

“SMART GREENHOUSE”

The project team:

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Modern agriculture has been making a progress on an unprecedented scale. More recently, hydroponics was considered a unique technology for growing plants without soil. And now it is being replaced by a new technology - aeroponics.

Aeroponics is a method of growing plants not only without using soil, but also without any substrates at all. A method in which the root system of plants is located in the air, and not in water, as in the usual hydroponics. Being in the air, the root system is constantly sprayed with nutrient solutions using special nozzles.

For each plant, the composition of the solution changes, as does the number of waterings per day. At the same time, it should not be allowed that the roots dry out. Due to the fact that this method takes up a small area, and there are no problems associated with the soil, namely: weeds, weeding, dirt, diseases; it has become very popular with farmers interested in high tech cultivation methods. You can emphasize the fact that the care of plants with this method of growing can be fully automated, adjust the necessary watering, climate, lighting, and so on.

Aim of the project: improving the efficiency, economy and environmental friendliness in agriculture using the technology of growing plants in the air through the development of a smart greenhouse "SMART GREENHOUSE" (hereinafter referred to as a smart greenhouse).

Objectives of the project:

1. Research (additional) factors affecting the comfortable environment of plants in greenhouses: temperature, humidity, illumination, carbon dioxide content.
2. Development of design documentation for the manufacturing a smart greenhouse.
3. Development of an algorithm for collecting and processing information from sensors that control a comfortable environment for growing plants.
4. Acquisition of the necessary materials and components for the manufacturing a prototype of a smart greenhouse.
5. Development of software for automation of irrigation, lighting, etc., controlling a comfortable environment for growing plants.
6. Testing a prototype of a smart greenhouse.

The project practical relevance:

1. Increase in crop yields.
2. Saving water resources.
3. The opportunity to provide areas with food, where there is no opportunity for the developing agriculture.
4. Improving the ecological state in agriculture.

A smart greenhouse consists of separate boxes, each of which can be adapted to a particular type of plant. Temperature, humidity, and illumination of each box are adjusted individually, which ensures accelerated and fruitful growth of plants.

Figure 1 structurally shows the technology of growing plants in the air.

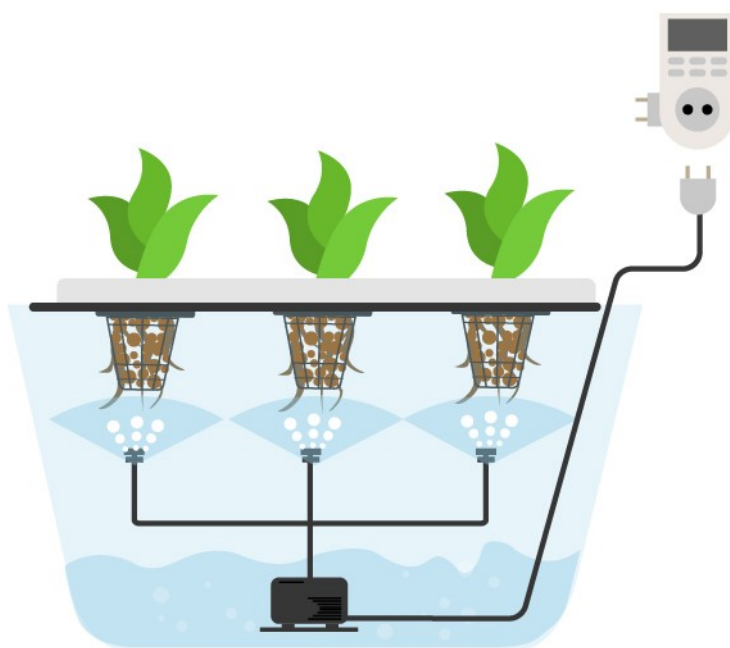


Figure 1 - Technology of growing plants in the air (aeroponics)

Each box includes the following elements:

- module for planting plants;
- irrigation system of pipes and fine nozzles;
- reservoir for nutrient solution;
- pump pumping solution into the irrigation system;
- automation that controls watering.

The module for planting plants is a rectangular module with special holes in which planting cups with seedlings are installed. In order for the plants to be held in a glass, a substrate is used.

An irrigation system is located inside the module. This is a frame made of small diameter plastic tubes. It is connected to a pump that supplies fluid to the system. Nozzles are installed in the tubes. The nozzles form (spray) a mist from the nutrient solution in the module, which irrigates the plant root system.

The solution tank is a plastic or stainless steel tank, insulated to maintain a certain temperature of the solution. Plastics and stainless steel are used because of the inertness of materials to chemicals. They do not oxidize under the influence of fertilizers, do not change the composition of the nutrient medium.

Watering is carried out according to the schedule of a given time using a timer - usually 5 seconds. watering every 1.5 - 5 minutes. Irrigation is connected to a single smart greenhouse control unit.

The solution unit is designed to prepare a nutrient solution of a given concentration and with an optimal pH value by mixing two or more mother liquors and an acid with water. High-quality and continuous mixing of water with mother liquors and acid takes place in controlled injection mixers. The control unit monitors the parameters of the nutrient solution and maintains them at a given level. Irrigation is controlled according to a program set by a specialist - agronomist. This makes it possible to flexibly program the amount of water and mineral fertilizers leaving the solution unit, allowing optimal organization of balanced plant nutrition.

Not only timely watering, but also optimal illumination will help to get a good harvest. As for lighting, LED lamps are the most competitive in terms of their characteristics. They are characterized by low power consumption and give out most of the solar spectrum. White LEDs

exist that can emit the full spectrum of sunlight and help grow plants entirely under artificial light.

A safety device must be installed to protect against voltage surges. Its choice is based on the recommendations of the LED lamp manufacturer. After installing the device, the wires are wired according to the location of the lamps.

To create optimal illumination, an automatic system is created, which, among other things, will save energy. Special sensors will monitor the light and automatically turn on or off the backlight.

Getting high results when growing vegetables, flowers, seedlings, lettuce directly depends on the quality of providing plants with optimal conditions for growth and development. And one of the most important of these is a well-balanced microclimate. A few years ago, microclimate control could be carried out manually by an operator, but with the advent of a large number of engineering systems in the greenhouse, as well as with increased requirements for the quality of maintaining a microclimate, today, not a single industrial greenhouse can do without an automatic control system.

A modern greenhouse includes many executive engineering systems, that is, devices that allow you to control the microclimate of the greenhouse:

- Heating system. The main task of the heating system is to maintain the temperature set by the agronomist. Typically, greenhouse heating consists of several separate circuits (systems). The air temperature is controlled by changing the temperature of the water in the circuits, which is carried out using a mixing valve, which mixes in the required proportion the water from the heat source (direct heat carrier) with the water returned from the greenhouse (return heat carrier).

- Ventilation system. To ventilate the air inside the greenhouse, transoms (vents) are provided in the roof, the area of which is up to 30% of the total glazing area. The opening and closing of the vents is carried out using motorized gearboxes.

- Curtain system. Almost all new greenhouse projects are equipped with a curtain system, because it allows you to save up to 30% of heat resources, as well as protect plants from sunburn. The principle of its operation is that a special polymer material rolls up and unfolds over the plants, thereby cutting off the roof. Folding and deployment is performed using special gearboxes.

- Carbon dioxide feeding system. The most important parameter of the microclimate, along with temperature and humidity, is the concentration of carbon dioxide in the air. This is due to the fact that carbon is the main building material for a plant and the process of photosynthesis (production of dry matter) is impossible without carbon dioxide. The most economical solution is to use the waste gases of the boiler room for feeding, and this is the case in most greenhouse plants. But in some cases, you have to resort to using liquid carbon dioxide for feeding, which is a more expensive solution.

- Air recirculation system. To ensure air exchange in the greenhouse, fans are installed in its upper part. When switched on, they provide air movement, equalization of the thermal field and accelerate convective heat transfer; • automatic microclimate control system. It is designed to link all of the above systems into a single whole, into a single process with centralized control.

Heating and ventilation systems, curtains, carbon dioxide feeding and recirculation all work under the control of a special control unit, which is responsible for ensuring that the microclimate regime in the greenhouse exactly coincides with the agronomist's task.

For the possibility of centralization and control, it is necessary to use a component that allows reading and processing signals, which, based on the data received from the sensors, responds accordingly. Thus, supplying control signals to the executive components, namely the microcontroller. For an automatic irrigation system, you will need to use: a water level sensor, which will determine the current amount of water in the reservoir, thereby making it clear that it is necessary to add water in case of its lack in the reservoir; humidity sensor. In this way, the system determines when it is required to start the irrigation process; LCD display required for

monitoring humidity and visualizing the processes of setting up the irrigation system; a load control device that, after a signal from the microcontroller, triggers the water supply system; control system for the task and setting of irrigation processes. Alert device, serves to indicate the lack of water, so that it is added to its storage tank.

For the auto-ventilation system, it is necessary to use such elements as: a temperature and humidity sensor, depending on the readings taken by this sensor, the current state inside the greenhouse is determined; load control device, which, after a signal from the microcontroller, started the ventilation system. The following elements are required for the automatic heating system: a temperature sensor; a load control device that starts heating after a signal from the microcontroller; control system for the task and setting of heating processes; LCD display required for temperature monitoring and visualization of heating system adjustment processes.

Figure 2 shows the structure of a smart greenhouse based on the technology of growing plants in the air.

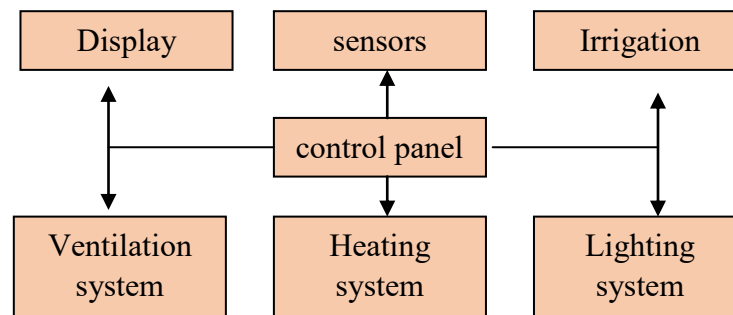


Figure 2 - The structure of a smart greenhouse based on the technology of growing plants in the air

Figure 3 shows photographs of the results of preliminary research and development of a smart greenhouse based on the technology of growing plants in an air environment.



Figure 3 - Results of preliminary research and development of a smart greenhouse

The project economic justification

To implement a prototype of the system, you will need to purchase the following components:

No.	Title	Cost, RUB	Total number, pcs.	Amount, RUB
1.	Monolithic polycarbonate "Borrex optima" transparent 8 mm, 2 × 6 m	6000	2	12000
2.	Lighting system	1700	4	6800
3.	Irrigation system	17000	1	17000
4.	Ventilation and heating system	15000	1	15000
5.	Sensors and display	15000	1	15000
6.	Consumables and tools	15000	-	15000
TOTAL:				80800

Expected results of the project

Aeroponics may be an effective alternative method of growing plants on an industrial scale, especially in regions with unsuitable soil for crop production. Also, aeroponics technology can be successfully applied as an effective way of growing greens and vegetables with the possibility of year-round harvesting at low costs in small farms for home use.

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