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RESEARCH ON DESIGN FACTORS THAT INFLUENCE ENERGY CONSUMPTION FOR AIR-CONDITIONING IN GREENHOUSES FOR VEGETABLES AND FLOWERS

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Abstract: *In greenhouses complex thermal phenomena take place for the exchange of hot or cold air, been signaled at the same time air circulation due to frequent venting. Air conditioning is one of the decisive moments in the scientific exploitation of greenhouses. By ventilation it avoids any accidents that may cause disturbance to the climate factors, especially in a hermetically closed greenhouse. Conditioning involves constant control and permanent supervising of heating, ventilation, moisture, shading and the concentration of carbon dioxide, using different methods, systems and devices. Automatic control ensure achievement of optimum parameters of the vegetation factors ensuring reliable obtaining productions. All the microclimate factors are influenced by the materials used in building of the greenhouse, the shape chosen for the design, the location and orientation of greenhouse, relief, exhibition ground, and soil composition.*
Keywords: *design factors, air-conditioning, energy consumption*

1. INTRODUCTION

In greenhouses complex thermal phenomena take place for the exchange of hot or cold air, been signaled at the same time air circulation due to frequent venting[1].
Solar energy that penetrates in greenhouses suffer significant changes, occurring largely with the passage of radiation through the material that covers the construction. Losses and accumulation of heat occurs, due to frequent air exchanges which strongly influences the greenhouse microclimate. All these factors are influenced by the materials used in building greenhouses, shape chosen for the design, location and orientation of greenhouses, relief, exhibition ground, soil composition. Air Conditioning seeks to ensure a status and composition of the air in greenhouse, in order to allow a normal growth and development of plants, simulating their fructifying ability. It has a crucial role in regulating inner temperature and water regime, to increase the exchange of air between the inner and the outside atmosphere, the reduction or increase of evapo-transpiration. By conditioning it seeks to maintain meteorological factors to the levels required by plants and foreseen in the greenhouse draft [2]. Conditioning involves constant control and permanent supervising of heating, ventilation, moisture, shading and the concentration of carbon dioxide, using different methods, systems and devices.

2. DESIGN FACTORS THAT INFLUENCE ENERGY CONSUMPTION FOR AIR-CONDITIONING

The elements which make part of skeleton structure of the greenhouse forms a surface where sunlight does not penetrate inside it. The shadows projected by them in different positions of the sun on the horizon are highly variable and in most cases above their real weight.
Representing graphically the influence of shading in greenhouses with structural elements, in Figure 1 highlight the effect of light loss interpreted in a cross-section of the building. Can be noticed that the most powerful shading is caused by the shaft of construction along its entire length, and it is all because of this phenomenon to two factors, namely:

- own shadow of the volume caused by non-transparent large pieces of structure generally crowded central longitudinal area;
- projected shadow bounded by lengthwise lines or the one that intersects surface separation, which moves in an average curve and are projected over the greenhouse crops.

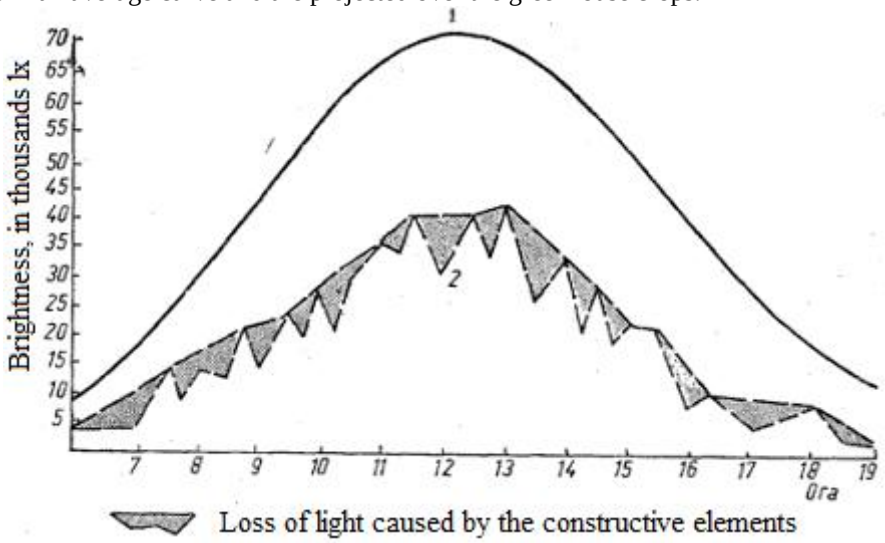

Figure 1. Influence of constructive elements of the intensity of greenhouses
1- outdoor light intensity curve; 2 - light intensity curve in greenhouse

In the cultivated area the shade is projected by greenhouse constructive elements such as gutter, mane and intermediate panels on the opening of over 3 meters (fig. 2). Greenhouses block water drainage trough between blocks raise significantly the percentage of shading. The length and width of the shadow of these design elements were designed following variations: as the sun descends on the horizon shadow grows in width and length, and the high position of the sun from the horizontal width and length of the shadow decreases [3].
Another series of pieces that shade the plants is formed by the side walls and the roof lath that limits the glass panels and supports them (Fig. 2). The lath is very common in the construction skeleton of greenhouses, and totalize the highest percentage of shadows on the crop. Thus, a greenhouse with many lath wood, with distances between them (120 x 52 cm) has a 40% up to 45% of shadows. A greenhouse with small wooden or metal lath, placed between them at a greater distance (220 x 120 cm) with wide openings between the pillars has a shading percentage of 25% -30%. From the point of view of using light, the better are the plastic greenhouses, having a shading percentage of 5-10%.

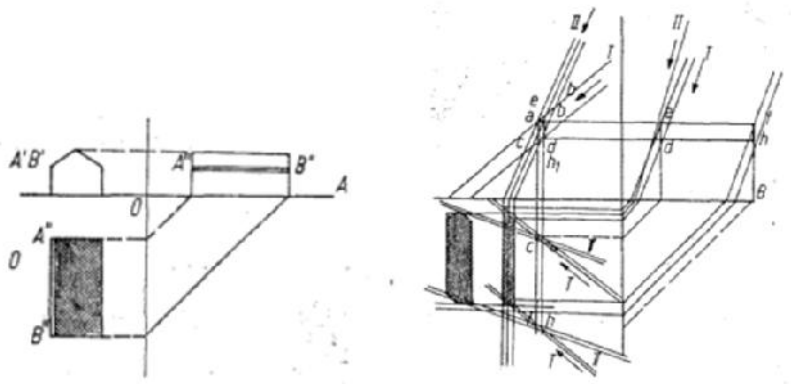

Figure 2. The shadow of the panels, ridges and mourning

Outside the main building elements indicated above in greenhouses with large openings there are helpful piece (transverse and longitudinal counterbraces) or wind braces girder which also contributes in reducing greenhouse light.
The level of shading in greenhouses apart from constructive elements are participating the ventilation and the heating elements that make up their entire technological function but by choosing operational solutions can occupy space outside of the interposer in the direction of penetration of sunlight.

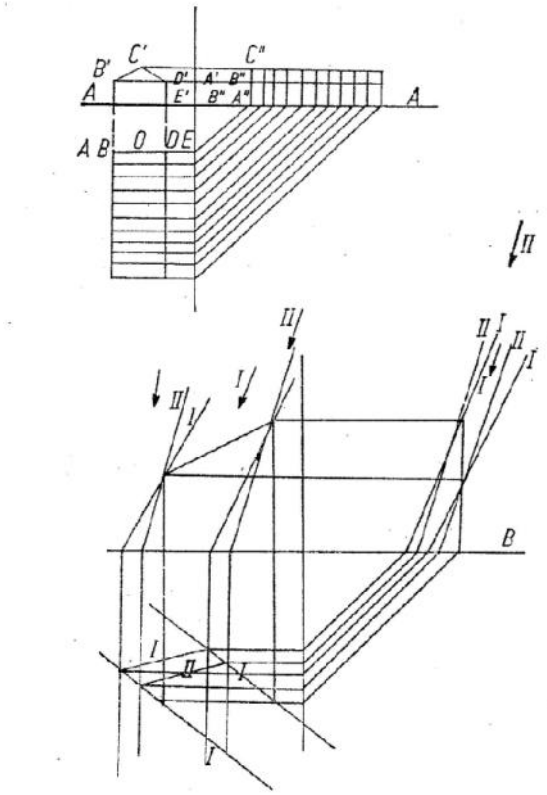

Figure 3. Lath shadow waged vertical and inclined:
A- position of parts in the construction of greenhouses in 3 projections (horizontal, front and side);
B- held various positions of lath shadow of the sun at different inclinations: I-first position of the sun II - second position of the sun; III- third position of the sun

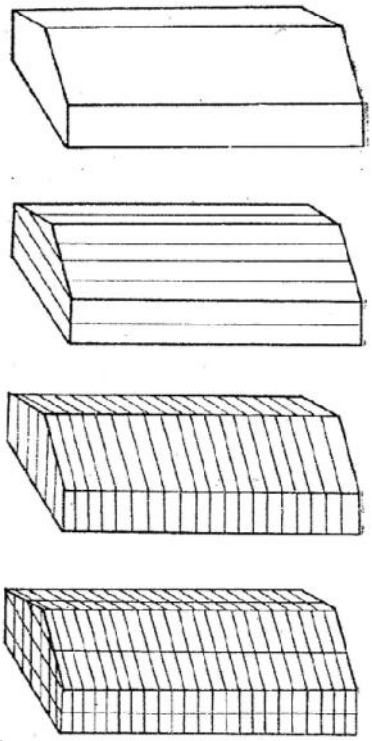

Figure 4. Models greenhouses with different opaque and transparent areas (as Koza) at an angle of 32 ° and the thickness of 3 mm glass

Depending on the chosen constructive scheme there are known constructive designs based on the patterns showed in Figure 4 by Koza in 1972. Based on this constructive given schemes, in our country were made greenhouses, taking into account the construction materials used in model D. The C model is an improved construction and is made by take into account tha fact of increasing transparent areas and allowing better illumination. The B model excludes transversely lath involving expensive solutions without offering substantial extra light. The A model is the ideal solution achievable given that industry provides self-supporting transparent materials, such as polyesters.

Based on the above aspects can be deduced that light regimen in greenhouses depends largely in function of constructive particularities that are part of construction frame that covers the greenhouses. The percentage of shading has a variation limited by the size of structure elements according to their placement in the construction frame.

3. AIR CONDITIONING

Air conditioning is one of the decisive moments in the scientific exploitation of greenhouses. By ventilation it avoids any accidents that may cause disturbance to the climate factors, especially in a hermetically closed greenhouse.

Among the components of the environment, relative humidity and temperature are factors which are influenced by aeration and ventilation measures.

In the context of this paragraph two terms are used to achieve one or the same purpose, which refers to:

- aeration representing natural ventilation, spontaneous or infiltration of outside air (judging by heat loss) caused by the temperature gradient and wind speed amplified; This is the driving force of heat loss during operation of the heating system; it helps lower greenhouse temperature and CO_2 needed for photosynthesis supplement intake [4];
- ventilation or forced ventilation representing the mechanism that the air circulation inside the greenhouse is the result of some facilities and devices that require altering the composition of the environment in a short time.

The displacement air, where spontaneous ventilation through infrastructure leaks is given by the following equation (Okada and Takakura, 1972);

$$V = s\left(\frac{2g}{\gamma}\right)^{\frac{1}{n}} * \Delta P^{\frac{1}{n}} \quad , \qquad (1)$$

Where:

V – is the rate of the airflow in m^3 / h;
S – the effective area of orifice in m^2 (n = 2);
g – acceleration of gravity in m / sec^2;
γ – specific weight in kg/m^3;
n – experimental constant ranging between 1 and 2;
ΔP – the pressure difference, in kg/m^2.

In the greenhouse, as in any building through windows and other openings, there is a constant exchange of air when outside air penetrate into the greenhouse and indoor air comes out. Air circulation is caused by the action of wind and gravitational pressure. The last one occurs due to the difference between outside air temperature and inside air temperature. In greenhouses a low air circulation takes place especially along side of the roof. The air circulate upwardly towards vertical walls, along which it plays a leading role, so that air circulation occurs every frame. At some radiation an air exchange occurs between the frames [5].

From the data of the Agricultural Technical Institute Wageningen, Netherlands, it appears that from 15 cm above the ground, under sunny day with no wind, the air velocity increases with the increasing temperature difference between outside and inside. At 100 cm in height, along the south wall, growth is reduced due to the ascending air current braking (which arises with the increase of radiation) along the glass wall. It is formed due to the cold air moving gradually downwards.

At 1.9 m high, the influence of temperature difference between inside and outside is low, with the exception point situated at 100 cm high along the south wall, where is smaller as from 15 cm, but greater than 1.9 m.

The level of air velocity is low, between 5 cm / sec - 15 cm / sec. The speed of 20 cm / sec were recorded in exceptional situations. The taller greenhouses the measured air speeds are higher. In lower greenhouses horizontal component of the air velocity exceeds the vertical component of its speed.

In greenhouses with glass the airing involves certain rules that must be taken into account. Is indicated that for every section of the greenhouse that every slope to have its own system of opening and closing of windows or ventilation. For new greenhouses being built is recommended that the ventilation windows to be 20-25% of the total surface of the glass, depending on the respective climatic conditions, taking into account temperature and wind dominant. In spring and summer, can be used for air supply and exhaust both side windows and the windows of the ridge. Autumn and winter windows will be opened only from the ridge.

Ventilation in greenhouses covered with plastic requires special attention and care throughout the growing season. Block greenhouses requires a certain technique for ventilation. On sunny days is indicated to remove the side panels and part of the roof panels. If an increased frequency of wind the panels will not be removed from the side of dominant direction. If time is variable, with warm sunny days and cold cloudy days the ventilation should be made gradual by opening regular roof panels. On plastic greenhouses, ventilation take places by raising plastics at different heights of the side walls. In this case it should consider how to vent hot or cold days and on days with strong winds. Failure to follow these considerations may lead to plant damage due to excess heat greenhouses or building damage.

4. CONCLUSIONS

1. In greenhouses complex thermal phenomena take place for the exchange of hot or cold air, been signaled at the same time air circulation due to frequent venting.
2. Conditioning involves constant control and permanent supervising of heating, ventilation, moisture, shading and the concentration of carbon dioxide, using different methods, systems and devices.
3. The elements which make part of skeleton structure of the greenhouse form a surface where sunlight does not penetrate inside it. The shadows projected by them in different positions of the sun on the horizon are highly variable and in most cases above their real weight.
5. Air conditioning is one of the decisive moments in the scientific exploitation of greenhouses. By ventilation it avoids any accidents that may cause disturbance to the climate factors, especially in a hermetically closed greenhouse.

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