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DESIGN AND CONSTRUCTION OF PHYTOTRON-GREENHOUSE COMPLEXES

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Abstract. *A brief historical analysis of the experience of development of structures and equipment for the study of plants in artificial conditions is given. The analysis of constructions and parameters of modern phytotrons and greenhouses for carrying out scientific researches in agrarian institute establishments is executed. The technological structure of phytotron greenhouses is considered on the example of the scientific center of grain research. Spatial planning solutions of the first floor of the laboratory complex and the block of greenhouses-phytotrons for search works are developed. It is noted that the uniqueness of equipment and engineering systems require appropriate organizational and technological justifications for construction and installation work.*

Keywords: *phytotron; greenhouses; spatial planning decisions; research technology; technology and organization of construction.*

Introduction Modern research centers for the development of selection and genetics of the grain group of agro-industrial products are designed to provide engineering and technological capabilities for research, to expand the number of crop rotations several times, to model different operating conditions.

Main text Such centers include direct laboratory research centers with traditional laboratories, equipped with different types of equipment for their purpose, technological capabilities, weight, size, as well as greenhouses - mini-boxes with modeling and providing the necessary individual temperature and humidity, etc. Outdoor areas with heated soil in the winter-spring period allow the adaptation of plant products.

Ancillary services include preparation of containers with substrate and soil and planting of seeds, sanitary pass, elevators, as well as life providing systems and structures of the complex with energy and technological needs.

The design of such centers requires a detailed analysis and development of the production technological part of the object, substantiation of the requirements of spatial planning decisions, development of engineering and technological systems. The area of greenhouse mini-boxes is 50-100 sq m and provides for the use of the necessary engineering and technological equipment.

Results Scientific and technical support ensures the efficiency of many types of production activities. In the agricultural sector, the creation of promising varieties of different crops is based on the use of artificial climate laboratories – special phytotrons and original mini-blocks of greenhouses.

As early as the nineteenth century, agricultural scientists became interested in the issues of artificial plant development. Professor A S Famintsin studied the effects of light on various crops, including algae. He proved for the first time that the process of CO_2 assimilation and starch formation in plant cells is more active under artificial lighting [1]. In the works of Academician K A Timiryazev, in those days it was confirmed that there is no big difference in the effect on the development of sunlight and irradiation from lamps. A method of taking into account the photosynthesis of CO_2 absorbed by the plant, determining the spectrum of chlorophyll use and light assimilation has been developed, and for the first time a substitute for soils, a made substrate, has been used. Almost simultaneously with specialists from Germany, the first vegetation houses (greenhouses) were created at the Petrovsky Academy, including for research. It is shown that such structures, especially with plant lighting systems, allow to accelerate selection processes. The main results of research by Academician K A Timiryazev set out in his doctoral dissertation "On the assimilation of light by plants" (1875) and scientific work "Sun, life and chlorophyll" (1903), which became the theoretical basis for the subsequent creation of modern phytotron-greenhouse complexes.

The active development of this area of research was carried out in the second half of the last century. In the city of Pasadena (USA), on the initiative and under the leadership of F Vent, a climatic complex for the study of plants was created [2], which was named phytotron.

In general, there is no single classification of structures in the world that have the conditions for fully functional regulation of the microclimate. A number of authors have made attempts to do this. Such work is being carried out at the present time [3].

Tools for effective plant breeding are being developed, in particular molecular markers of traits (genes, libraries, maps, etc.) with subsequent storage in the database of phenotypes and their characteristics. Similar areas also work in agricultural institutes and centers of this country.

In Canada, the Agricultural Experimental Station (Lethbridge, Alberta) has one of the most modern PhGCs, comprising eleven greenhouses and about one hundred vegetation chambers. In other cities in Canada (Guelph, Ottawa), as well as in all research departments of agricultural universities and agricultural stations, there are PhGC of various types and kinds.

Currently, most US universities have appropriate facilities and installations of artificial climate. In particular, the PhGC at Duke University (Durham, North Carolina) includes six greenhouses and 47 climate chambers and cabinets, and the University of North Carolina (Rally, North Carolina) has three greenhouses and 58 chambers, respectively, and cabinets.

Modern PhGC have a strong experimental base. The peculiarities of the interaction of proteins with phytotron receptors [4], the joint effect of ozone and drought conditions on the formation of biological volatile organic compounds [5] are studied, and also the peculiarities of growing new substances and materials for the PhGC, in particular champignons, are being studied [6].

In Ukraine, one of the world's most powerful PhGC was created on the basis of

the Myronivka Wheat Institute. The total usable area of greenhouses for research is more than 5500 sq m, and three selection greenhouses – 4200 sq m.

Phytotron equipment includes chambers for research at plus and minus temperatures, different levels of illumination of plants, humidity, etc.

Extensive research has been conducted on the basis of PhGC in Myronivka [7], methodological bases of energy-saving technology of growing grain crops in artificial climate and in the field have been developed. Ways of development of adaptive plant growing of artificial climate in interrelation with tasks of selection and seed production of traditional grain and vegetable cultures, and also siderates, medicinal, tropical, stevia, aloe, etc. are shown.

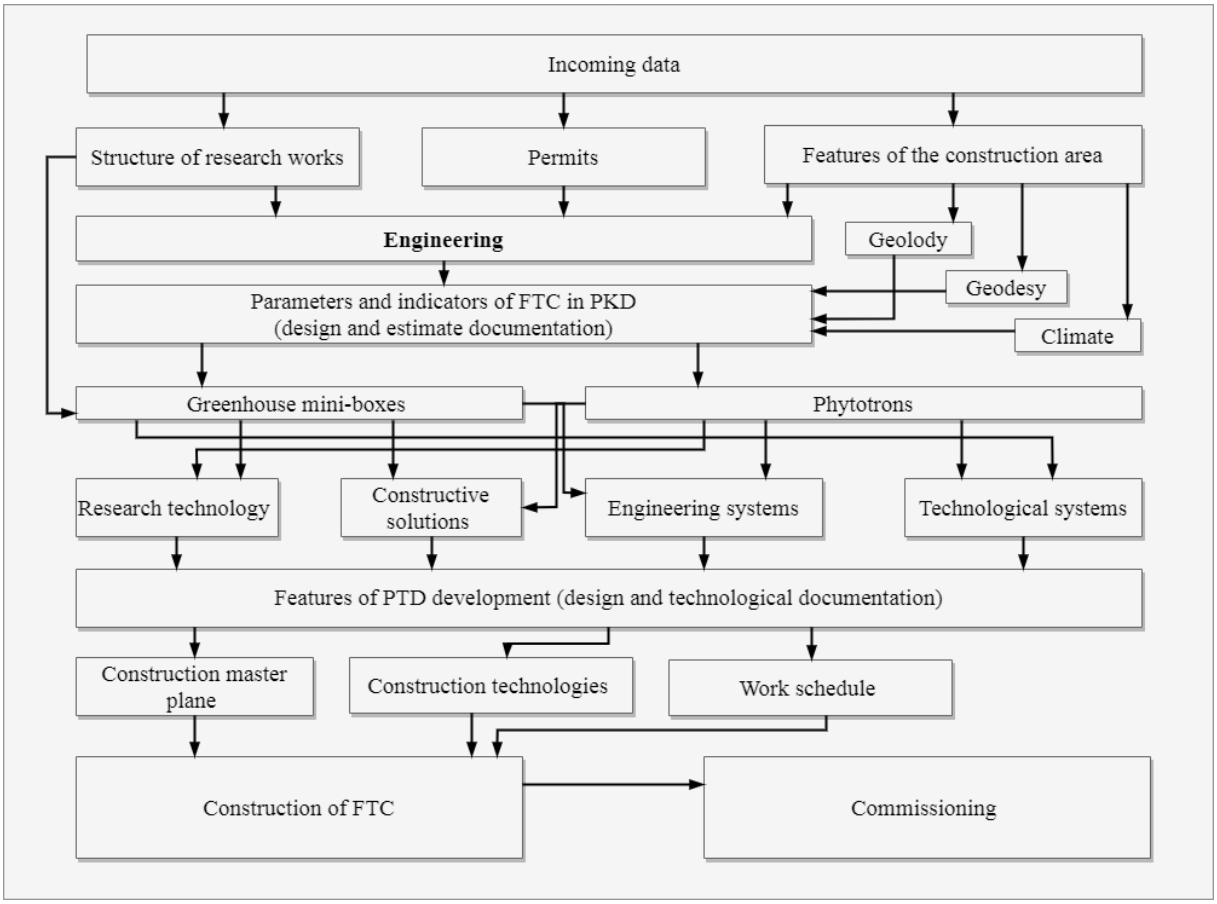

Figure. 1. Scheme of design and construction of PhGC.

Author's development

The use of irrigation or fertigation systems is based on soluble units of design capacity with the supply of nutrient solutions on a dropper with a capacity of 1.0-2.0 liters per day.

Direct phytotrons are characterized by size (volume), functionality, energy performance.

Growth climatic rooms with a cultivation area of 1 to 25 sq m are equipped with shelves with lighting and have a large climatic range with adjustable supply of conditioned fresh air. Sterile humidity is provided by a special steam humidifier.

Phytotron-greenhouse complex includes the following main elements (Figure 3): laboratory and research building (capital building); transparent blocks in hothouse

designs; open areas with soil heating; auxiliary services, facilities and life support systems of the complex.

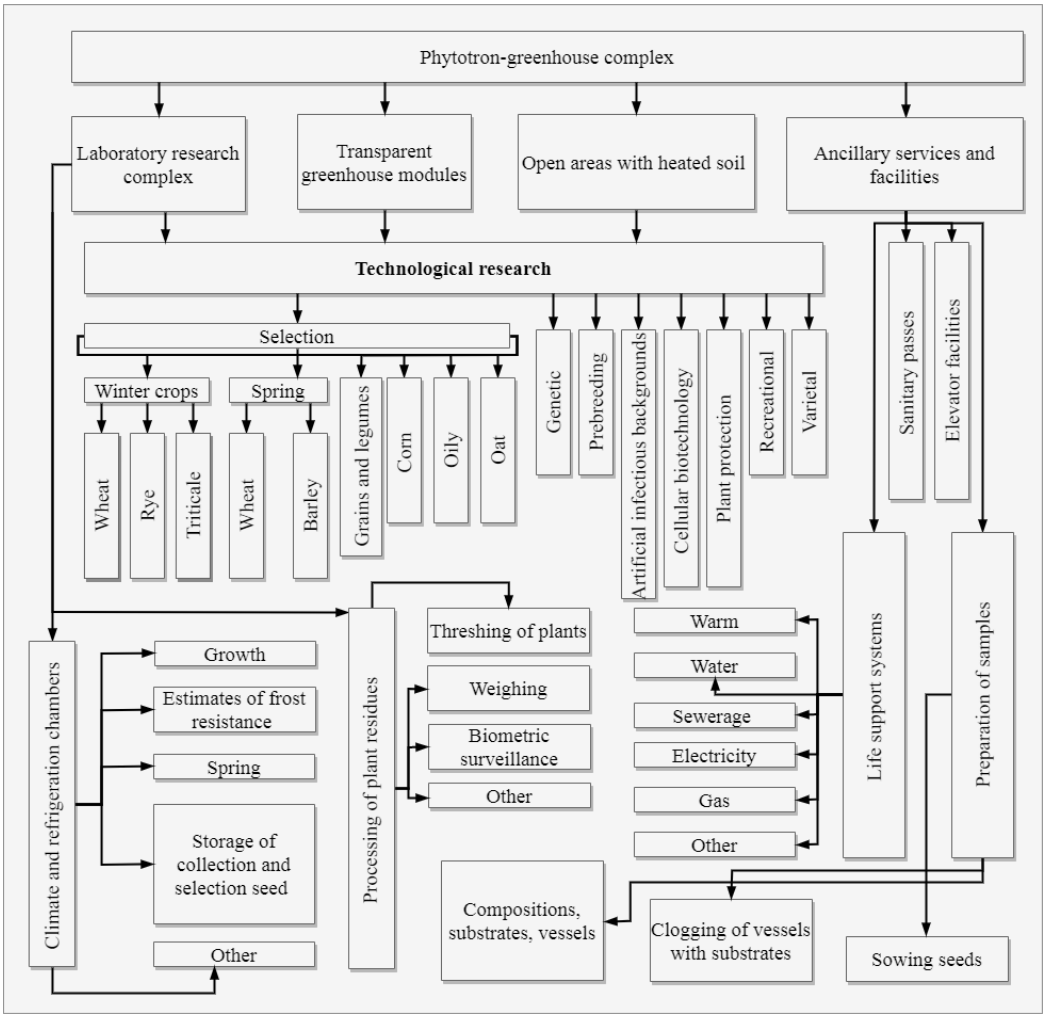

Figure 3. Technological (production) structure of PhGC.

Author's development

Technological (production) activities in research institutions for the study of grain crops consist, first of all, in carrying out work with the selection of plants: winter (wheat, rye, triticale) and spring (wheat, barley), as well as with oats, corn, grain-legumes and oilseeds.

In parallel, genetic registration, analytical, varietal, prebreeding, cell technology and plant protection studies are conducted.

These studies are carried out directly in the laboratory building (Figure 4, room 5) and in greenhouse boxes (Figure 4, boxes 10-11). Phytotrons or growth chambers of complete delivery (in particular, room 53 on the first floor) are located on the floors separately in the laboratory building.

The other area of the basement is allocated for special refrigeration equipment: frost resistance assessments; vernalization; storage of collection and selection seed material.

In laboratories, research is performed using special equipment for threshing plants with stationary and spike threshers, weighing, biometric monitoring, counting seeds with bags, etc.

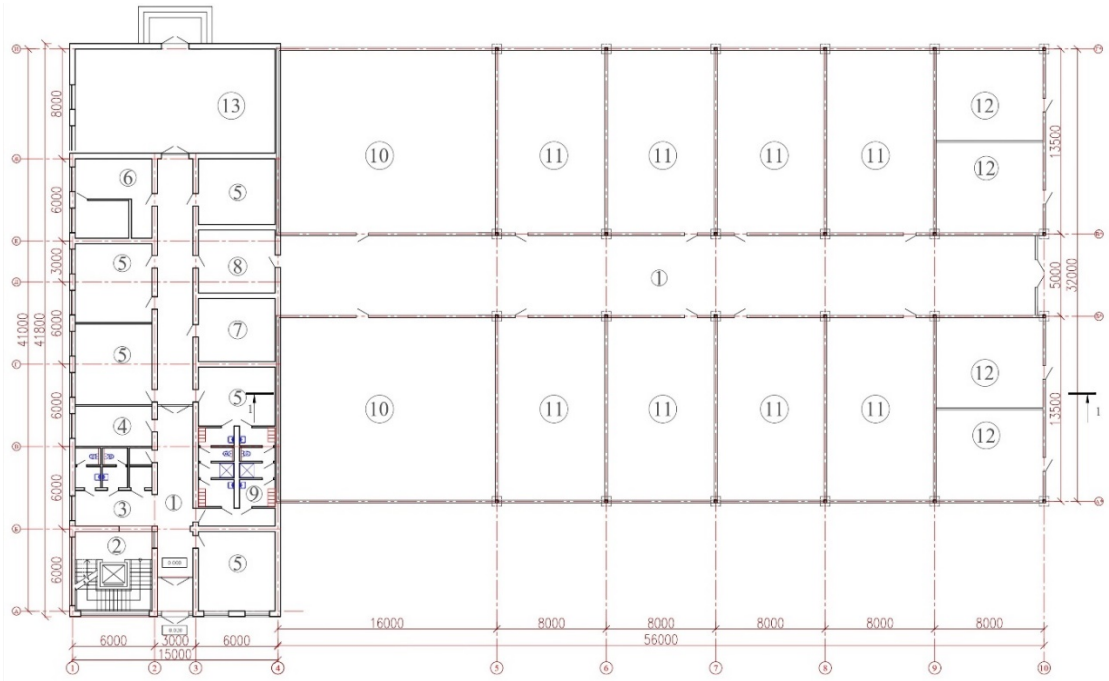

Figure 4. Plan of the first floor of the phytotron-greenhouse complex:
1 - corridor; 2 - staircase with a freight elevator; 3 - bathroom; 4 - operator; 5 - research laboratories; 6 - life support unit; 7 - service unit; 8 - vestibule corridor; 9 - sanitary pass; 10-11 - mini-greenhouses - boxes of the selection department, respectively: winter wheat, rye and triticale; spring wheat and barley; oats; grain and legumes; genetics and prebreeding, cell biotechnology; 12 - department of creation of infectious backgrounds; 13 - hall of growth chambers.
Author's development

High requirements are given to the device of special hothouse boxes for storage of artificial infectious backgrounds (Figure 4, boxes 12). These are the requirements for the density of structural elements, the need for separate isolated (Figure 5) inputs and outputs, and so on.

An important stage of project activity is the creation of design and technological documentation for the direct construction and installation work. Particular attention is paid to the following: dimensions and installation of technological equipment of phytotrons and refrigerating chambers; saturation of greenhouse mini-boxes with engineering and technological systems and equipment; high level of automation of research processes and provision of temperature and humidity regimes.

The result of research**.** The method of designing spatial planning solutions, engineering and technological systems of phytotron-hothouse sets is created.

The three-story research and laboratory building with outbuildings and transparent mini-blocks in greenhouse structures was developed on the basis of research centers for the study of grain crop selection.

Summary and conclusions Modern phytotron-greenhouse complexes are high-tech samples of equipment and systems and require the provision of these areas of research and high-quality life support systems.

The design and construction of such complexes involves the use of knowledge systems for research methods of technological features of different crops, the need to

ensure appropriate parameters and indicators.

At the same time, high-quality design of construction technology and organization of works is also important.

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