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Construction Of An Outdoor Laboratory (Greenhouse) For The Cultivation Of Selected Exotic Vegetable Species

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ABSTRACT
A greenhouse is an outdoor laboratory that provides a controlled environment for scientific research and education allowing for the manipulation of variables like temperature, light and humidity that are crucial for studying plant growth and development. This research work focuses on the construction of a mini sized cost-effective greenhouse structure for the purpose of research activities. The construction of the greenhouse was done using bricks, frame made of galvanized steel poles, wood, woven net, nails, metal net and poly-carbonated corrugated roofing sheet cover of 170gsm. The greenhouse has a surface area of 23.1m^2 and volume of 92.4m^3. The conventional lean-to pattern was adopted with slant roof and mesh net above the brick wall around it to suit our tropical climate. The constructed greenhouse will assist students to gain tangible experience in Biological and environmental sciences as well as collection and comparism of data including learning about plant life cycles. This project serves as a model for the needed innovation in Biology and Agric-education in technical colleges.
Keywords: Greenhouse structure, controlled environment, cost-effective, tropical climate.

INTRODUCTION

A greenhouse is an outdoor laboratory that provides a controlled environment for scientific research and education, allowing for the manipulation of variables like temperature, light and humidity that are crucial for studying plant growth and development. Some of the benefits of the outdoor laboratory (greenhouse) include cultivation of plants and crops year-round by protecting them from extreme temperatures and other harsh outdoor elements as well as better yields (Bucur, 2010). Greenhouse cultivation various crop species helps provide a controlled and efficient environmental condition for their optimal growth and productivity.

The greenhouse is a framed structure that is covered with transparent materials like polycarbonate (PC), polyethylene film, acrylic, polyvinyl chloride (PVC) film or glass. It's construction usually consists of two parts namely the frame and covering material. The greenhouse covering material acts as a barricade to air movement and helps traps energy which heats up the system (DeGannes *et al*, 2014, Prasad and Kumar 2014).

Different types of greenhouse exist but the attached and stand-alone structures are the two main common types. It is best for the greenhouse to be located in the south or southeast side of a building or shade trees where it gets the maximum sunlight (Ashok, A. D. and Sujitha, 2020). Morning sunlight is most desirable as it allows the early photosynthesis that aids optimum growth of plant. An east side location captures sunlight the most from November to February (Bucur, 2010).

Greenhouse farming optimizes the available resources like water, nutrients, energy, space, capital and labor, and thereby creates the desired plant product or biological processes (Murat, 2012, Ale *et al*., 2019).

For the purposes of greenhouse design, the need for adequate light and ventilation, protection from rain and, insect exclusion are primary concerns. An effective design uses insect proof netting for side walls and a passively ventilated polycarbonate panel roof. In many developing countries, a need exists for a low-cost greenhouse, using locally available materials where possible (Hickman, 2010).

The best orientation for greenhouses in tropical climates is east–west which allows for maximum interception of light levels throughout the year. In selecting the site for the structure much attention should be given to orienting it for maximum light intake (Ashok, A. D. and Sujitha, 2020). However, in the tropics, there is abundance of light all through the year. Therefore, it is to ensure that there are no large trees or buildings that cast shadow onto the structure for maximum productivity.

This research seeks to set up a cost-effective greenhouse design that can withstand local weather conditions in Nigeria, assess the growth, yield and adaptability of exotic vegetables in a greenhouse environment and assess the costs and benefits of greenhouse cultivation compared to traditional farming practices in Nigeria. This study aims to design, construct and utilize an outdoor laboratory (greenhouse) at Federal College of Education Technical Ekiadolor to enhance student learning and research in biological and environmental science through hands-on training, evaluate and promote the cultivation of exotic vegetable species suitable for Nigeria's climate and act as a living laboratory where students can learn the act of seedling production.

METHODOLOGY

This work was carried within the premises of Federal College of Education (Technical), Ekiadolor. The selected site which is in the east-west direction receives sunlight for over 8 hours, close to water source and has minimal shading. The design selected was one that works with the Nigerian tropical climate to encourage ventilation, shading and protection from rain.

The following materials were used to set-up the outdoor laboratory; cement, concrete, sand, woven net, metal net, PVC pipes, pipe connectors, plastic pots, poly-carbonated roof panels, nails, wood, water tank, , galvanized steel poles and paint.

The construction of the greenhouse involved four stages which are laying of the foundation, establishing the frame, covering the frame and roofing. The foundation was laid using 6” hollow block to a height of 2 ft 6 inches on an area of 3.3m by 7.0m. Galvanized poles were used to establish the pillar (frame) for reinforcement while treated wood was used for the roof frame. The roof was covered using transparent poly-carbonated corrugated sheets and the four side views above the brick walls were completely covered with the woven net and reinforced with the strong metal net for proper ventilation and for the prevention of crop burnt.

RESULT

The greenhouse constructed in a conventional lean-to style pattern at an angle of 30^0 had an area of $23.m^2$. The greenhouse was fabricated and assembled using six galvanized poles of 2700mm length and 50mm diameters, wood of 7500mm length, width 3870mm and (2x4) 50mmx100mm and (2x2) 50mm x 50mm thickness, poly-carbonated corrugated roofing sheets cover (170gsm) and woven net around the four upper sides 762mm above the ground level. The door of the greenhouse measured 7000mm in length width 3370mm. The greenhouse components (the beam, the supports and the roof materials were installed on a non-reinforced foundation. The beams, the roof laterals and the supports were joined together with the use of nails. The height of the greenhouse measured 4meters at the lowest side while the orientation was east-west.

DISCUSSION

A functional cost-effective greenhouse with a surface area of $23.1m^2$ and volume of $92.4m^3$ which adapts well to our tropical climate was constructed for research purpose. The conventional lean style pattern was

used to avoid water retention at the roof. The greenhouse was constructed behind the laboratory building to help manage wind velocity and destructive wind. The woven/insect net used round the upper sides of the structure is to encourage ventilation and cooling of the greenhouse. The non-reinforced foundation was adopted because of the size of the greenhouse which is not for large scale activities while the height of 4metres is to encourage good airflow and easy accessibility. The orientation of the greenhouse was east-west so it can maximize morning sun and reduce afternoon heat stress. The brick walls were erected for rain protection.

CONCLUSION

The mini greenhouse project at FCE Technical Ekiadolor was successfully designed and constructed for research purposes such as the cultivation of exotic vegetables and for the enhancement of student skills. It will assist students to gain tangible experience in biology, environmental science and horticulture as well as collection and comparism of data including learning about plant life cycles. This project serves as a model for the needed innovation in Biology and Agric-education in technical colleges.

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