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Survey

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Challenges and Prospects of Selected Controlled Environment Agriculture (CEA) Structures in Ibadan Metropolis

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Over the years, the concepts of climate change and global warming has been continually studied and its expected effects have been well documented. These environmental issues have reduced the effectiveness of open field agriculture and as such other cultivation methods had to be devised; controlled environment agriculture is one of such methods. This survey was conducted in three selected controlled environment agriculture structures within Ibadan City to determine the challenges and some environmental factors affecting the use of controlled environment agriculture structures in this area. The research methodology used included visual inspection, field measurements and personal interviews. The results showed that that only a few of the factors that could be controlled were being controlled in all the locations visited and that controlled environment agriculture is still in the research stage in Ibadan particularly when talking about the crop cultivation aspect. Other challenges in its usage included inadequate water supply, epileptic power supply, lack of adequate ventilation, litter management, egg cannibalism, feed management and poor maintenance. It was suggested that the controlled environment agriculture structures management should provide alternative power and also introduce devices that will aid air and heat movement as well as temperature control. Reuse of litter for manure and proper maintenance were also recommended.

Key words: CEA structures, poultry house, greenhouse, screen house, Ibadan.

INTRODUCTION

Stephen [1] defined climate change as a periodic modification of the Earth's climate due to a number of changes in the atmosphere as well as interactions between the atmosphere and other geologic, chemical, biological, and geographic factors within the Earth's system. NRC [2] stated that the scientific consensus on climate change is "that climate is changing and that these changes are in large part caused by human activities" and "it is largely irreversible" as opined by Solomon *et. al*. [3]. The effects of climate change on agriculture and food production around the world due to increased carbon dioxide (CO_2) levels as well as other greenhouse gases in the atmosphere include higher temperatures, altered precipitation and transpiration regimes, increased frequency of extreme weather events, and modified weed, pest and pathogen pressure as maintained by Easterling *et al.* [4]. CO_2 emissions from energy generation in 2010 were the highest in history; this value was 5 percent higher than the previous record, set in 2008. However, International Energy Agency (IEA) [5] reported that in 2009 emissions were slightly lower and this was attributed to the world recession. In Africa, it has been iterated that due to climate change, "Southern Africa could lose more than 30 percent of its main crop, maize, by 2030" [6,7]. The 2001 Intergovernmental Panel on Climate Change third assessment report concluded that the poorest countries would be hardest hit, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability and new or changed insect pest incidence. Omobowale [8] stated that "Just as climate change portends serious negative

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impacts on agriculture, the practice of agriculture has also contributed significantly to the problem of climate change and global warming. Farming (both livestock and crops) as well as some other agro allied activities results in the emission of CO_2, CH_4, N_2O as a direct result of the combustion of fossil fuels, deforestation, land clearing, bush burning, manufacture of agricultural machinery, application of synthetic nitrogen fertilizer and livestock waste. About 12 percent of anthropogenic greenhouse gas emissions globally are attributed to agriculture. This calls for a drastic action that would lead to a cost effective and climate compatible way of practicing agriculture.

Climate change, agriculture and Nigeria: the true picture

The most populous country in Africa, Nigeria accounts for approximately one-seventh of Africa's people. It is a said that at least 24 cities have populations of more than 100,000 people in Nigeria. The United Nations estimates that the population in Nigeria would reach 289 million by 2050, a development which is likely to make Nigeria rank as the 8th most populous country in the world [9]. The survival of a nation depends to a large extent on its ability to feed its populace. Similarly, the ability of a nation to feed its populace depends on the availability of food products at an affordable price when due. Africa though blessed with numerous edible crops, seasonal variations do not allow for year round supply [8]. Yusuf *et. al.* [10] reported that already food insecurity is in some countries, climate change has further worsened the situation and Africa is faced with a serious threat of total chaos should the predicted effects of climate change on the continent be left unattended to. Nigeria long had an agricultural economy but now depends almost entirely on petroleum. While oil wealth has financed major investments in the country's infrastructure, Nigeria remains among the world's poorest countries in terms of per capita income. Oil revenues led the government to ignore agriculture, and Nigeria must now import farm products to feed her people. The rural economy that supports many Nigerians is based on the productivity of the land, 33 percent of which is cultivated. As a result of stagnation in agricultural development by the mid-1990s, agriculture's share of exports had declined to less than 5 percent as published by Akoroda [11]. Ministry of Environmental (MOE) [12] stated that the major contribution to the decline has been linked with the negative effects of climate change on crop production. Once an exporter of food to nearby countries, Nigeria now must import food to meet domestic demand. The effects of climate change/global warming are already evident in Nigeria with desert encroachment presently approximated at 0.6km per annum.

Controlled environment agriculture (CEA)

Controlled Environment Agriculture (CEA) is a system by which the natural environment is modified to achieve optimum plant growth thereby increasing crop yield. Omobowale [8] stated that while open field agriculture is seasonal, multiple harvests are possible through CEA because crops grown in greenhouses do not necessarily depend on the outdoor climatic conditions. In plant growth process, certain factors are of importance such as light, CO_2, temperature, humidity, nutrients and water. For animal rearing and production at optimum condition, environmental factors such as humidity, light duration and intensity as well as temperature play a vital role. All these factors can be modified to create the best conditions for improved plant yield and economic returns. The concept of controlled environment agriculture was born out of the need to combat the negative effects of climate change. CEA provides secure, healthy, cost effective year round production of many premium, edible, high value plant and animal species most especially when used with unique energy saving innovations. Israel is an example of a nation that has successfully utilized CEA to achieve economic development and attain food security. Sharma [13] wrote that Israel lack good soil and abundant water resources, but she has developed greenhouse technologies that enabled farmers to grow more than three million roses per hectare per season and an average of 300 tonnes of tomatoes per hectare per season. This amounts to four times the achievable yields in open fields. CEA offers various options as to what method can be adopted whether for animal or cop production. These include soil culture, screen house, soilless culture or hydroponics, aquaculture, aquaponics and animal husbandry.

Survey Location

The study location is Ibadan which is the capital city of Oyo State and the third largest metropolitan area by population in Nigeria. Ibadan has a tropical wet and dry climate with a lengthy wet season and relatively constant temperatures throughout the course of the year. The study was carried out at three (3) distinct locations in the Ibadan metropolis. These were the Greenhouse located at Department of Crop Protection and Environmental Biology, University of Ibadan (Plate 1), the Screen house (Plate 2) situated at the Institute of Agricultural Research and Training, Moor plantation, Ibadan and the Poultry house (Breeder Unit) (Plate 3), Federal College of Animal Health and Production Technology, Moor plantation, Ibadan. Three survey methods were considered which included the stage one, this involved the identification of the study area and field visits to the study area. Stage two was the visual inspection of the structures as well as personal interview with various personnel on the operation, uses and factors being controlled as well as devices used in the control. Stage three was based on consultations with relevant authorities.

Greenhouse

The greenhouse is used specifically for research

Plate 1: Greenhouse.

Plate 2: Screen house.

Plate 3: Poultry house.

purposes. The environmental factors of concern being modified in this greenhouse are levels of shade and light as well as water and pest control. The structure was oriented in the EW direction and this serves the purpose of reducing shadows inside the structure. The structure was constructed with a variety of materials all serving different purposes. The length of the building is about 7.4m with a width of about 3.7m. It has a concrete floor and wall up to a height of about 0.8m and this has a metal frame driven into it and completing the structure outline up to the roof. Immediately on top of the concrete wall is a transparent white glass wall of about 0.6m in height, and thickness of 0.2cm. The glass is responsible for allowing sunlight into the structure. It is followed by a wire mesh up to the roof level; this provides ventilation for the structure in terms of temperature regulation, air inflow and outflow and supply of fresh air for photosynthesis. The roof is made of transparent glass to allow sunlight through. There are also stands in the greenhouse to enable planting of crops that may need to be elevated above the ground level, these stands are made of metal and exist at a height of 0.8m above the ground. Extra lighting in the greenhouse is provided by two (2) fluorescent tubes with a rating of 36 watts in each structure. There are however two (2) designs to this extra lighting. One design had the tubes hanging from the roof while the other design had the tubes anchored to the wall. Both designs were however elevated at a height of about 2.6m above the ground. The design also had a control chamber (room) so as to minimize the influence of external environmental conditions.

Screen House

The screen house was established in 2007 as part of the structures of the Plant Pathology unit of the Institute of Agricultural Research and Training and as such is used specifically for research purposes of insect control in a planting environment. Other factors being controlled are air particulate and water. The screen house is oriented in the east-west direction. The height of the structure is about 3.6m with a length of 20.72m and a width of 5.92m. The floor of the screen house is constructed with concrete and it also has a concrete side wall to a height of about 0.4m, the purpose of this sidewall is to prevent splash from rainfall from entering the structure. The frame of the structure is made from aluminum poles which are used to form an arc at the roof section. A rubber screen or mesh is used to seal the entire structure. This mesh is responsible for the prevention of the entrance of insects and other larger air borne materials. A polythene material was placed a few meters above the screen roof; this serves as a rainfall deflection roof to ensure that rainfall does not enter the structure. The clearance between the nylon roof and the mesh top is about 0.5m. The screen house has a foundation that is about 0.96m in height. The floor of the structure has a slight slant to it which is to allow for excess water to flow out of the structure under gravity toward some pipes which were installed at the lowest slant point to carry water out of the structure.

Poultry house

The structure visited in this location was a modified atmospheric poultry house for the purpose of raising breeder's which are. poultry animals whose eggs are taken to the hatchery for production of day old chicks and it has been in operation since 2011. The environmental factors being modified in this poultry are light and heat as

Plate 4: Wire Mesh and Screen Wall.

Plate 5: Broken water pipe.

well as feed and water to ensure optimum performance. The building site, orientation, insulation, roof overhang, and equipment design all influenced the temperature inside the poultry house. The structure was positioned so that the roof line runs from east to west. This orientation keeps direct sunlight from coming through the sides and causing heat to build up within the poultry house. The roof was made of asbestos shingles which is a mixture of mineral fibre and Portland cement. The length of the structure is about 21.5m with a width of about 7.2m. The frame of the structure is made from wood while the walls are made of wire mesh and rubber netting. The rubber netting is to ensure that flying insects and objects are prevented from gaining access into the poultry and the wire mesh is to provide some form of obstruction or mechanical support to the netting material when poultry birds push against it (Plate 4). The building also takes into consideration the fact that when it rains on windy days, large amounts of water can be transported into the poultry house from the sides and as such the external parts of the structure is fitted with uncoilable trampoline material which is uncoiled during rain and rolled back up after the rains have stopped. This prevents unwanted amounts of water from gaining access to the poultry and creating additional problems. The floor of the poultry house is made of concrete with wood shavings as bedding material. The wood shavings help in making litter removal less stressful or problematic. The concrete floor also forms a side wall up to a height of about 0.6m. This helps prevent rainfall splash from entering the poultry house. Experience has shown that poultry animals tend to lay eggs in secluded areas or in corners where there is possibility of minimal interference. There is therefore the provision of laying boards for the chickens to lay their eggs. A large percentage (not all) lay their eggs in the boards and this helps ease egg collection. The structure has a control chamber to ensure that the effects of external conditions are minimized when workers enter the poultry house. It also has two chambers. One chamber is for the male birds (about 110 of them) and the second (larger one) is for the female birds (about 700 of them).

The males are released in the morning to mate with the females and they are returned in the evening. The temperature of the environment in the poultry is modified by using a number of fans all with different power ratings but ranging from 50 watt to 135 watt. There are 7 fans in each structure arranged in a diamond formation. The fans are set to operate at varying speed depending on how hot the environment is. The birds in the poultry are fed twice a day and this is usually a factor in the lighting period. They are fed at around 5AM and at around 6PM. It should be noted that feeding rate is reduced at high temperature, so the birds tend not to feed late in the morning, at midday and also not until late in the evening.

Data were surveyed in terms of types, shapes and dimensions of structures, materials and style of construction, environmental modifications and devices used as sources of water and light, type of ventilation, maintenance of structure, labour requirements, energy input and hygienic conditions of the structures. The data were analyzed using descriptive statistics to ascertain the presence of various environmental parameters in the structures.

Challenges faced in the structures

Greenhouse challenges

The major challenge faced in the operation of this structure is down to poor maintenance culture and it is problematic because users (mainly research students) have to manually carry out operations that should be automatically done. The poor maintenance of the structure poses problems in terms of water availability, despite the presence of water supply system, poor maintenance has resulted in the damage of the water system (Plate 5) and as such users have to manually carry water to the structure. Epileptic power supply coupled with poor maintenance prevents the proper use of the greenhouse. Some of the glass sections of the wall and wire meshes have been removed from their fixtures and as such there is a poor light control system (Plates 6 and 7). Also some parts of the glass have been covered by dust coating which reduced the penetration of light into the greenhouse.

The air inside the greenhouse was very humid on the

Plate 6: Mesh missing.

Plate 7: Glass section missing.

Plate 8: Water Supply Tap.

day it was visited. It was observed that the sun was very intense and the day was relatively windless. In the absence of wind to move hot air out of the structure, the air became extremely hot and humid. Air circulatory systems (e.g. suction fans) can be provided to improve the humid conditions.

Screen house challenges

Despite the provision of facilities for the watering of planted crops, the process has to be manually carried out because poor maintenance has resulted in the taps not functioning at all (Plate 8). Water has to be conveyed using small buckets from a distance of over 200meters. The screen house was designed to ensure that insects and particles greater that the screen size should not enter the structure. This aim however has been defeated by the presence of holes in the net fabric. This is as a result of poor maintenance culture as this could have been repaired quickly before it became larger. Some of the holes in the screen which is supposed to allow for inflow and outflow of air have been clogged due to accumulated dust on the surface and as such some parts of the screen house have been rendered impermeable to air (Plate 9). There are also holes in the polythene material that was used as a shield for the roof of the screen house.

Plate 9: Dust Accumulation on Roof and Screen.

Poultry house challenges

Litter management is a huge challenge because it can constitute nuisance to the health and comfort of the poultry birds. Heaps of these were found but it has to be removed frequently as it can serve as a source of pathogenic breeding. When it is wet, it is problematic because it can generate a lot of odour. After evacuating the litter, the bulk of the litter which contained faeces, urine, feed, water and possibly feather were dumped in a corner of the compound and allowed to biodegrade under natural environmental condition. Feed management problem was also observed. The feeding rate of the poultry animals is not constant. If feed is supplied to the animals in excess, the remnants after feeding is usually spilled on the floor and this will also create additional litter problems. The same applies to water. Excess water in the water trays will be spilled on the floor and this will create a slurry-like litter which is more difficult to manage. In almost all poultry establishments, egg cannibalism is a major concern. This is a situation whereby after laying of eggs, the egg will be fed upon by the poultry bird. Due to the fragile nature of the egg shells, it poses little or no resistance to the force applied by the beak of the poultry birds. Epileptic power supply was another observed problem in the structure. The devices for light and

Table 1: Analysis of Properties at the various Locations.

Properties	Greenhouse	Screen house	Poultry House
Water	Yes	Yes	Yes
Light	Yes	No	Yes
Heat/air	No	No	Yes
Soil	Yes	Yes	No
Bedding Material	No	No	Yes
Insect Restriction	Yes	Yes	Yes
Air Particulates	Yes	Yes	Yes

temperature modification i.e. fluorescent tubes and standing fans have to be powered sometimes at irregular times or intervals. It is troublesome because of the epileptic power supply that is prevalent in Nigeria. Alternative source of energy (fuel) is being used but this can be costly because of the large number of fans, fluorescent tubes and other electrically powered devices.

The various properties as well as their control at the various locations are shown in Table 1. In the greenhouse and the screen house there wasn't any bedding material because the floor was cemented and there wasn't much interaction between the crops and the floor as the crops were all planted in buckets or pots.

Conclusions and Recommendations

The major challenges facing the adoption of CEA in Ibadan metropolis for commercial farming activities include the following:

Policies, rules and regulations (Local, state and federal): These serve as hindrance to controlled environment agriculture because there are no policies that are formulated to allow or assist the farmers to imbibe this agricultural practice.

Water supply and source of power: These are both extremely important either for crop cultivation or for animal husbandry. However, their supply in Nigeria is not guaranteed and as such they are challenges facing the adoption and practice of CEA in Nigeria.

Design and Maintenance of structures: There are some faulty aspects to the design of CEA structures in Nigeria and the maintenance is a big problem because of the poor maintenance culture in this country. In addition to this, while some countries have adopted CEA for large scale commercial agriculture, we are still trying to maintain this practice for research purposes albeit unsuccessfully.

Education or training of operators: The personnel who will be put in charge of controlling the CEA structures will require to be trained because the adoption of this practice is still in its infancy and as such to obtain maximum performance from this practice, people who know about the practice will have to be put in charge and this will require operators training and education.

Funding for research and development: Availability of funds to further the research and development of CEA in Nigeria is a hindrance.

Technology adoption: There were a lot of instances in which certain processes could or should be automated. However this was not the case and a lot of processes which are highly efficient with automation are carried out manually.

The concept of labor versus technology: The introduction of CEA as an agricultural practice is bound to displace unskilled labour from their jobs. This is because it will involve the introduction of technological devices to carry out practices like spraying, weeding, irrigation etc which unskilled labourers are used for on a farm. Therefore this concept is a challenge particularly in a country like Nigeria where there is mass unemployment.

CEA benefit on the long run far outweighs the initial expenses. This is because yields are higher in greenhouses than in open field agriculture (OFA) as a result of the optimal growing conditions, balanced plant nutrient and year-round production which is possible in controlled environments (Jensen, 2010). The above mentioned problems are however surmountable with the introduction of relevant policies and the application of skills and technologies which are present in the country.

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