drip irrigation with 90% of the daily irrigation requirement can give maximum yield of cowpea inside a naturally ventilated poly house.

Variation in number of beans with different treatments of irrigation was observed. The detailed comparison among the treatments showed that treatment with 120% of irrigation requirement (I_5) gives the least number of beans. From irrigation trial, it is evident that 90% of irrigation requirement is enough for producing maximum number of beans in cowpea grown inside a naturally ventilated poly house.

The data on average weight and length of individual bean after 53 days from planting was not influenced by different treatments. So it is revealed that the biometric observations have no significant difference.

Irrigation rate significantly affected irrigation water use efficiency (IWUE). It ranged from25 kg/ha mm in I_5 to 73 kg/ha mm.

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APPENDICES

APPENDICES

APPENDIX I . Grain Size Distribution of the Soil Sample (Coarse Fraction)

Sl No.	IS sieve	Particle size (mm)	Mass retained (g)	% retained	Cumulative % retained	Cumulative % finer (N)
1	4.75mm	4.75	142	14.2	14.2	85.8
2	2mm	2	127	12.7	26.9	73.1
3	1mm	1	89	8.9	35.8	64.2
4	600µm	0.6	85	8.5	44.3	55.7
5	425µm	0.425	57	5.7	50	50
6	300µm	0.300	55	5.5	55.5	44.5
7	212µm	0.212	60	6.0	61.5	38.5
8	150µm	0.150	9	0.9	62.4	37.6
9	75µm	0.075	14	1.4	63.8	36.2

APPENDIX II . Results of Soil Analysis

	Amount (kg/ha)
N	250.88
P	27.3
K	213.92
pH	7.5(neutral)

APPENDIX III. Daily Climatic Data during Crop Period (Inside Poly House)

Date	Maximun temperature ^{0}C		Minimum temperature ^{0}C		Relative humidity %	
	M	E	M	E	M	E
26-09-2014	30.1	31.5	29	29.2	82	80
27-09-2014	35.2	37	27.8	28.8	65	64
28-09-2014	33.4	33.8	28.7	28.9	67	71
29-09-2014	35.4	30.1	29.1	27.1	65	70
30-09-2014	30.0	29.8	27.8	27.8	76	72
01-10-2014	33.5	31.6	29.4	29.8	77	75
02-10-2014	34.0	32.1	26.3	26.1	68	72
03-10-2014	34.2	32.3	26.4	26.0	69	70
04-10-2014	33.6	32.0	25.2	24.8	72	79
05-10-2014	35.0	35.1	26.5	26.6	64	68
06-10-2014	32.9	32.5	22.4	22.1	78	76
07-10-2014	32.3	31.9	23.6	22.8	79	77
08-10-2014	28.3	35.3	26.9	26.9	81	61
09-10-2014	30	32.9	27.9	32.5	81	68
10-10-2014	30.6	31.5	29.7	28.9	81	79
11-10-2014	32.1	31.7	23.2	22.9	78	77
12-10-2014	31.4	31.0	22.7	22.0	80	79
13-10-2014	33.4	33.0	24.6	24.3	73	71
14-10-2014	34.8	34.2	24.4	24.1	64	73

15-10-2014	34.2	34.0	24.6	24.3	68	72
16-10-2014	34.1	33.8	31.3	30.4	68	70
17-10-2014	35.4	34.8	28.7	27.3	64	70
18-10-2014	31.6	30.3	28.7	27.4	73	70
19-10-2014	28.6	27.8	23.8	23.5	80	78
20-10-2014	27.2	26.5	23.7	23.0	81	79
21-10-2014	32.7	31.9	28.4	27.6	74	70
22-10-2014	31.6	30.7	23.4	22.6	75	73
23-10-2014	31.6	30.9	23.8	23.0	75	72
24-10-2014	31.9	31.3	23.4	23.0	73	71
25-10-2014	30.7	30.5	26.9	29.9	90	87
26-10-2014	32.6	31.8	23.3	22.7	78	77
27-10-2014	31.8	30.5	23.6	22.8	78	74
28-10-2014	29.2	30.8	28.4	29.8	85	81
29-10-2014	29.8	30.0	28.7	29.0	83	79
30-10-2014	29.1	31.6	28.5	30.9	82	78
31-10-2014	29.4	30.1	24.6	24.9	85	82
01-11-2014	28.5	30.0	28.1	28.5	82	81
02-11-2014	30.1	32.1	24.6	27.3	81	78
03-11-2014	30.4	31.3	29.0	30.1	82	76
04-11-2014	31.2	31.4	24.4	26.8	75	72

05-11-2014	33.5	33.7	25.1	25.8	72	70
06-11-2014	33.2	33.6	21.0	21.9	74	72
07-11-2014	30.6	30.9	30.1	30.0	73	76
08-11-2014	28.4	28.9	28.0	28.1	87	90
09-11-2014	29.4	30.0	28.4	28.8	85	89
10-11-2014	28.1	31.3	27.7	30.3	86	87
11-11-2014	28.9	30.2	28.1	28.9	85	88
12-11-2014	28.1	30.8	26.7	30.3	89	77
13-11-2014	31.9	32.2	30.1	30.8	72	75
14-11-2014	28.4	28.9	27.7	27.9	82	85
15-11-2014	29.7	30.6	28.2	29.5	79	77
16-11-2014	28.0	28.4	27.4	27.7	80	83
17-11-2014	29.6	29.9	28.3	28.4	81	83
18-11-2014	28.6	28.8	26.4	26.6	79	80
19-11-2014	29.0	29.8	26.4	26.9	79	82
20-11-2014	27.4	27.9	25.6	25.9	76	78
21-11-2014	27.7	27.9	25.4	25.5	76	77
22-11-2014	28.5	28.9	24.9	25.0	75	78
23-11-2014	27.5	28.0	26.6	26.9	77	79
24-11-2014	28.4	28.9	27.5	27.8	78	80
25-11-2014	28.5	28.9	25.4	25.9	76	79

26-11-2014	27.2	27.5	27.1	27.2	67	70
27-11-2014	27.9	30.0	26.6	26.9	68	72
28-11-2014	27.8	28.0	27.5	27.5	81	84
29-11-2014	28.9	30.1	24.1	24.8	67	71
30-11-2014	30.1	30.9	25.5	25.9	68	72
01-12-2014	29.8	30.2	26.8	27.0	69	74
02-12-2014	30.0	30.5	29.1	29.5	65	68
03-12-2014	32.7	32.9	22.4	22.9	62	66
04-12-2014	32.1	32.5	21.3	22.0	60	64
05-12-2014	32.8	33.0	20.9	21.0	62	68
06-12-2014	32.6	32.9	21.5	21.8	60	66
07-12-2014	31.9	32.0	28.5	28.9	65	69
08-12-2014	30.4	30.9	30.2	30.5	69	68
09-12-2014	31.7	31.9	29.9	30.0	67	70
10-12-2014	31.0	31.5	26.9	29.9	66	69
11-12-2014	32.2	32.6	27.8	28.0	63	67
12-12-2014	33.2	33.6	29.9	30.0	62	64
13-12-2014	32.1	32.0	26.7	26.4	65	62
14-12-2014	31.9	32.2	29.9	30.0	65	69
15-12-2014	33.0	33.6	26.8	27.6	64	66
16-12-2014	29.0	33.0	28.4	31.7	80	62

APPENDIX IV. Daily Climatic Data during Crop Period (Outside Poly House)

Date	Maximun temperature ^{0}C		Minimum temperature ^{0}C		Relative humidity %	
	M	E	M	E	M	E
26-09-2014	29.5	29.6	27.0	27.4	79	77
27-09-2014	35.5	36.7	27.8	27.8	77	66
28-09-2014	30.5	33.5	28.7	28.8	77	76
29-09-2014	31.6	34.5	29.1	27.1	75	74
30-09-2014	28.4	33.1	27.8	27.2	81	77
01-10-2014	30.9	31.0	23.3	24.1	75	73
02-10-2014	33.5	33.7	24.3	28.7	76	72
03-10-2014	33.1	33.9	24.5	27.7	82	79
04-10-2014	32.5	33.6	24.1	26.8	81	77
05-10-2014	32.6	34.6	28.6	29.0	82	79
06-10-2014	30.1	32.6	28.7	28.7	80	76
07-10-2014	29.2	32.4	27.8	28.0	76	71
08-10-2014	27.4	32.4	26.9	26.9	83	66
09-10-2014	29.2	33.1	27.9	32.5	82	64
10-10-2014	30.0	33.9	29.7	29.9	73	69
11-10-2014	30.9	32.4	28.7	28.9	73	68
12-10-2014	30.6	33.9	28.2	28.5	74	67
13-10-2014	32.0	34.6	29.0	29.4	75	63
14-10-2014	33.3	34.9	30.4	30.6	77	61

15-10-2014	33.7	34.1	30.7	30.9	70	68
16-10-2014	33.4	33.7	31.0	31.3	70	67
17-10-2014	31.8	32.0	29.7	30.0	72	68
18-10-2014	29.2	29.9	28.7	28.9	77	73
19-10-2014	27.3	28.3	26.7	26.7	76	68
20-10-2014	26.9	27.0	25.3	25.6	79	63
21-10-2014	30.8	31.0	28.5	28.8	68	61
22-10-2014	29.9	30.9	26.7	26.9	74	64
23-10-2014	30.8	31.0	27.8	27.9	70	69
24-10-2014	30.4	31.8	27.7	27.8	71	68
25-10-2014	30.2	30.6	28.9	29.9	75	71
26-10-2014	31.7	32.1	29.2	29.6	80	77
27-10-2014	31.2	31.4	29.9	30.0	79	71
28-10-2014	29.3	30.4	28.4	28.8	83	75
29-10-2014	28.9	30.1	28.2	28.8	78	69
30-10-2014	29.2	31.6	28.4	31.1	79	72
31-10-2014	29.1	30.3	27.3	27.9	73	65
01-11-2014	28.4	30.0	28.1	32.3	82	79
02-11-2014	29.4	32.4	28.0	28.3	81	76
03-11-2014	29.9	31.2	29.0	30.2	73	71
04-11-2014	30.0	31.9	29.2	30.0	75	73

05-11-2014	30.1	33.8	27.8	29.0	82	79
06-11-2014	31.1	33.7	25.9	26.0	75	77
07-11-2014	29.5	30.7	28.9	30.0	77	74
08-11-2014	28.1	30.0	28.0	28.8	80	78
09-11-2014	29.2	30.3	28.4	29.0	80	79
10-11-2014	28.1	31.1	27.7	30.3	85	75
11-11-2014	28.1	30.5	28.2	29.5	83	79
12-11-2014	28.1	30.5	26.9	30.3	84	74
13-11-2014	31.0	32.1	27.0	30.8	72	62
14-11-2014	28.4	30.2	27.7	28.1	82	79
15-11-2014	28.7	30.6	28.2	30.1	77	75
16-11-2014	27.8	28.9	26.9	27.0	77	76
17-11-2014	29.0	30.2	28.5	28.9	78	69
18-11-2014	28.0	29.5	27.2	27.3	73	70
19-11-2014	28.5	30.2	26.8	27.1	80	81
20-11-2014	27.0	28.2	26.2	26.3	79	75
21-11-2014	27.2	28.0	25.6	25.8	78	76
22-11-2014	28.1	30.1	27.9	27.9	67	66
23-11-2014	27.2	28.6	27.0	27.6	72	70
24-11-2014	28.0	29.2	26.7	26.8	73	69
25-11-2014	28.1	29.3	27.9	28.0	68	67

26-11-2014	28.3	29.9	27.3	27.8	62	60
27-11-2014	27.2	30.2	25.9	26.2	75	71
28-11-2014	27.4	28.1	27.1	27.8	82	79
29-11-2014	28.2	30.5	28.3	28.4	80	78
30-11-2014	29.9	31.0	29.7	29.7	68	65
01-12-2014	29.3	30.6	27.6	27.8	67	64
02-12-2014	29.9	30.7	28.5	28.6	68	63
03-12-2014	32.0	33.0	29.7	29.8	65	62
04-12-2014	31.9	32.9	29.5	29.6	68	65
05-12-2014	32.4	33.5	30.4	30.5	62	60
06-12-2014	32.1	33.3	30.2	30.4	64	63
07-12-2014	31.3	32.3	29.9	29.9	70	69
08-12-2014	29.7	30.8	28.1	30.7	68	66
09-12-2014	31.4	32.0	30.3	30.2	69	67
10-12-2014	30.7	31.8	30.0	30.2	70	68
11-12-2014	31.9	32.9	28.9	29.0	72	70
12-12-2014	33.0	33.9	29.2	29.4	70	68
13-12-2014	31.9	32.2	29.9	29.9	70	69
14-12-2014	31.5	32.6	28.8	28.9	68	67
15-12-2014	32.0	33.9	29.8	29.9	70	68
16-12-2014	29.4	32.8	28.1	31.7	85	58

Standardization of Irrigation Requirement of Cowpea under Naturally Ventilated Poly House

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ABSTRACT

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ABSTRACT

Present study on standardisation of irrigation requirement of cowpea under naturally ventilated poly house was carried out in the experimental plot of PFDC farm, KCAET Tavanur. The objectives of the study were to determine the water requirement of the cowpea using CROPWAT and to schedule irrigation for cowpea inside naturally ventilated poly house. Weather parameters inside and outside the poly house were also compared.

Irrigation trial was carried out with five levels of irrigation viz. 80, 90,100,110 and The yield obtained from the irrigation treatments was analysed. The maximum yield was observed for the treatment $I_{2,}$ i.e. 90% of daily irrigation requirement (29620kg/ha). The minimum yield was observed in the case of treatment $I_{5,}$ i.e. 120 % of daily irrigation requirement (13673kg/ha). With respect to average yield, the different levels of irrigation showed significant difference. Compared to I_2, the yield from other treatments I_1, I_3, I_4, and I_5 were less by 14, 30, 34 and 54%. Irrigation amount considerably affected irrigation water use efficiency (IWUE). It ranged from 25 kg/ha-mm to73 kg/ha-mm. The study revealed that drip irrigation with 90% of the daily irrigation requirement can give maximum yield of cowpea inside a naturally ventilated poly house.