

GREENHOUSE DESIGNS USED IN HYDROPONIC

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Abstract: *There are many known geometries of greenhouses in the world due to the diversity of climate and weather conditions that differ from one country to another, as well as the connection of design with the aim of production. Hydroponic, especially the vertical farming system, requires optimum use of area. This article presents a study of the designs of greenhouses used in hydroponic.*

Key words: *Protected cultivation, vertical farming, soilless culture, single houses, multi-span houses, greenhouses roofs, greenhouses shapes*

INTRODUCTION

Protected cultivation is the term for the agricultural technique that maximizes crop development. The greenhouse is a structure that uses the energy of the solar radiation that is intercepted to create a microclimate that is more suited to the needs of the crops [10]. Although temperature, in addition to humidity, is an essential component of plant growth, greenhouses are typically made of plastic, glass, or fiberglass because they can transmit light and hold heat, resulting in extremely high temperatures within the greenhouse [9]. A well-designed greenhouse structure must achieve a number of important objectives, including inexpensive construction and operating costs, effective mechanical attributes, effective ventilation systems, low heat consumption, and provision for high light transmittance [7]. Utilizing greenhouse technology, crop yields can be increased by precisely adjusting internal climate growth parameters including temperature, humidity, light intensity, and CO₂ concentration [2]. The reason for developing this system is that due to plants do not have a capacity to grow in their original environment. Hydroponic needs to grow in protected environments to increase its efficiency, improve the quality of products and extend the season. Technology hydroponics allows to increase the output of products per unit area and makes it possible to receive products year-round, which is very important for providing fresh vegetable products to the urban population [1]. Plant breeders and producers face how to choose the appropriate greenhouse design, and this depends on several factors such as climate, economic costs, purpose of production, etc. So, in order to choose the appropriate type of the greenhouse when using vertical farming (hydroponic system), it depends on, the optimum utilization of the area of the greenhouse and the efficiency of the exploitation

of solar radiation. **The purpose of this paper** is to present an overview of types designs used in protected agriculture in hydroponic.

Green house designs:

Since hydroponic is grown in protected environments, it uses the same design of the greenhouses.

Based on the shape of the roof, greenhouses can be classified under the following criteria [6]:

Greenhouses are divided into two types: single (unconnected) (Fig.1.A), (Fig. 2) or multiple (connected) greenhouses (Fig.1.B) :

1-Spherical dome:

This type is only used in cloudy areas with weak solar lighting in most days of the year, as this design allows the maximum amount of sunlight to pass through, and it is only suitable for single houses.

2- Hyperbolic paraboloid:

It allows the penetration of a high percentage of the sun's rays throughout the day and is used especially in areas far from the equator where the intensity of illumination is very low. It is also used only in single houses.

3- Quonset or Tunnel:

It is used as its predecessors in single houses only, and it permeates a large portion of the sun's rays during most hours of the day. This form is the most common form in single greenhouses.

4- Elliptical or (Modified quonset):

It is an axis from the previous Quonset and is commonly used when establishing a complex of greenhouses connected to each other, and it is characterized by the possibility of exploiting the space on the sides of the house.

5- Gothic arch:

It is a shape with a pointed knot, taken from the Gothic style that prevailed in the Middle Ages in Europe.

6-Mansard roof:

It is a form with two longitudinal sides, the lower of which is steeper than the upper, and it is only suitable for single houses.

7- Gable even span:

It is suitable for glasshouses and plastic houses, whether connected or not, and is characterized by the presence of two slanted roofs of equal width. This form is the most common form in glasshouses in particular.

8- Gable uneven span:

One side of the roof is longer than the other side, meaning it is steeper, and it is suitable for glasshouses and plastic houses, whether connected or not, but it is not commonly used except in houses built on the sides of hills, where the wide inclined roof faces the sun to allow the greatest amount of light energy to improve lighting and heating.

9- Lean –to:

This type of house is adjacent to a building or an annex to the house, and the roof is sloping towards one side only, which is the side facing the sun. It is usually small and is often used in the production of seedlings and ornamental plants.





1-Spherical dome



3-Quonset or Tunnel (Photography (personal))



4-Elliptical or (Modified quonset)



5- Gothic arch



6-Mansard roof



7-Gable even span



8- Gable uneven span



9- Lean -to

A-Single (unconnected) greenhouses [[5], (<https://www.pinterest.com/pin/820007044639808551>, <https://m.made-in-china.com/product/10-50-M-Single-Span-Tunnel-Greenhouses-Are-Simply-Suitable-for-Africa-1923821322.html>, <https://www.gothicarchgreenhouses.com/Gothic-Arch-North-Greenhouse.htm>, <https://www.gothicarchgreenhouses.com/gable-greenhouses.htm> , <https://whyfarmit.com/lean-to-greenhouses>)]



1-Ridge and furrow



2- Gable even span



3-Saw tooth

B-Connected houses (multi-span houses) [<https://www.gothicarchgreenhouses.com/gable-greenhouses.htm>]

Fig. 1 Classification of greenhouses based on the shape of the roof

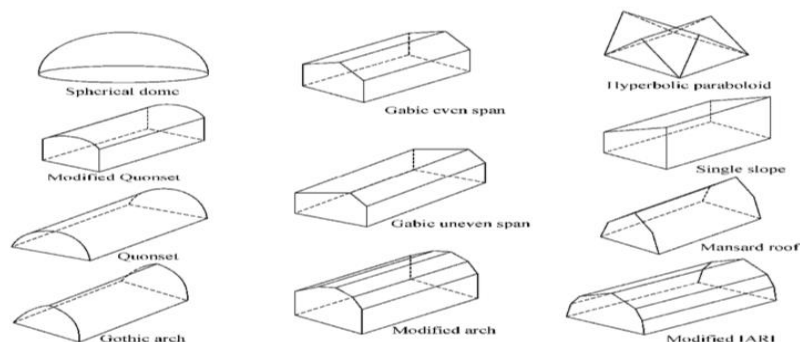


Fig. 2 Classification of greenhouses based on the shape of the roof- (geometrical shape) [8]

Connected houses or (Multi-span houses): there are two main forms of this type of houses:

1-Ridge and furrow:

This type consists of a group of modified Quonset houses and is mostly used for plastic houses. Gable even span it is mostly used for glass houses.

2-Saw tooth:

This type consists of a group of adjacent houses of gable uneven span and is used mostly for glass houses.

Elliptical (Modified quonset) design is the most optimal design in terms of exploiting the optimal area of greenhouses, especially when using vertical farming because the land can be used more efficiently by increasing the internal area of the greenhouse, and maintaining the temperature inside the greenhouse than any other system. outer sides of the greenhouses are exposed to weather fluctuations as the lower the surface of the cover, the less heat loss, and the ease of conducting agricultural operations and the introduction of modern machinery, unlike the tunnel (Quonset) design, for example, 0,5 m distance left from the side walls of the greenhouse (not exploited by agriculture) (fig.3) .

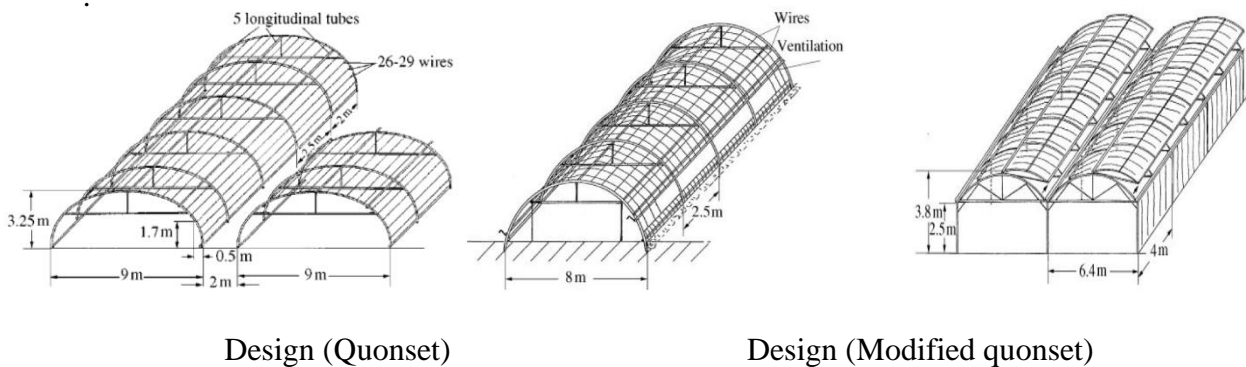


Fig. 3 Exploiting the interior area between two types design (Quonset and modified quonset) [11]

Çakır et al. [3] found that a comparison among five common greenhouse types (50 m², 100 m², 150 m², 200 m², 250 m², 300 m² and 400 m²), with regard to total solar radiation. The results show that greenhouses are usable and suitable for using in cold climate regions to increase the productivity. In addition, the elliptic type is the optimum one in all analyzed types of greenhouses (Fig. 4).

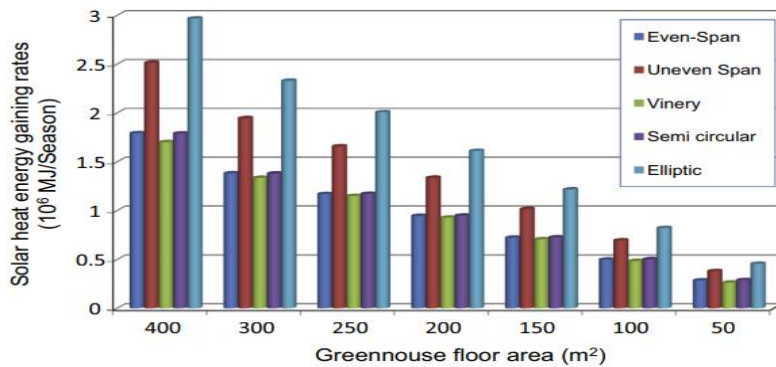


Fig. 4. Total solar energy gaining of greenhouses for optimum (k) (ratio of length to width of greenhouse) numbers and (GAA) (greenhouse azimuth angle) according to different floor areas in greenhouse season [3]

CONCLUSIONS: The designs of greenhouses vary according to the diversity of the climate and the desired purpose, and hydroponics, especially the vertical farming system,

depends on the optimal use of space. So, it is considered a design (Elliptical) the most desired by producers and companies to exploit the agricultural area.

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