VERTICAL GREENHOUSE - ECONOMICAL AND ECOLOGICAL ALTERNATIVE FOR HIGH-ENERGY CONSUMPTION PROTECTED SPACES

SERA VERTICALĂ - ALTERNATIVĂ ECOLOGICĂ ŞI ECONOMICĂ A SPAŢIILOR PROTEJATE ENERGOFAGE

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Abstract. *In the framework of a CEEX research-development project accomplished by the SCDL Buzau collective, has been realized an experimental model of a vertical greenhouse which was also patented. This type of protected space ensures proper environment for growing flowers, medium size vegetable transplants, good work conditions for the personnel, multiplies the surface used at ground level and also reduces the energy consumption. The enclosed space consists in a metallic structure that comprises a servicing enclosure and a technological enclosure, inside of which is a chain transporter with swing where the plants are cultivated. The ensemble has a slow ascending-descending movement. For vegetable growing, the metallic structure is covered by a transparent material, glass or an insulating material. The heat/air conditioning source is mounted under the technological enclosure. On the inferior part there are aeration windows and the roof is foldable so it allows natural as well as artificial aeration.*

Key words: vertically developed greenhouse, transplants production, seeds drying, seed production vegetables

Rezumat. *În cadrul proiectului CEEX/2005 al SCDL Buzău a fost realizată o seră dezvoltată pe verticală, brevetată în anul 2008. Acest tip de spaţiu protejat asigură condiţii optime pentru dezvoltarea plantelor, multiplică suprafaţa la nivelul solului, reduce consumurile de energie termică, creează condiţii mai bune de muncă pentru personal. Spaţiul protejat se compune dintr-o structură metalică care cuprinde o incintă de deservire şi o incintă tehnologică de tip turn cu un transportor cu cupe cu mişcare ascendent-descendentă lentă în care sunt cultivate plantele, acestea fiind expuse la lumină şi temperatură optime. Structura metalică a serei este acoperită cu material transparent - sticlă sau policarbonat. Climatizarea serei se face cu o sursă de căldură poziţionată sub transportorul cu cupe, în perioadele cu temperaturi ridicate se creează un curent de aer prin deschiderea ferestrelor de la baza serei şi a acoperişului rabatabil. Circulaţia aerului este forţată prin acţionarea ventilatorului de la baza serei.*

Cuvinte cheie: seră verticală, producere de răsaduri, uscare seminţe, producţie de seminţe de legume

INTRODUCTION

The regular greenhouses list a number of disadvantages, apart from the economical efficiency that is specific to the enclosed spaces: the thermic efficiency is low especially for low stem vegetables because the heat sources placed on the lower part and on the sides of the greenhouse ensure only a small part of the heat that is necessary in order for the plants to grow, because most of the heated air will rise toward the top of the greenhouse. Another drawback is that when the outside temperature is high, due to the greenhouse effect, the temperature inside the greenhouse grows very much, and the ventilation systems can't reestablish the proper temperature regime and it puts the plants through significant thermical stress.

MATERIALS AND METHOD

The project we are proposing is a greenhouse that ensures a multiplied germinative bed surface for plant growing on the same ground level surface, and that creates proper light and heat conditions for the plants. The vertical greenhouse fills in a void in the enclosed space domain. It is meant to be used for flower and vegetable growing, low stem flowers and seed drying (Roman Gh., Dumbravă M., 1998). It also has the advantage that it can be used all throughout the year.

Fig. 1. Vertical greenhouse

The vertical greenhouse, which is a CEEX research-development project accomplished by the SCDL Buzau collective, is conceived so that it solves this technical issue and eliminates the disadvantages of the existing enclosed spaces: it consists of frame made up of pipe pillars and steel beam frame, with bezels for windows , which form an enclosure that develops vertically and is functionally correlated with a vertical transportation system with an ascending-descending movement, triggered by an electric engine through an electronic motor speed control.

RESULTS AND DISCUSSIONS

The transportation system consists of:

- the support ensemble located at the top of the greenhouse. It has two bars that are anchored on the frame of the greenhouse, with four bearings mounted on them that sustain four special chain wheels through four axes.

- the gearing ensemble situated at the lower part of the greenhouse consists of an electric engine triggered by an electronic motor speed control. This speed control imprints the movement to a worm reducer and the movement goes to the chain drive that activates two of the special chain wheels from the lower part of the greenhouse.

- the rocker conveyer is made of two chains, arranged on the aisles of the greenhouse.

Fig. 2. The transportation system

Fig. 3. The gearing ensemble

The chains have some parallelepiped beakers mounted on them that are arranged symmetrical and are fixed with some anchoring devices. On the lower part of the greenhouse are also two stretching devices mounted on the greenhouse bars that act on the inferior arms of the two conveyer chains. The greenhouse climatization is made up of the windows, situated at the low level of the greenhouse, of the folding roof, which is activated by two lifting jacks, of the heating devices and of the cooling fans, situated in a tank, under the bucket carrier. Adjusting the heat range: in case the atmospheric temperature is low, the heating devices must be switched on; in case the atmospheric temperature is high, the windows situated at the low level of the building must be opened, as well as the folding roof, and in case it is required, the cooling fans may be switched on, as well. Adjusting the temperature must be performed taking into consideration the breeds of plants which are to be grown, as well as their growth/development status; thus, for the emergence status the temperature must be higher, while during the growing status the temperature is to be adjusted function of the moment of sowing.

Fig. 4. The rocker conveyer

In case the sowing conditions are not met, although the calendaristic date indicates a proper time, by lowering the temperature, the development of the plants is slowed down, triggering an effect of higher resistance to inappropriate conditions. For the procedure of drying vegetable and flower seeds, the heating and cooling systems must be activated, in order to diminish humidity.

By changing the number of spaces which are assembled inside the rectangular buckets, the installation conveys the possibility to adjust the light, function of the species which is to be grown, as well as its development status.

The installation may adjust the speed of the bucket carrier, managing to successively expose the plants to different intensities of light and temperature, at different time ranges. In case of proceeding to drying seeds, the installation can control the heating and cooling ranges, so that the germination is not affected, regardless of the atmospheric conditions.

Assembling the installation: to be performed on a North-South direction, taking into consideration the moving direction of the bucket carrier. The greenhouse is to be equipped with ventilation windows, heating devices and cooling fans, properly sized to correspond to the growth conditions of the plants.

Our assessed objective has been achieved, that is, the construction of a greenhouse which, starting from a certain given ground surface, offers an enlarged surface of germinative layers for plants and conveys proper conditions for a better use of the light and heat inside its precinct. The vertical greenhouse has been tested to produce vegetable and flower seedlings, low stem flowers and dry vegetable and flower seeds.

The data referring to the use of the vertical greenhouse for the production of seedlings has been collected subsequent to the experiments performed within S.C.D.L. Buzau, on five vegetable species – tomato, green pepper, eggplant, cabbage and salad, as well as on four flower species - *Tagetes, Petunia, Salvia, Dahlia*. The tests have been performed in a classical, horizontal greenhouse, designed and subdivided with the purpose of seedling production and in a vertical greenhouse, a patent of S.C.D.L. Buzau, designed for the production of seedling production and vegetable seeds drying.

The vegetable seedlings have been produced in alveolar pallets, divided into 4.5/4.5 cm cells, the flower seedlings in pallets with 4/4 cm cells, while the nutrient was disinfected and treated peat coal. Thus, 12750 seedlings have been produced under this process, during one cycle.

Observations have been recorded, on the temperature inside the spaces where the seedlings were produced, by recording the temperature ranges every 4 hours. The speed of development and growth has been observed as well, by daily measuring the temperature at the high level inside the building, throughout the testing period. The phenological data have been recorded as well, subsequently calculating the phenophase ranges.

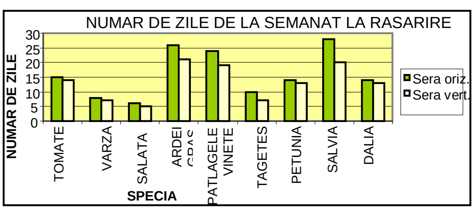

Fig 5. Number of days between sowing and emergence

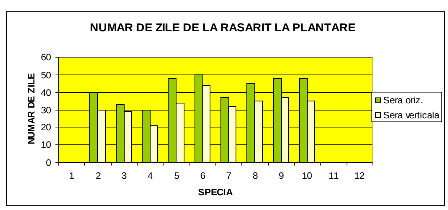

Fig 6. Number of days between emergence and planting

With all the species under study, the time range between sowing and emergence and the time range between emergence and planting is shorter, in the case of vertical greenhouse, compared to the horizontal greenhouse, due to the proper microclimate for the emergence and the growth of plants, which is created inside such a type of greenhouse. This proper microclimate is based on the upward circulation of the warm air and the fast uniformization of the temperature, as well as on the vertical movement of the plants, by means of the 10 especially designed buckets, a movement which conveys a higher firmness of the plants at the moment of planting and prevents the seedlings from elongating their stems.

Fig. 7. Seedlings in vertical greenhouse

Further testing has been performed in order to determine the efficiency of the vertical greenhouse for the process of drying vegetable seeds (Gapşa F. şi colab., 1995, Gheorghe Florica, Burnichi Floarea şi col., 1996**).** The tests have been performed on vegetable marrow seeds, (variety: Hapy). The seeds have been extracted, washed and subject to drying on the same day. Under the classical procedure, there was an amount of 50 kg of seeds subject to natural drying, on textile base, inside a non-ventilated room, initial humidity = 35%, final humidity = 11%, exposure time = 28 hours. The second procedure was performed inside the vertical greenhouse, with an amount of 50 kg of vegetable marrow seeds, while the cooling fans were functioning. The seeds were placed inside the buckets, on sieves.

CONCLUSIONS

The vertically developed greenhouse brings added value to the seedling and low stem flowers production technology in enclosed spaces using a more efficient system, economically and also environmentally wise. According to this project, the greenhouse has a number of advantages:

1. Ensures a multiplied germinative bed surface for plant growing without needing extra ground level surface. The experimental model covers an area of 12 m2 at ground level, and the cultivated surface is 48 m^2, which means it's four times the ground level area;

2. The rocker conveyer helps gradually expose all the plants equally to natural light. The vertical construction of the greenhouse leads to a more efficient use of the heat coming from a cooling fan in the lower part of the installation, because the warm air circulates towards the roof, and the heat is absorbed by the biological material and also by the installation, so that the temperature of the air that gets to the upper part of the greenhouse is much lower than in the case of regular greenhouses. It's easier to control the humidity and temperature for the vertical greenhouse through windows and vents, because in case of sunstroke and high humidity level, the air circulation covers the entire space of the installation;

3. Using the vertical greenhouse for seedling and flower production ensures a reduction in the germination interval (the time range between the sowing and the emergence) by 17.93% and also in the interval of growth and development of the biological material in order to set up the crops (the time range between the emergence and the cultivation) by 21.63%. The daily medium growth rate of the vegetative unit at tomatoes in a vertical greenhouse is 0.74 cm. The request for flower transplants and flowerpot flowers has increased during the past years and the vertical greenhouse is very fit for this use;

4. This greenhouse solves the vegetable seed drying issue that is currently performed in improper conditions because of the material cleanliness and the lack of efficiency. The seed drying is presently made in open air: this involves a lot of manual labor, the risk of contamination, the risk of damage during bad weather, therefore the germination loss risk. The exposure time reduction means a saving of 40 hours/100 kg dried seeds, with a value of 1.75 lei/kg, corresponding to 54.7%.

5. The energy consumption needed to activate the rocker conveyer is minimum, because the two arms of the installation are balanced and the only energy needed is just to handle the frictions;

6. The labor conditions for the personnel are much better than in the rest of the enclosed spaces: the work posture is better, the working temperature is bearable, and the air is purified more efficiently in case of chemical treatment;

The greenhouse test model is the first phase of the research conducted in order to improve the performances of enclosed spaces. The research engineers from S.C.D.L. Buzau collective want to have the vertical greenhouse prototype produced and commercialized by a specialized company.

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