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РЕСПУБЛИКИ КАЗАХСТАН

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OF THE REPUBLIC OF KAZAKHSTAN

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NAS RK is pleased to announce that News of NAS RK. Series of chemistry and technologies scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of chemistry and technologies in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of chemical sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Химия және технология сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Химия және технология сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді химиялық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия химии и технологий» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по химическим наукам для нашего сообщества.

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N.K. Nadirov[1], V.G. Nekrasov[1], Y.V. Solodova[1],
T. Srymov[2], D.T. Suhanberdieva[2], M.A. Kultore[2]

[1]National Engineering Academy of the Republic of Kazakhstan, Almaty, Kazakhstan;
[2]Al-Farabi Kazakh National University, Almaty, Kazakhstan
neftgas@inbox.ru, vadim.nvg@mail.rusolodova.e@mail.ru

HOTHOUSES OF NEW GENERATION

Abstract. The principle of thehothouse of thenew generation was first mined-out for the terms of continental climate of Kazakhstan. It is set that for the continental climate of Kazakhstan traditional hothouses as the protected area of soil with a glass or pellicle protection do not provide the required efficiency. Traditional hothouses allow to increase a production of fruit and vegetable goods volume due to a few cycles of growing (in spring are up to 2 cycles, in winter are up to 3-4 cycles). Additional costs on theconstruction of thebuilding, on heating and supplementary lighting increase expenses, that at modern market prices on vegetable products results in the height of fruit and vegetable unit cost, and also to that the term of recoupment of hothouse makes 6 and more. Fundamental technical solutions are offered for the hothouse of the newgeneration, that allow to produce fruit and vegetable products in any region of thecountry during the whole year round. It will provide substituting for an importin the vegetable sector of theeconomy, assists strengthening of food safety. The hothouse executed as a trench with the use of local and cheap building materials having small losses of thermal energy in that technology of growing is based on full application of artificial terms and many-tier shelving will provide high technique-economic indexes and small term of recoupment of expenses on thebuilding.
Keywords: hothouses, sun, wind, steady development, proceeded in energy sources, energy-savings.

In the world, there is an extensive experience of year-round production of vegetables thanks to the use of greenhouses. Thus, in Spain, Japan, and Turkey, total greenhouse area reach 40000-50000 hectares or more, and a specific area of the protected ground has values from 1.177 to 0.576 ha per 1000 people.

The Republic of Kazakhstan has taken a number of measures on development of greenhouse technologies. Greenhouse Association of Kazakhstan was established. In Shymkent, a factory for the production of greenhouse components was launched. The Programme for the Development of Agro-Industrial Complex (AIC) of the Republic of Kazakhstan for 2010-2014 plans an annual input of at least 10 ha of greenhouse space. In the follow-up Programme for the development AIC RK for 2014-2020 "Agribusiness-2020", the necessary area of greenhouses in the period from 2014 to 2017 should increase from 364 to 461 hectares and stabilize at this level until 2020, as providing the market demands in early winter and vegetables [1].

The typical greenhouses have several disadvantages. Thin films of glass fencing or plastic is a poor thermal insulation, that in the cold period of the year leads to great losses of heat. So, the heating system of various designs used in the greenhouses. This leads to increased cost of funds. E.g., in the continental climate, for heating 1-hectare plot in winter one needs to spend up to 200 t of fuel equivalent per year. The fuel component in the cost of products reaches 40 to 80% depending on the region and type of greenhouses. In fact, the rate of energy consumption of greenhouses is the most critical in terms of the commercial viability of production of greenhouse products. This is why increasing energy conservation is often the primary goal of all greenhouse complexes [2].

Among the options to reduce the cost of energy consumed for heating and lighting modern greenhouses, the most popular is the use of alternative heat sources [3-10].

The cost of alternative energy sources is quite high, and these sources have a number of significant disadvantages: occupy large areas depending on weather conditions, time of day, season. Despite rapid growth in recent years, the use of wind and solar energy remains an exotic and expensive experiment. Some energy specialists claim that the total share of alternative energy by 2020 will not rise significantly above 1% of world energy consumption.

To ensure the efficient use of renewable resources and energy as a factor of sustainable development of economy of the Republic of Kazakhstan, the Ministry of Environmental Protection, in accordance with the Concept of Transition of the Republic of Kazakhstan to Sustainable Development for 2007-2024, approved by the Presidential Decree № 216 dated November 14, 2006, developed the strategy "Efficient Use of Energy and Renewable Resources of the Republic of Kazakhstan for Sustainable Development until 2024".

A year-round production of vegetables requires greenhouses with suitable microclimate both in winter and summer.

In 2011-2014, under the auspices of the Ministry of Education and Science, the work was carried out under the Programme «Scientific and Technological Support of the Energy Sector of Economy of the Republic of Kazakhstan (renewable energy sources, energy saving)". Within the Programme, a project has been accomplished "Development and Testing of Combined Technologies of Renewable Energy)".

In the process of work, for a real study, the combined system/greenhouse using renewable energy (solar, wind) and commercial energy (gas, electricity) as a consumer of energy was built - area 75 m^2 equipped with vacuum solar heaters, PV panels, wind generators, battery and automatic control unit. Characteristics were obtained for the combined power system [11-20].

Photo 1 - Elements of using solar and wind energy in the experimental greenhouse

It has been established that in the continental climate of Kazakhstan conventional greenhouses as a protected plot of ground with glass or plastic fencing do not provide the required efficiency. Based on that, the principle of greenhouses of a new generation for continental climate conditions of Kazakhstan has been formulated. The table below shows the principal technical solutions for the new generation greenhouses.

Table - Principal features of new generation

Conventionalgreenhouse	Newgenerationgreenhouse
The "greenhouse" term - hothouse construction for growing seedlings, vegetable, fruit and ornamental crops, as well as for breeding and preservation of tropical and subtropical plants, conducting biological studies, etc.; room of coated glass or transparent foils and plastic. Heating greenhouses - solar, biological (biofuels), technical (water, steam, electric). Winter greenhouses to operate year-round, spring - in spring, summer, and autumn.	**The notion of the term "greenhouse of the new generation"-** agro-industrial production facility for all season mass production of fruit and forage crops in conditions of artificial microclimate and application of special energy and agricultural greenhouse production technology.
Production building of greenhouse is made in the form of a carcass from light elements with transparent fence walls and roofs made of glass, special transparent film or cellular polycarbonate.	**Production building of greenhouse is** made in the form of the industrial type construction element, including multilevel and multilayered ones with the walls of construction materials (bricks, hollow blocks, foam concrete, aerated concrete, special sandwiches, etc.) and the roof with low thermal conductivity. To reduce costs, in frame/carcass structure it is preferable to use local building materials: raw brick, adobe, straw plaster panels, blocks of pressed straw, etc.
Planting area. Natural soil is used. Feature - during the cultivation season, in the soil without natural winter freezing nematode (special kind of worms that can irreparably damage the root system of the plants) grows in number. Soil regeneration is performed by replacing the topsoil that is labor-intensive operation.	**The planting area.** Planting is done on multi-tiered shelves that allow you to have a planting area several times larger than the territory occupied by the greenhouse.
Substrate for plant root system. Soil layer with organic and mineral fertilizers.	**Substrate for planting.** The artificial soil in trays (regeneration of soil by replacing trays), hydroponic version applies a substitute soil (gravel, etc) or the substrate for the root system is not used in the aeroponic version.
Heating system. Combined heating, solar radiation, penetrating through the transparent barrier, as well as (in winter) artificial heating systems: gas, liquid or solid fuel. The peculiarity of the heating system when growing on soil - growing area is determined by the greenhouse area, whereas the entire volume of greenhouse air needs to be heated under large square wall covering with low heat-insulating properties.	**Heating system.** Entirely based on industrial heating systems. To reduce the cost, cheap energy is used such as power plants' exhausted steam, excess gas from oil companies, coal from local collieries, substandard wood sanitary clearing of forests. It is preferable to use renewable sources of energy, thermal water, the Sun. The energy of sunlight is used by special systems, including vacuum solar collectors, seasonal and daily water heat accumulators as part of the main circulating heating systems.

Ventilation system and creating the desired gas composition of air. Ventilationiscarriedoutbymeansofopenabletransoms.	**Ventilation and averaging the temperature and gas composition is implemented**via ventilation system with forced convection. Air carbon dioxide enrichment through special systems (running CO_2 through cylinders, hydrocarbon fuel combustion, etc.).
Power supply source. Power supply for electricity consumers (lamps, lighting, pumps, irrigation systems, etc.) is carried out from centralized sources of electricity - electricity networks with a fixed tariff.	**Power supply source.** Power supply for electricity consumers is carried out from centralized sources of electricity or from autonomous sources of electricity on gas or solid fuels. Having obtained economic justification, generating electricity from renewable energy sources (solar PVs, wind generators, micro-hydropower plants) using chemical batteries unit is feasible. The electronic automatic control system is applied to coordinate the use of different energy sources and to use optimal mode.
Lighting conditions. Use of sunlight entering through the transparent barrier. This light can influence only plants, located at the same level, i.e. on greenhouse soil, in addition, transparent glass, fence or polymer barrier, especially in the context of a dusty fence conduct not the whole stream of sunlight, distorting the natural spectrum of sunlight.	**Lighting conditions.** Artificial light sources are used for each tier shelving, special lamps for greenhouses or energy luminescent bulbs, as well as particularly efficient LED light sources with a special biological range. The lighting period and intensity and duration of "artificial night" is regulated for plants of different kinds by a special automatic system. Prospectiveloweradditionallightingofplants.
Summer mode. In the midst of the summer season greenhouses with transparent fence are usually exposed to excessive overheating. To prevent this, the screening system is applied with special reflective coatings. Screening large areas of greenhouses is a tedious operation. The excess solar energy just dissipates in the environment.	**Summer mode.** Conditions for maintaining the microclimate is unified for winter and summer mode. Lighting conditions of plants using artificial light sources on the multi-tiered shelves inside greenhouses are the same for summer and winter modes, as they are regulated by the special lighting system.
Watering and fertilizing. To create the required humidity of soil, sprinklers are applied, fertilizers introduced via usual method when preparing the soil for planting and during the growth period in the form of inter-seasonal feeding by types of cultivation in the open ground.	**Watering and fertilizing.** Drip irrigation is used when applying special drip systems. With hydroponics, they are an integral part of the technology. Additives in water solutions are used during irrigation. In the aeroponic system, a similar system with nozzles to create an aerosol and irrigate the root systems is used.
Mechanization of production. Mechanization tools in line with cultivation technology in the open soil (low power tractors, electric cars, etc.) are used.	**Mechanization of production.** Mechanization tools: from the usual small-scale mechanization equipment (electric cars, elevators to service the upper tiers of shelves) to vertical or horizontal mechanized conveyor systems with a full cycle of cultivation mechanization when planting, growing, harvesting, regeneration planting substrate operations, etc.

Conventional greenhouses allowto increase production of fruits and vegetables through a few cycles of cultivation (in spring - up to 2 cycles, in winter-up to 3-4 cycles). Additional costs for construction of a heating facility and for additional lighting increase the expenses, which in the current market prices of the vegetable products leads to an increase in the cost of fruits and vegetables, and the greenhouse payback period becomes 6 years and more.

The new generation of greenhouses allowsto produce horticultural products in all regions of the country all year round. This ensures the import substitution in the vegetable sector of the economy, promotes food security. Feed direction in greenhouse technologies allows developing cattle breeding in the desert regions of the country.

Set out principles were tested on a single module greenhouse shelve.

The shelved greenhouse is a construction from the bent corner profile with perforation collected on bolted connections into a single spatial frame in dimensions (length, width, height)-3000 × 3000 × 1000 mm.

On the shelves, as on one pilot module, the necessary technologic requirements for a new generation of greenhouses were reproduced.

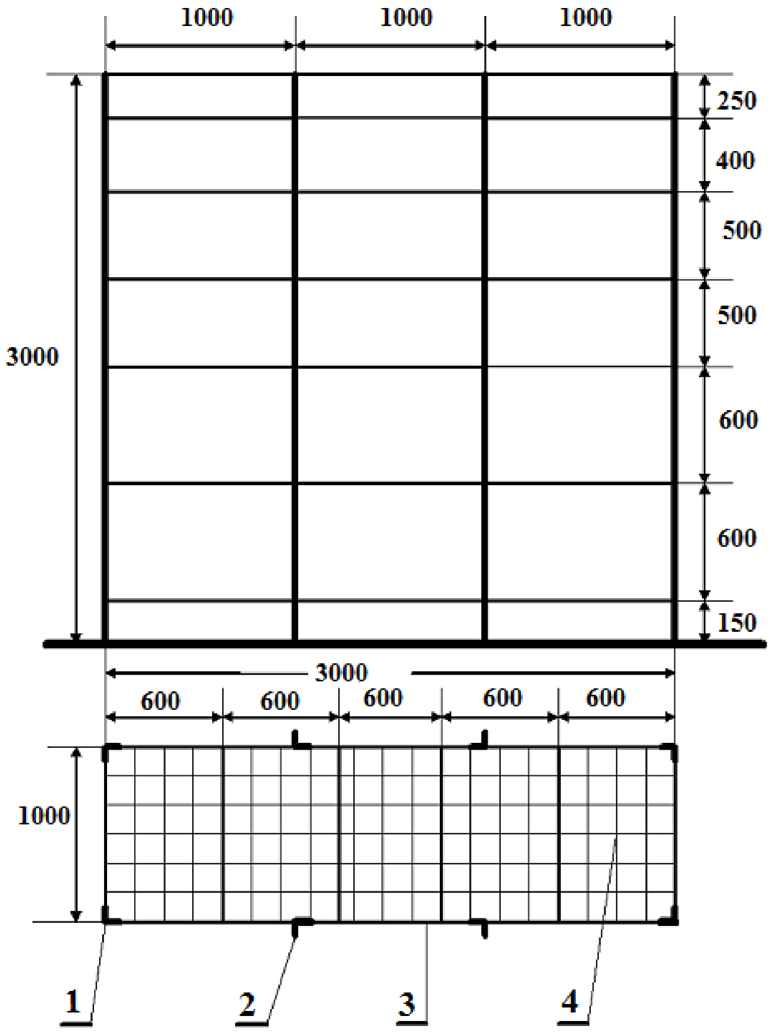

Figure 1 - Scheme of a greenhouse shelve frame and its dimensions:
1 -corner racks; *2* -central racks; *3* -frame shelves; *4* -grids of shelves

Greenhouse shelve equipment is shown in the photo below.

Photo 2 - Tank, water, and nutrient solution supply pump, as well as a drip irrigation system

Photo 3 - Gas regulation fan (photo on the left). "Cold steam" and air ionization device and (right)

Photo 4 - Shelve for growing plants

Left - case for regulating gas lifted for servicing, right - cover protects shelving, creating an optimum microclimate for plants.
Photo 5 - Hothouse shelve during in vitro cultivation experiments

Experiments with greenhouse shelving fully confirmed the reality of technology of cultivation of vegetative production totally in artificial conditions.

On the basis of such technical solutions, we have developed several options, both for businessmen and for large greenhouse facilities, for the production of hydroponic green fodder.

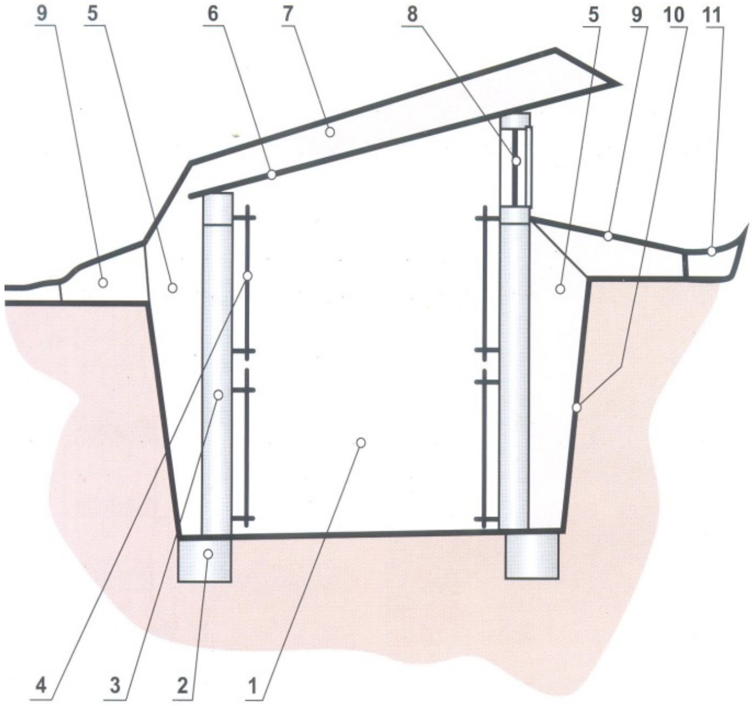

Figure 2 - Scheme of trench greenhouse (left): the operating room; 2-strip foundation; 3-metal racks; 4-wall-covering; 5-filling of the insulating material; 6-ceiling overlap; 7-thermal insulation of the roof with waterproofing; 8-laminated window glazing; 9-wall slopes; 10-slope waterproofing; 11-waterproof chute

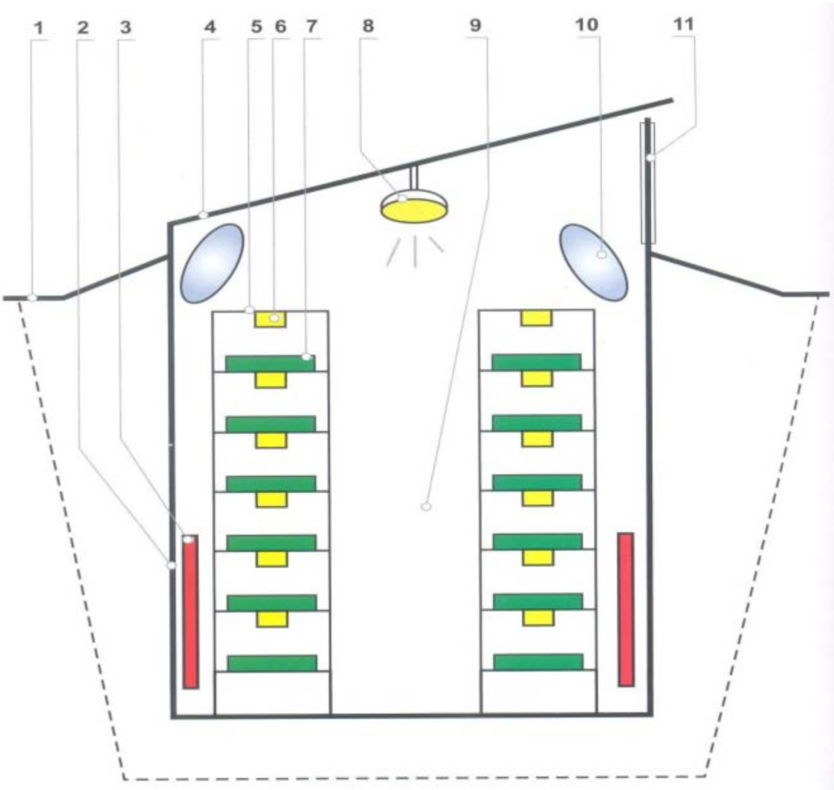

Figure 3 - Scheme of arrangement of trench greenhouses (right): 1-soil level; 2-wall; 3-heating system radiators; 4-roof; 5-multi-layered hothouse rack; 6-sources of artificial lighting; 7-trays for cultivation; 8-security lighting lamp; 9-process passage; 10-fans; 11-double-glazed light aperture

For the industrial mass production of vegetables, optimized trench greenhouses were designed. Due to the trench profile, cost of construction walls is reduced. Besides, cultivation area increased due to two rows of shelves with a width of 2 m each with the possibility of two-way servicing of shelves

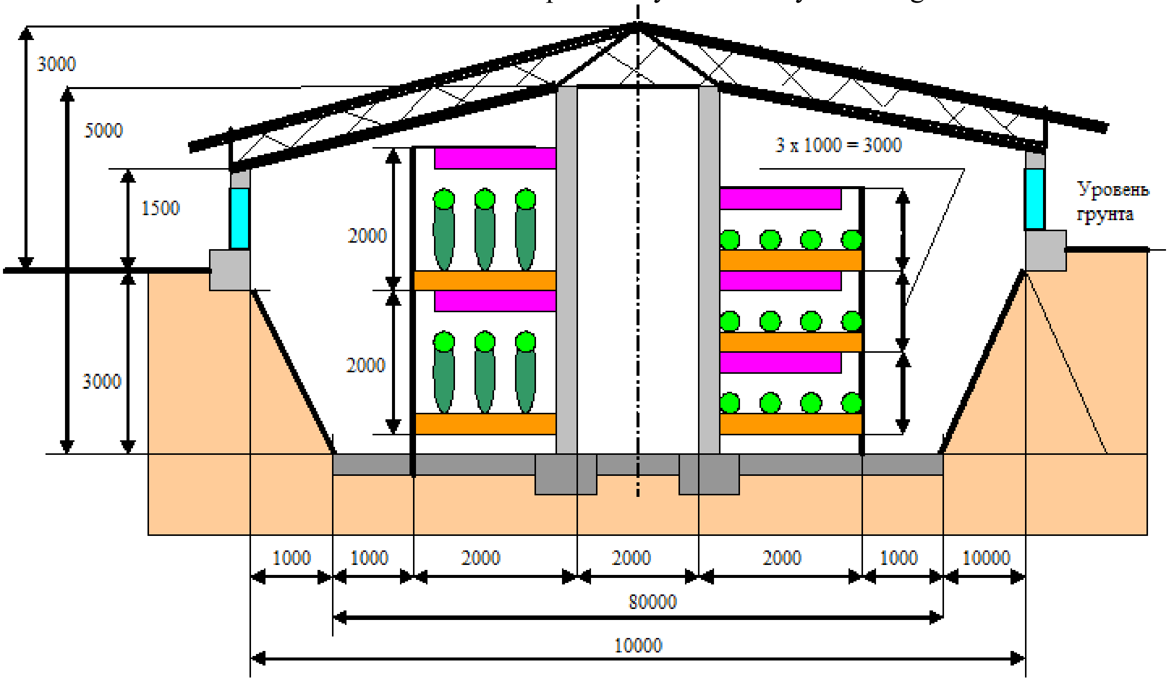

Figure 4 - Optimizing construction of trench greenhouses

Such technological elements, as a source of thermal energy in the form of the heat source with coolant circulation system, motor generator when applying autonomous power supply run in a separate compartment of the greenhouses. Greenhouse power supply is possible from commercial energy (solid, liquid or gas) and renewable energy (solar, wind, micro-hydropower plant, etc.).

The principle of fully insulated greenhouses has been tested during an industrial experiment. The experiment was carried out in the experimental greenhouse, executed according to the scheme of gelio-greenhouse, i.e. with three walls heat insulated and transparent fence for south wall. The transparent fence was made of insulating cellular polycarbonate. To create an environment completely isolated, the transparent fence was closed both outside and inside, which prevented the flow of sunlight, as well as provide additional thermal insulation. Lighting in the industrial experiment was provided by sodium lamps.

Photo 6 - Transparent fencing insulation of the experimental greenhouse from outside

Photo 7 - Transparent fencing insulation of the experimental greenhouse from inside
(on the photo, artificial lighting bulbs visible)

The experiment consisted of two cycles of growing cucumbers, from September to December 2014, and from January to April 2015. The experiments fully confirmed the correctness of the choice of a new design of greenhouses.

Photo 8 - Plant parameters were monitored in the process of growth, development, and fructification

Overall, the greenhouse made in the form of a trench with the use of local and low-cost building materials, with small loss of thermal energy, which is based on the application of the artificial cultivation technology and multi-tiered shelving, will yield high technical and economic results and will have a small payback of the construction costs.

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Н.К. Надиров, В.Г. Некрасов, Е.В. Солодова, Т. Срымов, Д.Т. Суханбердиева, М.А. Култоре

ЖАҢА БУЫН ЖЫЛЫЖАЙЫ

Аңдатпа. Қазақстанның континентальды климат жағдайы үшін алғаш рет жаңа буынды парниктік принципті жылыжай жасалды.

Қазақстан континенталды климаты үшін шыны немесе қабыршақты қоршаумен қорғалған дәстүрлі жылыжайлар қажетті тиімділікті қамтамасыз етпейтіндігі анықталды.

Дәстүрлі жылыжайлар өсірудің бірнеше циклды (көктемде - 2 циклге, қыста - 3-4 циклге дейін) өсірусалдарынан, жеміс-көкөніс өнімдерінің көлемін арттыруға мүмкіндік береді. Жылыту және жарықтандыру үшін ғимаратты салудың қосымша шығындары, көкөніс өнімдерінің ағымдағы нарықтық бағалары жеміс-көкөніс құнының өсуіне, сондай-ақ жылыжайдың өтелу мерзімі 6 жыл немесе одан да көп уақытқа созылатын шығындарын арттырады.

Жыл бойы еліміздің кез-келген өңірлерінде жеміс-көкөніс өнімдерін шығаруға мүмкіндік беретін жаңа ұрпақты жылыжайға арналған негізгі техникалық шешімдер ұсынылады. Бұл экономиканың көкөніс секторында импорт алмастыруды қамтамасыз етеді және азық-түлік қауіпсіздігін нығайтады.

Жергілікті және арзан құрылыс материалдарын пайдаланып, шұңқыр түрінде жасалған жылыжайда өсіру технологиясы толықтай жасанды жағдайларды және жинақталған тіректерді пайдалануға негізделген жылу энергиясын аз жоғалтады, жоғары техникалық және экономикалық көрсеткіштерді және құрылыс шығындарын қысқа мерзімде өтеуді қамтамасыз етеді.

Түйін сөздер: жылыжай, күн, жел, тұрақты даму, энергия көздері, энергия үнемдеу.

Information about the authors:

Nadir Karimovich Nadirov - Academician of NAS RK, Doctor of Chemical Sciences.

Place of work: The National Engineering Academy of RK. Tel. (7272) 291 31 71

Vadim GergievichNekrasov- Candidate of Technical Sciences.

Place of work: The National Engineering Academy of RK. Tel. (7272) 291 31 71

Elena VladimirovnaSolodova - Candidate of Biological Sciences, Corresponding Member, The National Engineering Academy of RK.

Place of work: The National Engineering Academy of RK. Tel. (7272) 291 31 71

Talgat Srymov - 2nd-year graduate (Master) student, UNESCO Department of Sustainable Development, Al-Farabi Kazakh National University

Denise SuhanberdievaTalgatovna - 2nd-year graduate (Master) student, UNESCO Department of Sustainable Development, Al-Farabi Kazakh National University

Marat AjdarhanovichKultore - 2nd-year graduate (Master) student, UNESCO Department of Sustainable Development, Al-Farabi Kazakh National University

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