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Examination of how soil moisture content in Greenhouse is regulated in Wareng Sub-County Uasin Gishu County, Kenya.

Joseph Kipkemoi Sang
Jomo Kenyatta University of Agriculture Technology

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ABSTRACT

Greenhouse farming in Kenya is becoming a lucrative investment as well as a means of improving food production in marginal environments. The Greenhouse is intended to regulate external conditions including soil moisture content suitable to different types of crops. Many farmers use timers to control irrigation, but timers do not account to day to day changes in plant use. The aim of this study was to examine how soil moisture content in Greenhouse is currently regulated The study was guided by Mamdani Fuzzy Logic Theory that uses Nested "IF THEN RULES". Preliminary data was collected through Observation and Interview schedules. The population of the study comprises five greenhouse farmers and four field officers. Experimental Research Methodology was applied. The system was modeled using graphical notation in the Unified Modeling Language (UML) and developed using Experimental Prototyping. The Soil Moisture Sensor, Arduino Board, Water Pump are interfaced to develop the Intelligent System for Determination and Regulation of Soil Moisture Content. The study observed that following ways of managing the soil moisture content: Opening taps to run for 16 minutes in the morning and the evening. Checking the adequacy of soil moisture content by touching and squeezing the soil around the drip irrigation area. When the soil is squeeze and remain together then the moisture is adequate otherwise not adequate. Some Greenhouse farmers control the flow of water through the pipes by switching on and off the regulatory tap twice a day depending on the type of crop, soil and the stage of crop while Others were using a crude method which simply observing the wetness of the soil.

Introduction

Food has become a major issue which needs to be addressed for a nation to be stable economically, socially and politically. The most cost effective means to the achievement of optimum productivity in this sector has been over time considered to be achievable through the construction and management of Greenhouse. The difficulties in controlling the natural climatic conditions in which crops are grown is inevitable and there is need to invest in the creation of artificial micro climatic conditions that favor the cultivation of horticultural crops which are vulnerable to the extreme climatic and weather conditions. The present day microcomputers or personal computers are fairly versatile and can be interfaced to an experimental set up, using numerous sensors for high speed and large data storage (Chaudhry *et al.*, 2004).

The year 2011 was a particularly difficult period for Kenyans (Oparanya, 2012). After steady economic recovery in 2010 which saw the GDP growth reach 5.6%, the year 2011 began with a severe drought that affected most Kenyans whose livelihoods are dependent on agriculture and livestock. The greatest adversity that faced the country in 2011 was food shortage and famine that affected 2.4 million Kenyans, a problem that can be traced to global climate change (Oparanya, 2012).

During the last couple of centuries, the implementation of fertilizers and farming tools has increased the crop yield and thereby resulted in today's mechanized farming culture. To realize the optimum crop yield, water is a major carrier component of various nutrients in the plant growth. In recent years, additional steps towards production optimization have drawn the attention to electronics. The goal is to have computerized farms where all the environmental conditions as well as production details are monitored and evaluated (Soren, 2006).

The realization of Kenya's Vision 2030 will be achieved if the country is self-reliant in terms of feeding her people. Agriculture plays a major role and Kenya aims to promote an innovative, commercially-oriented, and modern agricultural sector (Ministry of Agriculture, 2012). This will be accomplished through; transforming key institutions in agriculture and livestock to promote agricultural growth, increasing productivity of crops and livestock, developing more irrigable areas in arid and semi-arid lands for both crops and livestock (Ministry of Agriculture, 2012).

Greenhouse is one of the tools that have been of major importance for the agriculture where the conditions for agricultural practices such as growing of food are unfavorable. The greenhouse introduces a controlled environment that can protect the crops in all seasons i.e. during the winter and the dry seasons in the tropics. It can also increase the growth rate of the crops, because the atmosphere and the fertilizers are easily adjustable in modern Greenhouse and growth boxes.

By controlling the environment and atmosphere in the greenhouse, the plant growth can be optimized. The watering

Tele:
E-mail address: jksangbarchok3@gmail.com

and air humidity can influence the overall health of the plants and increase their lifetime and survival rates (Mortensen, 2000).

Water moisture, temperature, light, humidity and carbon (iv) oxide (co_2) are the basic conditions that are monitored and controlled in a greenhouse system. An increase in the CO_2 concentration in the air can enhance the growth rate of the vegetation, and this rate is also closely related to the temperature. The cornerstone in plant growth is the photosynthesis, and since light is the only source of energy for this process, it obviously has a strong impact on the vegetation growth (Kirdmance, 2004).

Soil Moisture Management in Greenhouses

A study was carried out by Tabatabaei (2011), in Management of Water content of soil in cultivation of greenhouse cucumber. Tools such as Tensiometers and weighting of the soil to measure and determine soil moisture content were used. He established that the water content of soil is an important factor in greenhouse where it is directly related to the total amount of water consumed for irrigation. The study was good but the way of determining soil moisture content was tedious and not accurate.

Thompson, (2003) studied the irrigation scheduling of drip-irrigated vegetable crops grown in Greenhouse using continuous soil moisture monitoring. He established that a continuous monitoring of volumetric soil water content has considerable potential for irrigation management (IM). The dynamic protocols were developed for IM of drip-irrigated vegetable crops grown in soil, in Greenhouse using the EnviroSCAN system (ES). The upper limit was defined by vertical drainage at depth, and the lower limit by reduced crop water uptake when irrigation was withheld. He further indicated that a continuous soil moisture monitoring has considerable potential for irrigation management because it enables irrigation to be "tailored" to the requirements of individual crops and the characteristics of individual cropping locations, and it can be used to automatically control irrigation. What was lacking was the implementation of an intelligent system to regulate soil moisture content.

Water stress not only occurs due to inadequate water but also as result from too much water in the soil. Hochmuth, (2012) further pointed out that flooding in the greenhouses deprives the vegetables crops roots oxygen that is required for proper root functioning. In addition to affecting overall growth, nutrient up take and yield, water management affects fruit size and quality.

Muhammad (2010) looked at the available soil moisture as an important limiting factor in growth and productivity of the crops. He mentioned that Greenhouse vegetable growers commonly estimate the availability of soil moisture by plant and soil appearance. Slight wilting of succulent terminal leaves indicates water stress in plants. The farmers normally squeezed handfuls of soil taken from near the surface at several locations in the greenhouse. Soil that does not stay compressed in a tight ball is considered too dry and otherwise saturated soil. This implies that water deficiency can be damaging to crops since it can result in; Slowed growth rate, small fruits and, in tomatoes the blossom end rot often follow slight water deficiencies. Therefore, replacing traditional methods of estimating available soil moisture content with a more accurate method is necessary to maintain optimum soil moisture levels. The use of digital computers in process monitoring and control applications has expanded to include many production areas outside the industrial processes mostly using labVIEW software (Groover et al ,2002). But according to Chaudhry et al (2004) a larger sophisticated sensors and mother board such as Arduino board had been developed which can convert analog data to digital data that the computer needs. They also observed that all cases of communication via computer require data in digital form for both input and output data. An intelligent Irrigation system is a valuable tool for accurate soil moisture control in highly specialized greenhouse food production. The system will offer a simple, precise method for sensing soil moisture content and applying water to the greenhouse. Management time savings and the removal of human error in estimating and adjusting available soil moisture levels enable skilled farmers to maximize net profits.

Methodology

Research design is the plan and structure of investigation used to obtain evidence and answer research objectives (Mugenda, 1999). The study was conducted using experimental research design. According to (Oso et al, 2005), experimental method entails systematic manipulation of some characteristics and examination of the outcome. The study was carried out in selected Greenhouses in Wareng Sub-County, Uasin Gishu County. The three small scale Greenhouses and one large scale greenhouse are located a long Eldoret-Iten road. The other large scale greenhouse is located a long Eldoret-Kaptagat road. The population of the study will comprise of all the Greenhouse farmers and field officers in Wareng Sub-County, Uasin Gishu County who are in access to professional constructed Greenhouse. The total study population for this study was nine as shown in Table 1.

Table 1. Population and Sample Population of the Study

Respondent Categories	Study Population	Population to be sampled
Small scale Greenhouse farmers	3	3
Large scale Greenhouse farmers	2	2
Field officers	4	4
Total	9	9

Since the population was small, all the respondents were included in the study. The sample focused on informants who have experiences on Greenhouse management. Therefore, three small scale Greenhouse farmers, two large scale Greenhouse farmers and four field officers were sampled. This sampling was guided by sampling fact emphasized by (Krejcie and Morgan 1970), who state that if a population is less than ten then all should be sampled.

The instruments used for data collection were Interview schedule and observation were used to get information from Greenhouse farmers and field officers. Experiment was performed to determine the maximum and minimum thresholds of soil moisture content in greenhouse. Piloting was done by administering an Interview schedule to four respondents in Kesses Sub County to test reliability.

Findings and Discussions

The preliminary data was collected in Wareng Sub-County, Uasin Gishu County from selected farmers with Greenhouse and field officers. The study area comprises of farmers with small and large scale greenhouse constructed professionally.

Small Scale Greenhouse

The three small scales Greenhouse under study are located along Eldoret-Iten road. The researcher labeled them the Greenhouse A, Greenhouse B and Greenhouse C as per

Table2. Description of Small Scale Greenhouse

DESCRIPTION	REMARKS		
	GREENHOUSE A	GREENHOUSE B	GREENHOUSE C
Size of Greenhouse	8m width by 15m long.	16m width by 30m long.	16m width by 30m long.
Cover of Greenhouse	Plastic cover	Plastic cover	Plastic cover
Shape of Greenhouse	Oval	Triangular	Triangular
Type of crop grown	Tomatoes and Cabbages	Onions and Cucumber	Tomatoes and Pepper
Source of water	Borehole	Piped	Piped
Type of irrigation	Drip	Drip	Drip
Type of soil in the greenhouse	Loam	Mixed Forest soil	Loam
Method of monitoring Soil moisture content	Manual	Manual	Manual
Availability of electricity	Not available	Not available	Not available
Application of ICT infrastructure	None	None	None
Nature of work force	Semi-skilled	Skilled	Semi-skilled

Table 3. Description of Large Scale Greenhouse

DESCRIPTION	REMARKS	
	GREENHOUSE D	GREENHOUSE E
Size of Greenhouse	64m width by 90m long.(several of them)	32m width by 90m long.(several of them)
Cover of Greenhouse	Plastic cover	Plastic cover
Shape of Greenhouse	Oval	Triangular
Type of crop grown	Flowers	Flowers
Source of water	Piped	Piped
Type of irrigation	Drip	Drip
Type of soil in the greenhouse	Loam	Mixed Forest soil
Method of monitoring Soil moisture content	Manual	Manual
Availability of electricity	Available	Not available
Application of ICT infrastructure	Yes	None
Nature of work force	Semi-skilled and skilled	Semi-skilled and Skilled

the request of the farmers so that the identity is withheld. The table below shows the description of each greenhouse.

The three Greenhouses are adequately large and they were professionally constructed. All of them are covered with plastic paper as covers and used drip irrigation. The type of soil in the three Greenhouses was loam soil and mixed forest soil. All the three farmers had tomatoes, onions and cucumbers on their Greenhouse. None of them had electricity in the greenhouse though it is within the range. Most of the workers had experiences of over five years.

The three farmers also stated that the porosity or soil texture surface matters a lot when it comes to water filtration to the soil. Compacted soils are likely to over flood while fine soil cannot flood easily. The farmers said that if soil in the greenhouse is compacted the frequency of irrigation should be more but within short duration.

Large Scale Greenhouse

The two large scales Greenhouse were located within Wareng Division, Uasin Gishu County. One located along Eldoret-Iten road and the other was located along Eldoret-Kaptagat road. The two Greenhouses specialized on the growing of flowers.

The Greenhouses were fairly large in size. They covered an area of about six acres of land with a good number of employees. In both farms (Greenhouse), the workers were skilled with few who are semi-skilled. The two large scale Greenhouse uses drip irrigation. It has electricity for warming the greenhouses during the cold seasons and majorly for lighting at night.

The following findings are summaries of preliminaries data collected from both the greenhouse (farmers) and field officers in the study: Both the small scale and large scale farms in which the Greenhouse was using the following ways of managing the soil moisture content:

i) Opening taps to run for 16 minutes in the morning and the evening. Checking the adequacy of soil moisture content by touching and squeezing the soil around the drip irrigation area. When the soil is squeeze and remain together then the moisture is adequate otherwise not adequate.

ii)Some Greenhouse farmers control the flow of water through the pipes by switching on and off the regulatory tap twice a day depending on the type of crop, soil and the stage of crop.

iii) Others were using a crude method which simply observing the wetness of the soil.

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