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Greenhouses Specifications Appropriate to the Climate of the Sudan

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Abstract

Sudan weather conditions are characterized by having predominantly long and hot summers and short and mild winters. Such climatic conditions put a great strain on the types of crops that could be successfully grown under greenhouses. Cover used in greenhouses in Sudan was agreed with the standard specification, but not agreed with the standard length, width and height. Irrigation in all greenhouses in Sudan is by drip irrigation, result in salt accumulation this require leaching process, but this process does not find an interest in greenhouses. Also, in Sudan there is no interest for cleaning and sterilization which lead to increase infection by diseases, pests and insects. Cultural practices (land preparation, sowing date, variety or cultivar, soil type and its fertility, irrigation quantity and quality, fertilization dose and time of application, insecticides, pesticides and herbicides) do not apply correct in greenhouses in Sudan. Results from different locations in Sudan showed lower production compared with Europe and America. Cucumber production in greenhouses at different location gave different production and different cost of production and return. Also, different cucumber varieties gave different production in greenhouses. The main objectives of this publication are providing a compilation of greenhouse production practices and technologies presently in use in Sudan climate that have helped increase vegetables productivity and quality.

Keywords

Greenhouse, Specifications of Greenhouse, Sudan Climate

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1. Introduction

In recent decades, greenhouse area has raised worldwide, due mainly to the increased use of greenhouses for growing vegetable crops. Site selection is a key factor for profitable and sustainable greenhouse production. The main factors determining location and site selection of a greenhouse production are, cost of production, quality of produced yield, and transportation cost to markets (Nelson, 1985; Castilla, 2007). Obviously, cost and quality of production depend on the local climate and the greenhouse growing conditions. Other technical and socio-economic aspects (water and electricity supply, labour availability etc, also influence production costs and competitiveness (Castilla and Hernandez, 2005).

Today's greenhouse technologies mean it is possible to cultivate all horticultural species in any region of the world, provided that the greenhouse is properly designed and equipped to control the climatic parameters. However, for profitable and sustainable cultivation of the target crop, much stricter selection of the region is necessary, on the basis of climatic conditions and the requirements of the selected horticultural crop. Solar radiation is the main climate parameter needed to evaluate the climate suitability of a region for protected cultivation. Day length and solar radiation intercepted by a horizontal surface during daytime hours are measured to determine total daily solar radiation. Another basic climate parameter is ambient temperature. The

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stability of both values in different months of the year enables the representation of their mean monthly values (obtained by averaging data sets for several years) for a given location in the climate diagram, which represents the location's climate. Other climate parameters, such as soil temperature (closely linked to air temperature), wind, rainfall and air composition (humidity and CO2), influence to a lesser degree the evaluation of climate suitability (Castilla, 2007).

The evaporative cooling of greenhouses is based on the evaporation of the water in the mass of warm incoming air, thus allowing a decrease in temperature and increase in the humidity content of the air. This can be achieved by directly spraying water inside the greenhouse and combining it with natural ventilation (fog systems), or by obliging the incoming air to pass through dampened evaporative pads and installing fans to ventilate the greenhouse artificially (pad-fan cooling systems) (Seth and Sharma, 2007).

2. Climatic Requirements of Vegetables

The most commonly grown species in greenhouses are vegetables with medium thermal requirements (tomato, pepper, cucumber, melon, watermelon, marrow, green bean, eggplant); the aim is to extend the growing calendars beyond the conventional open-air cultivation season, and thus increase profitability. Nowadays, the production of greenhouse crops in geographical areas without suitable climate conditions is highly questionable since it entails significant and expensive artificial climate control. In any case, economic results determine the final selection of a greenhouse project location (Nisen et al., 1988.

Since, air temperature and humidity are the two major parameters affecting thermal comfort significantly, and only sensible load can be handled by an evaporative cooling system, conventional evaporative cooling system is suitable for dry and temperate climate where the humidity is low (Costelloea, and Finn, 2003), (Heidarinejad *et al.*,2009).

The indicated species, traditionally grown in the warm season, are adapted to average ambient temperatures ranging from 17 to 28°C, they are sensitive to the cold. Temperatures persistently below 10–12 °C over several days affect productivity, as do temperatures above 30–35 °C. Daily variation between day and night average temperatures (thermal periodicity) is required for proper physiological functioning; these thermal differences are between 5 and 7 °C. The minimum daily radiation requirements of these species are estimated at around 2.34 kWh $m^{-2}day^{-1}$, this means around 6 hours of light per day, to a minimum total of 500–550 hours of light during these three months. Other desirable climate parameters for these species would be soil temperature of more than 14 °C and ambient relative humidity of 70–90% (Nisen et al., 1988).

Controlling thermal environment in hot weather areas is very challenging. Removing excessive heat from the house requires using evaporative cooling pads, misting or fogging systems in conjunction with mechanical ventilation. In hot and dry climates, evaporative cooling process is the most effective and economical technique of air conditioning (Alodan and Al-Faraj, 2005).

In a greenhouse system the growth conditions are usually achieved through monitoring of all effective growth factors, such as carbon dioxide concentration, temperature, relative humidity, light and radiation. In fact, greenhouse agriculture offers better chances for off-season production of many crops (Ernst, 2004).

The principle of evaporative cooling reveals that the evaporative cooling system can only remove room sensible heat; therefore, the evaporative cooling system works finest in hot and dry climate where the maximum evaporative cooling will result (Chung et al., 2010).

It is a reliable method and requires minimum power consumption. To reduce temperature, in tropical and sub-tropical climates, has challenged the agricultural industry. The production rate of plants and livestock in these regions has been suppressed by the high temperatures and dry weather (Mohammed and Abdullah, 2005).

Generally, Sudan weather conditions are characterized by having predominantly long and hot summers and short and mild winters. Such climatic conditions put a great strain on the types of crops that could be successfully grown. This is very much true with most horticultural vegetables. With the increasing demand for many of the vegetables, such as tomato, potato, cucumber, etc., the need became urgent for their off-season production. Many attempts were made in this regard including the use of different types of evaporative cooling pads to reduce the temperature and alter relative humidity in greenhouses. However, their performance was not critically evaluated.

3. Specifications of Greenhouse

Framework consist of arch 48x1.5mm diameter galvanized steel pipes linked together by three longitudinal galvanized pipes of 32x1.2 mm diameter, plant support 32x1.2mm pipe, to make the structure stronger and for the plants to climb through, wind break "W" shape bars to make the structure stronger, made of 32x1.2mm pipe and six lines of 2.5mm diameter galvanized steel wires for the plants to climb with and one bisect door each greenhouse, 2m height x 1.8m width, galvanized steel frame, covered by poly film.

Covering: 200 micron poly film, 3-layer, cooling pad, size 2m height x 7.8m length x 0.1m width, 7090 type, ripple height 7mm made of strengthened kraft paper, excellent water keeping effect with aluminum alloy framework, anti-rust and nice looking.

Exhaust fan air delivery, 45000m^3 / h / set, Power dissipation, 1.1kw/set, 380V, 3 phases, size: 140cm x 140cm x 40cm,2 fans each span of greenhouse**,** with cable to connect the fans and the electric switch box and 0.75kw water pump (380V, 3 phrases) to supply water for the cooling pad and automatic electric switch board including the temperature sensor to test the temperature, to control the temperature automatically, to save your human resource cost.

4. Factors Affecting Greenhouse Location

The specific selection of a greenhouse location must take into account a variety of factors (Castilla, 2007), described below:

Topography: in principle, the location must be flat in width direction, with a slope in the main axes between 0 and 0.5percent, and never over 1–2 percent, as this would require terracing.

Microclimate: as with liquids, cold air moves downwards (as it is heavier than hot air) to the lower parts of the site, and stays there if there is no wind to carry it away.

Therefore, it is essential that the local topography is suitable for effective drainage of cold air during calm nights. Areas that are well illuminated and free from shadows are preferred.

Harsh weather conditions: sites should be protected from cold winds (usually from the north in the Northern Hemisphere), using windbreaks or taking advantage of the topography. If snow is to be expected, greenhouses must be positioned sufficiently far from trees or other obstacles to the wind, since snow may accumulate around such obstacles.

Irrigation: it should be emphasized that the availability of water (in sufficient quantity and of good quality) is an essential requirement for greenhouse growing of high added value crops. Many areas have been abandoned due to the lack of water in sufficient quantities and of acceptable quality.

Drainage: the drainage conditions must be good, especially in regions of high rainfall. Places with a high water table must be avoided.

Soil characteristics: whether cultivation is directly in the soil or in pots or containers, the soil must have properties appropriate for crops.

Pollution: for greenhouses located in urban areas, air pollution conditions must be evaluated, not only in terms of incidence on the plants themselves, but also with regard to residues deposited on the greenhouse, which can limit solar radiation (e.g. dust from factories).

Availability of space: space may be required for future enlargement, auxiliary facilities (e.g. water basins for collection of rainfall water or storage of irrigation water) and buildings (e.g. handling, stores, offices).

Availability of labour: If local labour is not available, it is necessary to consider the costs inherent in acquiring labour.

Infrastructures: proximity to transport networks (e.g. roads, railway), access to communication systems (e.g. telephone, internet) and availability of energy (e.g. gas, electricity) must all be considered.

Orientation: the position must be chosen to avoid shadows from hills or neighboring buildings. It is necessary to adapt the shape and slope of the roof to dominant winds, while maintaining the objective of maximum light in the greenhouse.

5. Green Houses in Sudan

Sudan weather conditions are characterized by having predominantly long and hot summers and short and mild winters. Such climatic conditions put a great strain on the types of crops that could be successfully grown. This is very much true with most horticultural vegetables with medium thermal requirements (tomato, pepper, cucumber, melon, watermelon, marrow, green bean, eggplant).

Through some visits to different greenhouses in Khartoum State (Jumoaia, Arabian company, Nopel group, Khandagawi farm, Um Dom farms and West Umdurman farms) we collected some information about construction, Performance, efficiencies, ways of environmental control and pests and diseases control and compared them with the standard methods in the world:

(1) Quality of the cover used: There are three types of cover used:

(a) plastic type made of poythlene, with thickness of 180 – 200 micron which agreed with the standard specification and having the advantage of transmittance of light of 85 – 95 %, protection against ultra violet which protect plants from Blight of sun, and Permeability of less infrared which having advantage in lack of heat gained loss at night.

(b) fiber glass which having advantages of, transmittance of light of 80 – 92 %, resistant to cold and temperature, homogeneity of thickness, less ultra violet transmittance, accurate in undulations measure and specific gravity of 1 – 1.1 gm / cm^3.

(c) glass type which having advantages of, less ultra violet transmittance, light transmittance of more than 90 %, but the disadvantages of these types are Smooth surfaces resistant forms construction.

(2) Construction of greenhouses in Sudan: all greenhouses in Sudan are not agreed with the standard length, width and height and this give a disadvantage in that, air ventilation, light and height of the plants.

(3) Leaching of salts from soil: irrigation in all greenhouses in Sudan is by drip irrigation, a disadvantage of drip irrigation is that salt accumulates near the periphery of the wetted area. This salt accumulation can be a matter of concern if the emitter placement does not coincide reasonably well with the location of the plant row, particularly for crops that are sensitive or moderately sensitive to soil salinity, this require leaching process, but this process does not find an interest in greenhouses in the Sudan.

(4) Cleaning and sterilization: if you have had re-occurring problems with pest, diseases and insects, perhaps your greenhouse and potting areas need a good cleaning. Attention to greenhouse sanitation and disinfecting are steps that growers can between crop cycles. Some growers wait until the week before opening a greenhouse before cleaning debris from the previous growing season. It is better to clean as early as possible pests to reduce their populations prior to the growing season. Unfortunately, in Sudan there is nothing interest for cleaning and sterilization which lead to increase infection by diseases, pests and insects.

(5) Cultural practices: good cultural practices is important factor to increase production in greenhouses, this include, land preparation, sowing date, variety or cultivar, soil type and its fertility, irrigation quantity and quality, fertilization dose and time of application, insecticides, pesticides and herbicides, all of these practices do not apply correct result in low production.

Table (1) shows a comparative between the production in exposed agriculture and greenhouse in America and Europe compare to Sudan. From this table, we concluded that there was a big different in production, this because of the suppressed by the high temperatures and dry weather as mentioned by Mohammed and Abdullah (2005).

Also, in a greenhouse system the growth conditions are usually achieved through monitoring of all effective growth factors, such as carbon dioxide concentration, temperature, relative humidity, light and radiation as mentioned by Ernst (2004).

From table (2), there was a big difference between cucumber production in exposed agriculture and greenhouse, in which, greenhouses gave more production than exposed one, this is because the greenhouse is properly designed and equipped to control the climatic parameters as mentioned by Castilla, (2007).

Cucumber production in greenhouses at different location gave different production and different cost of production and return (table 3 and 4), this is because of geographical areas without suitable climate conditions, is highly questionable since it entails significant and expensive artificial climate control. In any case, economic results determine the final selection of a greenhouse project location.

Different cucumber varieties gave different production in greenhouses (table 5), this is because of the suitable climate conditions for different varieties as mentioned by Nisen et al. (1988).

Table (1). A comparative between tomato production in exposed agriculture and greenhouse in America and Europe compare to Sudan.

country	Exposed agriculture	Greenhouses
America and Europe	30 tons / season	75 tons / season
Sudan (summer)	2 - 3 tons / season	40 tons / season
Sudan (winter)	10 tons / season	50 tons / season

Source: ministry of agriculture and irrigation Khartoum

Table (2). A comparative between cucumber production in exposed agriculture and greenhouse for one feddan in Arabian company

Item	Exposed agriculture	greenhouses
Running cost (SDP)	1875	75585
Production (kg)	7000	137557.5
Return (SDP)	14000	380538.8
Profit (SDP)	12125	304953.8

Source: Arabian company Khartoum

Table (3). A comparative between cucumber production and total return in greenhouses for one feddan at different location

Location	Number of green house	Total return (SDP)	Greenhouse return (SDP)
West Omdurman	20	1,280,000	64,000
Arabian company	150	14,400,000	96,000
Nopels group	97	12,918,000	133,175

Source: West Omdurman, Arabian company and Nopels group projects

Table (4). Cost of production of option in greenhouse at different location (SDP)

Project	Initial cost	Running cost	Labor	Electricity and water	Mean cost
West Omdurman	30,000	3,600	240	78	33,918
Arabian company	52,637.6	1,600	1,600	3,067.5	58,905.1
Nopels group	46,809.3	38,631.1	38,631.1	1,939.4	88,926.2

Source: West Omdurman, Arabian company and Nopels group projects

Table (5). A comparative between different cucumber varieties production in greenhouses at Jumoaia project

Site	Production (kg)		
	Darie	Jiasco	Romhi
1	7170	6000	9100
2	7380	6500	9200
3	6730	6400	9050
Mean			

Source: Jumoaia project Omdurman

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