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Status of greenhouses in Khartoum and Gezira States, Sudan

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ABSTRACT

Greenhouse technology facilitates the cultivation of most horticultural crops in any region of the world, provided that the greenhouse is properly designed and equipped to control environmental conditions. The objective of this study was to investigate the characteristics of greenhouses in Khartoum and Gezira States, Sudan, and show their drawbacks and disadvantages. A survey was carried out using a questionnaire and interviews with greenhouse owners in Khartoum and Gezira States. Khartoum and Gezira States have about 68 greenhouse projects, 33 of them were selected for the study. The data were collected during 2013 and were analyzed using statistical package for social sciences (SPSS) computer program. Results showed that 69.7% of greenhouses were privately owned and the vast majority of greenhouses were used to produce vegetable crops or seedlings. Results indicated that most of the greenhouses designs are not suited to the hot arid tropics of the Sudan. More than half of greenhouses had the arched system, most of them were covered by polyethylene, 69.7% of greenhouses were constructed in a single span, 72.7% had a single door, 76.3% of greenhouses had a height between 2.5 m to 3 m and 42.6% of them were 40 m long. Accordingly, an ideal greenhouse design is needed in which all the drawbacks and shortcomings are corrected to suit the arid conditions of central Sudan.

INTRODUCTION

The use of greenhouses for commercial production of horticultural crops in temperate regions is more than one and a half centuries old. The greenhouse design and production systems focused mainly on optimizing environmental conditions in winter to maximize off season vegetable production. During the past three decades, greenhouses were introduced in many tropical and subtropical countries for commercial production of horticultural crops, mainly during the hot summer months of the year (Weihong *et al*. 2005; Skylark and Arbel 2004; Gupta and Chandra 2002; Ali *et al.,* 1990).The effects of greenhouse orientation, height, roof shape, shape, size and distribution of openings have been studied and found to vary in different environmental conditions (Aldrich and Bartok, 1992).These factors need to be considered by greenhouse constructors and suppliers when selecting greenhouses for tropical and subtropical regions. Moreover, these factors alone are insufficient to guarantee economic success, which also depends to a great extent on layout design, covering material and selection of appropriate technology for cooling (Aldrich and Bartok, 1992).The use of greenhouses in the Sudan started in 1960, mainly for research activities (Alhussein, 2001). However, in recent years, there has been an increase in the number of greenhouses for commercial production of horticultural crops mainly in Khartoum and Gezira States. The objective of this study was to investigate the characteristics of greenhouses in Khartoum and Gezira States and show their drawbacks and disadvantages.

MATERIALS AND METHODS

Study Area

A survey was conducted in Khartoum and Gezira States to investigate the characteristics of the prevailing greenhouses. Khartoum State is located between latitude 15° 14′and 16° 38′N and longitudes 31° 34′ and 34° 21′. E .Gezira State is located between latitude 13°36′ and 15° 16′N and longitudes 32° 26′ and 34° 18′ E. All greenhouse projects in Khartoum and Gezira States were considered as the population of the study. According to the Ministry of Agriculture and Forestry (2012), the total number of greenhouse projects in Khartoum and Gezira States was 68, 33 of them were selected for the study. A questionnaire was designed for provision of information needed about greenhouses.

The questionnaire covered the greenhouse owner, greenhouse design, dimensions, construction system, door position and sterilization. Data collection also included interviews with 33 greenhouse projects owners. Data were analyzed using statistical package for social sciences (SPSS) to calculate frequency distribution and simple percentage for descriptive analysis.

RESULTS AND DISCUSSION

Greenhouse owners

Results revealed that 69.7% of the greenhouses were privately owned, 27.3% of them were owned by government organizations, while only 3% of them were shared between private owners and government organizations. It was observed that most of the greenhouses were privately owned which may be due to the high expected profits (Table 1).

Table 1. Distribution of greenhouses according to the owner.

Ownership	Frequency	%
Government	9	27.3
Private	23	69.7
Government and private.	1	3.0
Total	33	100

Greenhouse construction

According to the construction system, greenhouses in the Sudan are divided into upright and arched systems. Most of the respondents used the arched construction system (72.7%) and 27.3% of them used the upright system. In the arched system, there was an unused area, outside the cooling system and cultivation which could be 33% of the total area of the greenhouse (Table 2). The main advantage of greenhouses compared to open area is high area utilization and high yield per unit area. To achieve this advantage, there is a need for high capital investment. Thus, area utilization should be maximized by reducing unused area.

Table 2. Distribution of greenhouses according to construction system.

Construction system	Frequency	%
Upright	9	27.3
Arched	24	72.7
Total	33	100

Greenhouse covering materials:

Distribution of greenhouses according to covering materials is shown in Table 3. Results indicated that 78.8% of the greenhouses were covered by polyethylene and 18.2% by fiberglass. Fiberglass sheets are light in weight and impact resistant. They have a fairly high light transmittance that is slightly less than that of glass and polyethylene. Fiberglass covered greenhouses are also easy to fabricate. Polyethylene sheets are cheap, light in weight, available, easy to apply and have a high light transmittance. The main disadvantages of polyethylene sheets are that they reflect radiated heat back into the greenhouse and they have a very short life especially in the hot arid conditions of the tropics. The high percentage of utilization of polyethylene sheets (78.8%) was probably due to the fact that fiberglass sheets are more expensive than polyethylene. Ultraviolet stabilized grades, which last from 18 months to four years, still require more frequent replacement than most other glazing materials. Common grades of polyethylene are transparent to infrared radiation, however, grades are becoming available that blocked infrared radiation and reduce greenhouse heat (Bucklin, 2001).

Table 3. Distribution of greenhouses according to covering materials.

Covering materials	Frequency	%
Polyethylene	26	78.8
Fiberglass	6	18.2
Polycarbolic	1	3.0
Total	33	100

Greenhouse orientation:

The majority (84.8%) of greenhouses were in north-south direction and 15.2% of them were in east-west direction (Table 4). Sethi (2009) reported that uneven span shape greenhouse with east–west orientation received maximum light transmission all year round. Greenhouse air temperature depended on direction and shape of the greenhouse and the difference in temperature between uneven-span shape and quonset shape was 3.5°C to 4.6°C.

The north-south direction is a better direction in the hot summer conditions of the Sudan so as to avoid exposure of the greenhouse to high solar radiation.

Table 4. Distribution of greenhouses according to greenhouse orientation.

Orientation	Frequency	%
North-south	28	84.8
East-west	5	15.2
Total	33	100

Table 5 shows that 69.7 % of greenhouses were constructed in single span and 12.2% of them were multi- span. Constructing multi-span houses is considered to be better than constructing detached houses. In the multi-span houses, the air cooling efficiency increases while the dimensions remain fixed and easily managed. Whatever the size increases, the production cost per unit area decreases. Multi-span structure greenhouses are easier to equip with cooling, heating unit and/or computer control.

Table 5. Distribution of greenhouse according to construction.

Construction	Frequency	%
Single span	23	69.7
Multi span	7	21,2
Single and multi span	3	9.1
Total	33	100

Greenhouse height:

Table 6 shows that 76.3 % of the greenhouses had a height ranging from 2m to 2.5m and 23.7% of them were between 2.5m to 3m. The current trend in greenhouse technology is towards higher greenhouses for high temperature regions (Connellan, 2002). The current height of the greenhouse up to the gutter should be in the range of 3 m to 4.5 m instead of the traditional range of 1.5 m to 2.5 m. The height up to the ridge should be 3 m or more to obtain favorable climatic conditions for crop growth in tropical regions (Connellan, 2000).

Table 6. Distribution of greenhouses according to height.

Height (m)	Frequency	%
2 - 2.5	11	23.7
2.5 - 3	22	76.3
Total	33	100

Greenhouse length

Greenhouse length in the Sudan ranged between 34 m to 40 m. Results showed that 42.6 % of greenhouses were 40 m long, 24.1% were 36 m long and 33.3% of them were 34 m long (Table 7). Long greenhouses usually do not have uniform temperatures over the entire length. Hochmuth **(**2002) and Kittas *et al.* (2003) developed and experimentally validated a thermal model to predict the temperature gradient along the length of a large greenhouse (60 m) equipped with a fan pad ventilation system. The thermal model incorporated the effects of ventilation rate, roof shading and crop transpiration. The study showed that large temperature gradients up to 8°C were generated from pad end to fan end due to the significant length of the greenhouse. They recommended that length of greenhouses should not exceed 30 m to avoid variation in temperature within the greenhouse.

Table 7. Distribution of greenhouses according to length.

Length (m)	Frequency	%
40	14	42.6
36	5	24.1
34	14	33.3
Total	33	100

Greenhouse door

Most of the greenhouses (72.7 %) have single doors and 27.3% of them have double doors (Table 8). The single door may lead to the entrance of hot air and insects. It is very important that all greenhouses should be equipped with a double door or safety access system (SAS). The SAS could also be fitted with sticky yellow traps along both sides to trap entering insects. Tuzel (2013) and Bucklin (2001) reported that greenhouses should be built with an "airlock" entrance design which prevents the entrance of wind, insects, dust, and spores into the greenhouse. Such an entrance has the additional advantage of making doors easier to open and close when the fans are operating. The double entrance also prevents short-circuit air flow patterns when ventilation fans are in operation.

Table 8. Distribution of greenhouses according to door type.

Door type	Frequency	%
Single	24	72.7
double	9	27.3
Total	33	100

Greenhouse disinfection:

The use of solar radiation for greenhouse disinfection can be used in the Sudan due to the high light intensity. Table 9 shows that 54 % of the greenhouses used solar radiation for sterilization, 30.8% used chemical components and 15.2 % of them used both solarization and chemicals for sterilization. Solarization is a process that exposes the greenhouse to sun light by using transparent plastic materials with the objective of increasing the temperature of the soil for disinfection (Eltez and Tuzel, 1994). The effect of soil solarization can be improved if it is combined with alternative, low toxicity chemicals or biofumigation (Tuzel and Özçelik, 2004).

Table 9. Distribution of greenhouses according to disinfection.

Disinfection	Frequency	%
Solarization	18	54
Chemicals	10	30.8
Solarization and chemicals	5	15.2
Total	33	100

Crops grown in greenhouses:

Only half of the greenhouses (51.5 %) were used to produce vegetable crops and 30.8 % were shared with seedling production (Table 10). Generally, when designing the layout inside the greenhouse, flexibility should be kept in mind. Even though tomatoes, for instance, may be the intended major crop, factors may change that will force the grower to either grow another crop or more than one crop. Row spacing requirements, trellis design and irrigation design should be considered before the final layout is chosen. The layout designs should be flexible so that changes can be quickly made if necessary (Bucklin, 2001).Our observations indicated that most of the growers failed to produce summer tomato. The problems were mainly attributed to high incidence of disease, difficultly in controlling whiteflies and problems of maintaining uniform cooling in the greenhouse. As a result, most of the growers were forced to change from tomato to cucumber production.

Table 10. Distribution of greenhouses according to type of crop.

Type of crop	Frequency	%
Vegetables	17	51.5
Seedlings	6	18.2
Vegetables and Seedlings	10	30.3
Total	33	100

CONCLUSION

The existing greenhouse designs do not fulfill the environmental requirements which should prevail in modern greenhouses in the arid and semi- arid tropics of the Sudan. There are drawbacks and shortcomings of the exiting traditional greenhouses such as greenhouse construction system, direction, length, height, door position (sealing) and cooling system.

RECOMMENDATIONS

It is recommended that the following tips should be considered before constructing greenhouses in central Sudan:

1. Meteorological data for the past ten years of the area where the greenhouse is to be constructed is very necessary.
2. Greenhouses should not be oriented in east-west direction to avoid exposure to sun light along the length of the greenhouse.
3. Constructing multi-span greenhouses is better than constructing detached houses.
4. Construction system of the greenhouse should be upright instead of the arched system.
5. Length of the greenhouses should not exceed 30 m, to avoid variation in temperature within the greenhouse.
6. Height of the greenhouses should be between 3.8 m to 4 m at the middle.
7. A sliding door should be situated at the side of the greenhouse with an outdoor leading to an indoor.
8. Fiberglass is better than polyethylene because of its long life.

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الوضع الراهن للبيوت المحمية في ولايتي الخرطوم والجزيرة بالسودان

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الخلاصة

تتيح تقنية الزراعة المحمية إمكانية زراعة كل الأصناف من المحاصيل البستانية في كل البيئات، وذلك من خلال البيوت المجهزة ذات التصميم المناسب للتحكم في الظروف البيئية. تهدف هذه الدراسة إلى معرفة صفات البيوت المحمية الموجودة في ولايتي الخرطوم والجزيرة مع عرض مساؤيها وأوجه القصور الموجودة في تصميمها. جمعت المعلومات في 2013م بعمل مسح بالاستجواب المباشر للعينة باستخدام الاستبيان لجمع المعلومات المطلوبة. وتم تحليل المعلومات باستخدام البرنامج الإحصائي للعلوم الإجتماعية وتم حساب التكرار والنسبة المئوية للتحليل الوصفي. أوضحت النتائج إن غالبية تصاميم البيوت المحمية غير مناسبه للمناطق الجافه والمداريه في السودان. اوضحت الدراسة ان 69.71% من البيوت المحميه مملوكة للقطاع الخاص وأن أكثر من نصف البيوت ذات نظام مقوس (نصف القمر) وأن أغلبيتها تغطى بالبولي اثلين. أوضحت الدراسة أن **69.7%** من البيوت المحمية تم إنشاؤها مفردة وان 72.7%لها أبواب مفردة. كما أن الأغلبية منها تنتج محاصيل خضر أو شتول خضر. أوضحت الدراسة أن 76.3% من البيوت المحمية يتراوح إرتفاعها بين 2.5 – 3 متر وان 42.6% منها طولها 40 متراً. بناءاً علي هذه الدراسة يوصى بتصميم بيت محمى مثالي مناسب للمناطق الجافة وشبه الجافة في أواسط السودان يتم فيه تصحيح كل المساوئ وأوجه القصور.