

# SMART AEROPONICS

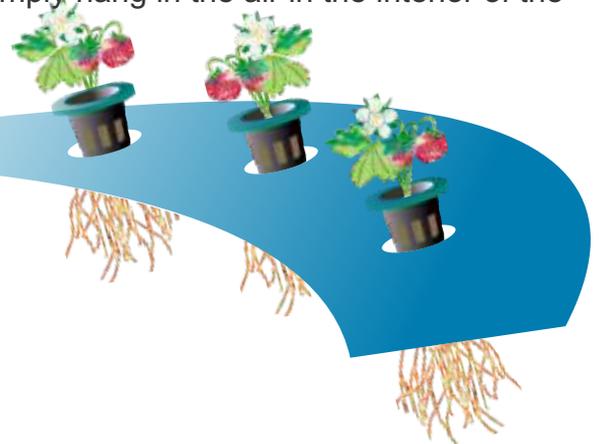
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## PURPOSE OF THE AEROPONICS

SMART-AEROPONICS is designed for growing plants by aeroponic in closed premises. Aeroponic is the process of growing plants in the air without using the soil, in which nutrients are delivered in the form of an aerosol to the roots of plants. Unlike hydroponic, which uses hydrated substrate, saturated with the necessary minerals and nutrients to support the growth of plants, the aeroponic method of growing plants generally does not involve the use of substrates. The basic principle of aeroponic growing plants is aerosol spray in a closed environment nutritious, rich in mineral substances, aqueous solution (hereinafter - mixture). Since an important component growth and development of plants is oxygen, plants grown on the principle of "oxygen saturation", are in containers in suspended state, their roots open and get maximum air. The root is practically independent, almost autonomous part of the plant with hormonal system and enzymatic apparatus. He may be minutes to convert absorbed CO<sub>2</sub> into carbohydrates, sugars into organic acids, nitrates into amines and amino acids. The plant itself is fixed by the supporting system in the trellised basket, and the roots, irrigated with the nutrient mixture, simply hang in the interior of the cultivation chamber.

The mixture is fed to the roots at short intervals so that the roots do not have time to dry. The leaves and trunk of the plant are isolated from the spray zone. With this approach, the environment remains free from pests and diseases associated with the soil, which means that plants can grow healthy and faster than plants grown in the soil. The use of aeroponics allows the creation of fully automatic plant cultivation systems, which are much simpler than systems using a substrate.



SMART-AEROPONICS works offline and does not require the constant participation of maintenance personnel. Due to the presence of controllers and sensors constant monitoring of all parameters of Aeroponics is provided. In the case of output of the measured parameters beyond the limits of the norm the SMART-SERVER informs the maintenance personnel of the need for corrective actions. Monitoring the parameters of the mixture and the air allows to achieve the maximum qualitative and quantitative parameters of the crop.



## ADVANTAGES OF THE AEROPONICAL METHOD OF PLANTS GROWING

### Ecological

Aeroponical cultivation of plants is considered a safe and environmentally friendly way of obtaining natural, healthy plants and crops. Also, the additional environmental benefits of aeroponics are the savings of water and energy. Compared with the usual growing of plants, aeroponics suggests a lower consumption of water and energy costs per unit of production. Plants fully absorb all the nutrients consumed. Nothing goes into the ground, groundwaters are not polluted, and there is no impact on microbial life in the soil.

### Absence of plant diseases

In aeroponics you can limit the transmission of infection by quickly isolating the infected area. In the case of soil, the disease can spread throughout the nutrient medium, infecting many plants. Also, the aeroponical method of cultivation automatically relieves plants from diseases that are inherent in the soil, as well as from a large number of pests living in the ground.

### Economic

The main economic advantage of aeroponics is that it does not require land for its production, and as a consequence it is possible to create multi-tier greenhouses for food production. Such an approach will help to solve the problems of a limited number of areas for cultivation of plants, and also will allow to grow food in unfit for agriculture areas. In one SMART-AEROPONICS device, about two thousand plants can be grown simultaneously with a horizontal area of about 3 sq.m. In comparison with traditional greenhouses, 20-60-fold economy of the area is achieved depending on the cultivated crop. This, of course, leads to significant savings in energy and financial resources.

### Intensification of production

An oxygenated root system accelerates the growth and development of plants. Favorable conditions created for crops increase yield several times compared to analogues grown in soil or in a substrate. Accelerated vegetation allows you to harvest several times a year, stably and without reference to fluctuations in the climate. In the classical plant growing there is always a limiting factor - lighting, humidity, lack of food, temperature, lack of CO<sub>2</sub>, etc. In aeroponics, most of the weak links in the chain are cut off, especially the blocking of elements in the soil. Almost ideal conditions are created for obtaining the maximum yield.

### Ease of use

It is very easy to care for plants. When planting, simply insert pre-seeded seedlings into baskets, add water and recommended nutrients to the tank. Most plants germinate within 7-14 days, ready for harvesting for 4-6 weeks and will continue to produce uninterrupted harvests for up to 6 months and longer. And to update or change it is enough to remove the old plant and rinse the irrigation system.

## STRUCTURE OF SMART-AEROPONICS GREENHOUSE

The structure of SMART-AEROPONICS is very simple and efficient. Hardware and software form a convenient complex for operation.

### The equipment:

- CULTIVATION CHAMBER with system of nozzles. There are three main types of Aeroponics cultivation chambers: horizontal, inclined, and vertical depending on the location of the baskets with seedlings. No light should enter the chamber to prevent unwanted algae growth;
- NUTRIENT MIXTURE TANK (One tank for one or several Aeroponics);
- AUTOMATIC PUMP (One pump for one or several Aeroponics);
- MIXTURE CHILLER (One chiller for one or several Aeroponics);
- VALVES and SENSORS;
- PHYTOLAMPS;
- SMART-SERVER which manages one or several Aeroponics (up to 99);
- WI-FI SMART-CONTROLLERS.

### Management and monitoring program

is a WEB page that the User can access locally and remotely. The WEB page is located on the SMART-SERVER. The user has the opportunity to create his own growing program or select a program from the list. After starting, the program controls the main functions of SMART-AEROPONICS, for example, irrigation of the root system and the turn on/ff of phytolamps, and also program monitors system parameters and the environment parameters, such as:

- temperature and conductivity of the nutrient mixture;
- air temperature and carbon dioxide content;
- measuring the consumption of the supplied nutrient mixture;
- measurement of leaf activity;
- measurement of supply voltage and power consumption of phytolamps;
- monitoring the phase of plant growth and an indication of the current day of cultivation.

In addition, the program sends reminders and messages about the parameters exceeding the permissible limits in the MESSAGES menu and in the TELEGRAM messenger group.



**USER**

**INTERNET**



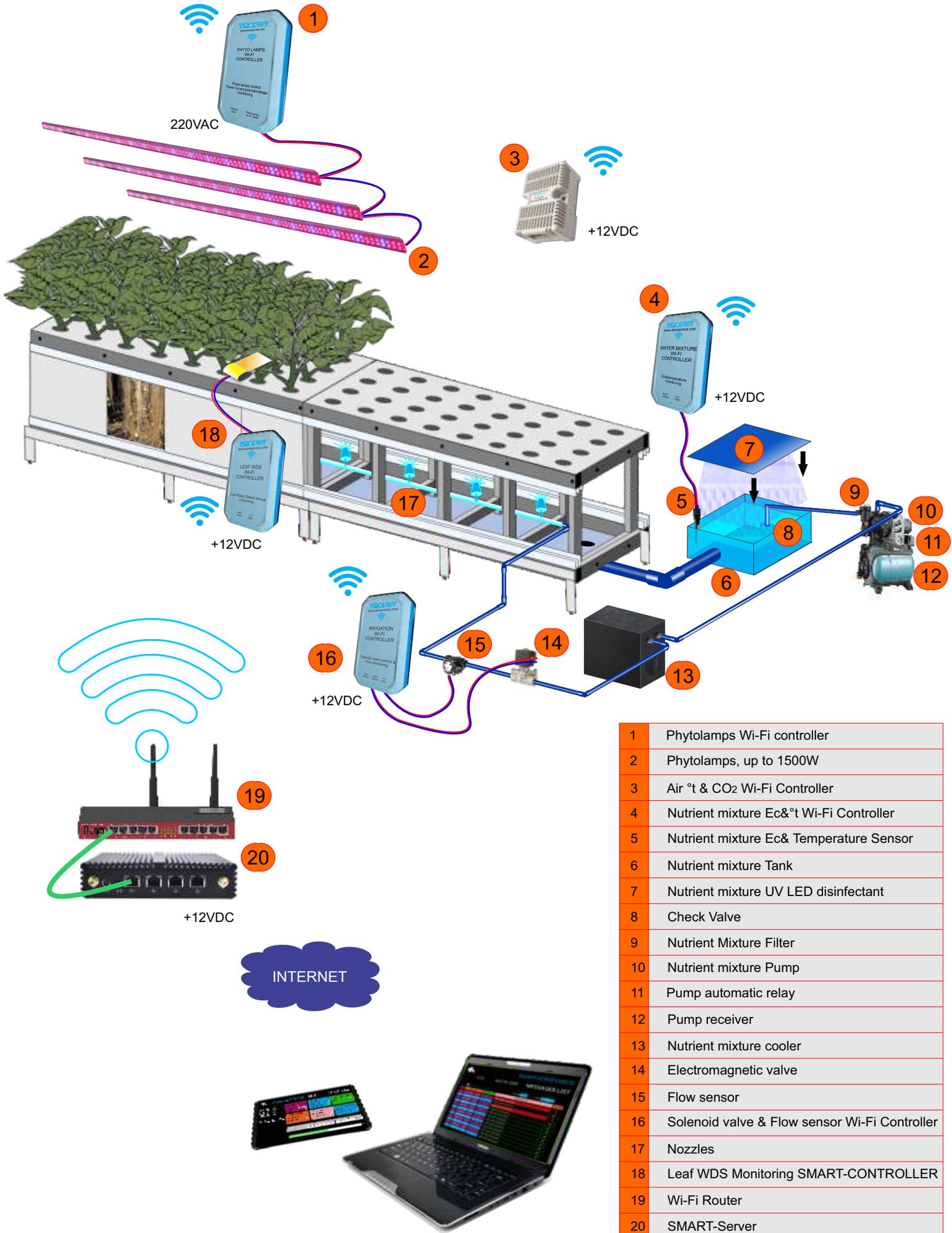
**SMART-SERVER**



<p><b>Irrigation control</b></p> <p>Electromagnetic valve control</p> <p>Flow monitoring</p> 	<p><b>Nutrient Ec&amp;t monitoring</b></p> <p>Temperature &amp; Ec monitoring</p> 	<p><b>Environment parameters</b></p> <p>Air Temperature &amp; CO2 monitoring</p> 	<p><b>Phytolamps control</b></p> <p>Phytolamps turn on/off by schedule</p> <p>Voltage and power monitoring</p> 	<p><b>Growing monitoring</b></p> <p>Leaf activity monitoring</p> <p>Growing phases scheduling</p> 
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**AEROPONICS**

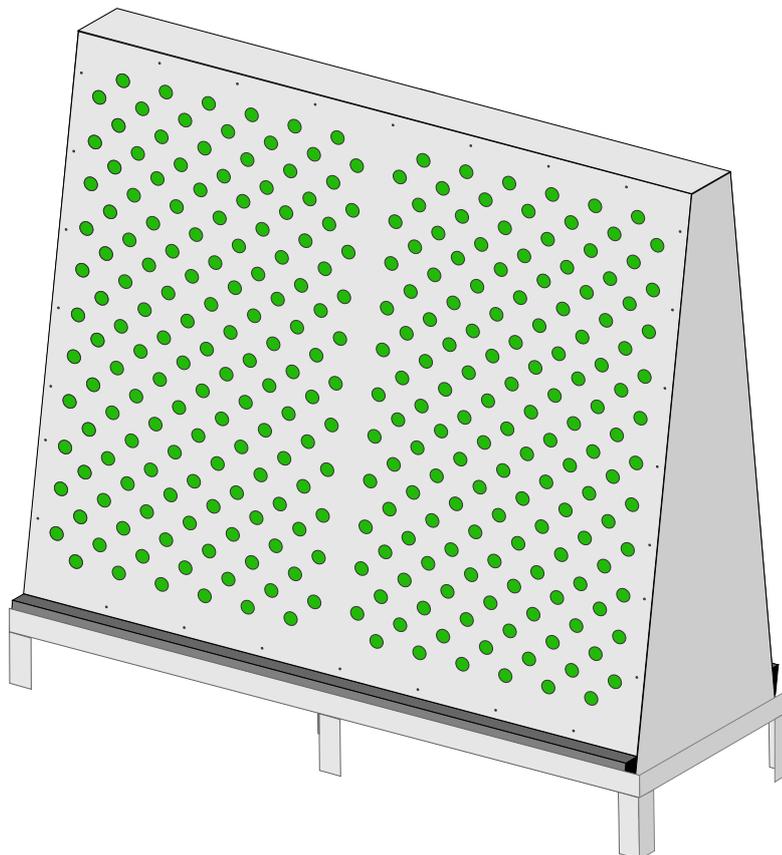
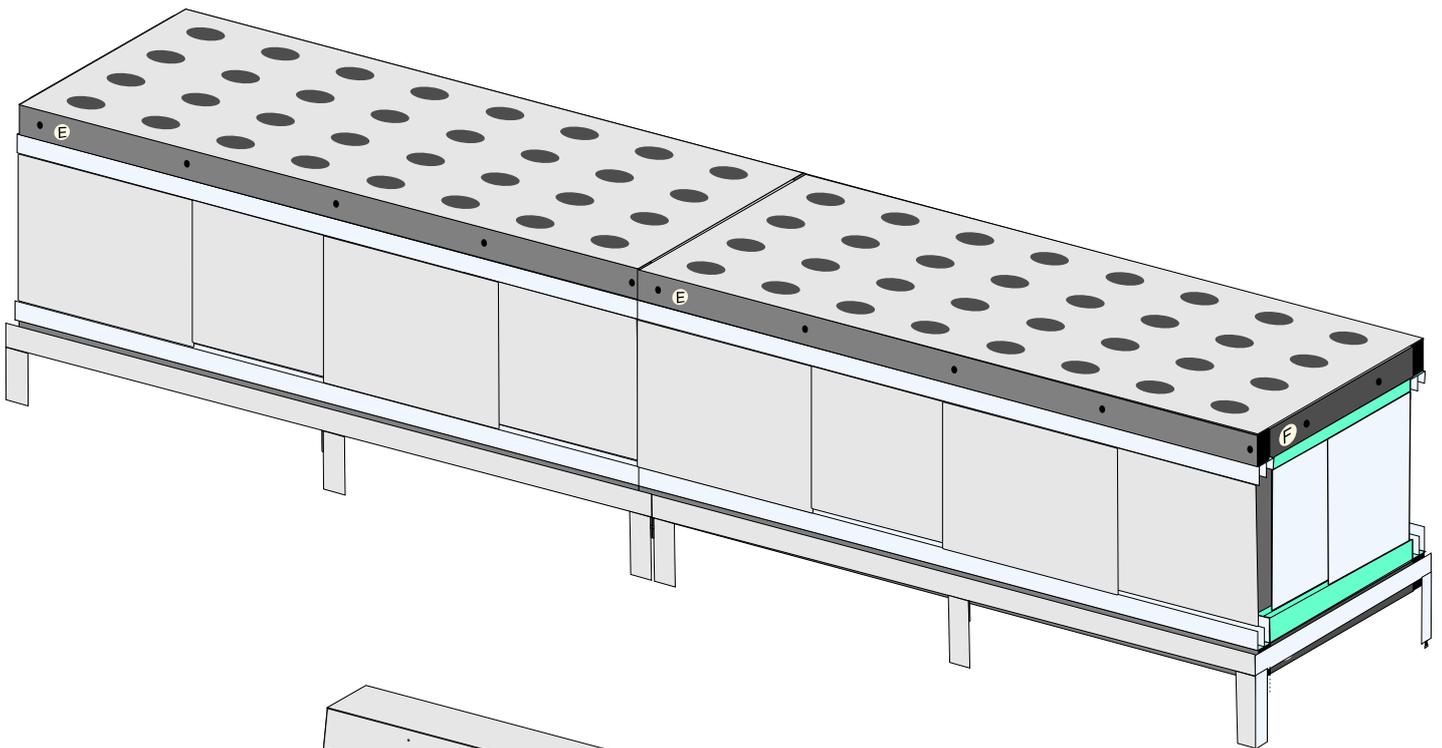


1	Phytolamps Wi-Fi controller
2	Phytolamps, up to 1500W
3	Air °t & CO <sub>2</sub> Wi-Fi Controller
4	Nutrient mixture Ec&t Wi-Fi Controller
5	Nutrient mixture Ec& Temperature Sensor
6	Nutrient mixture Tank
7	Nutrient mixture UV LED disinfectant
8	Check Valve
9	Nutrient Mixture Filter
10	Nutrient mixture Pump
11	Pump automatic relay
12	Pump receiver
13	Nutrient mixture cooler
14	Electromagnetic valve
15	Flow sensor
16	Solenoid valve & Flow sensor Wi-Fi Controller
17	Nozzles
18	Leaf WDS Monitoring SMART-CONTROLLER
19	Wi-Fi Router
20	SMART-Server

## DESIGN OF AEROPONICS

The Aeroponics consists of the following parts:

1. Basis of Aeroponics;
2. Cultivation chamber of Aeroponics (horizontal, inclined or vertical plane for arrangement of landing baskets);
3. Nutrient mixture supply system;
4. The system of collection of nutrient mixture
5. SMART-AEROPONICS management system

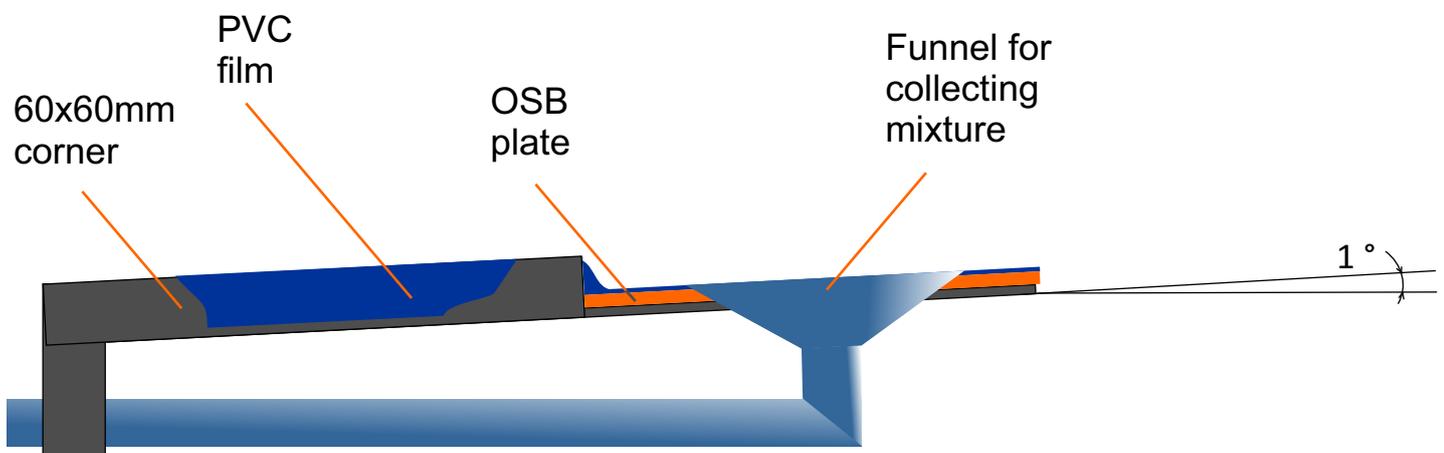
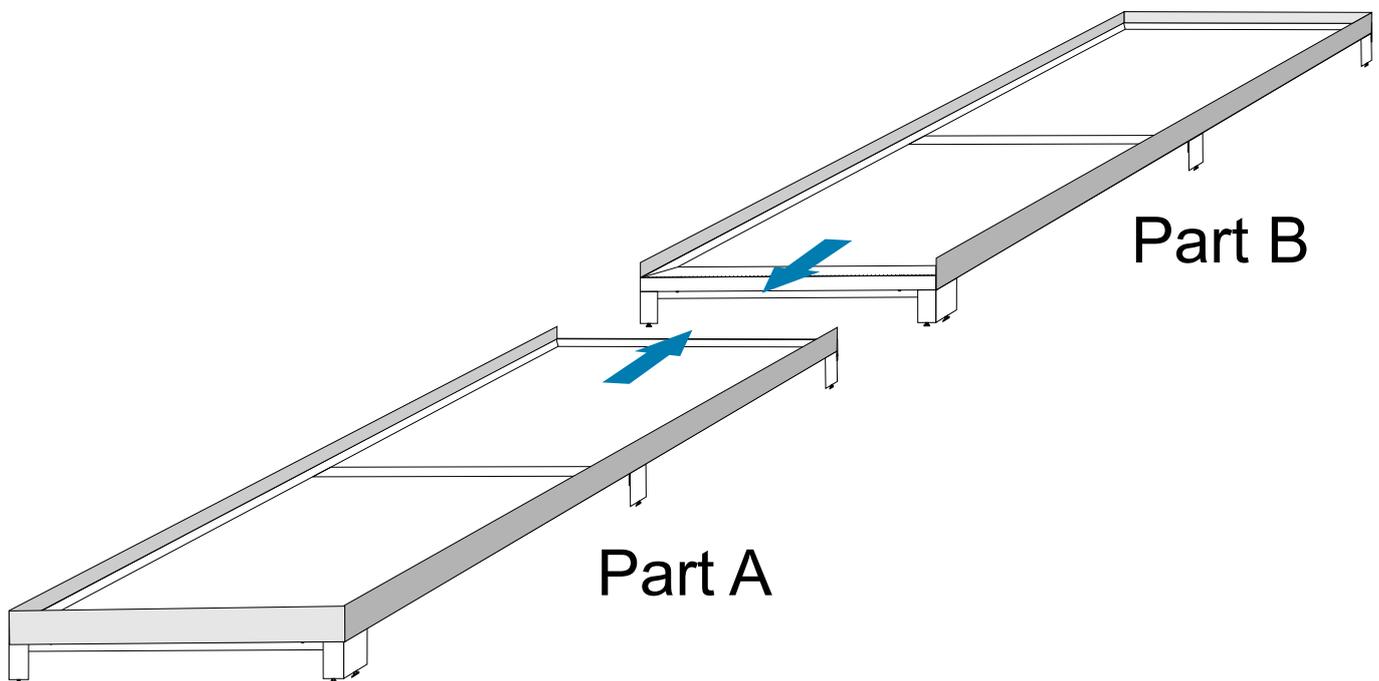


## BASIS OF AEROPONICS

The basis of the Aeroponics is a frame of a painted 60x60x4mm steel corner. An OSB plate with a thickness of 10 mm is embedded inside the frame. PVC film for pools is laid on top of the plate. The film covers the vertical walls of the corner. A single sheet of film forms a container for collecting the nutrient mixture.

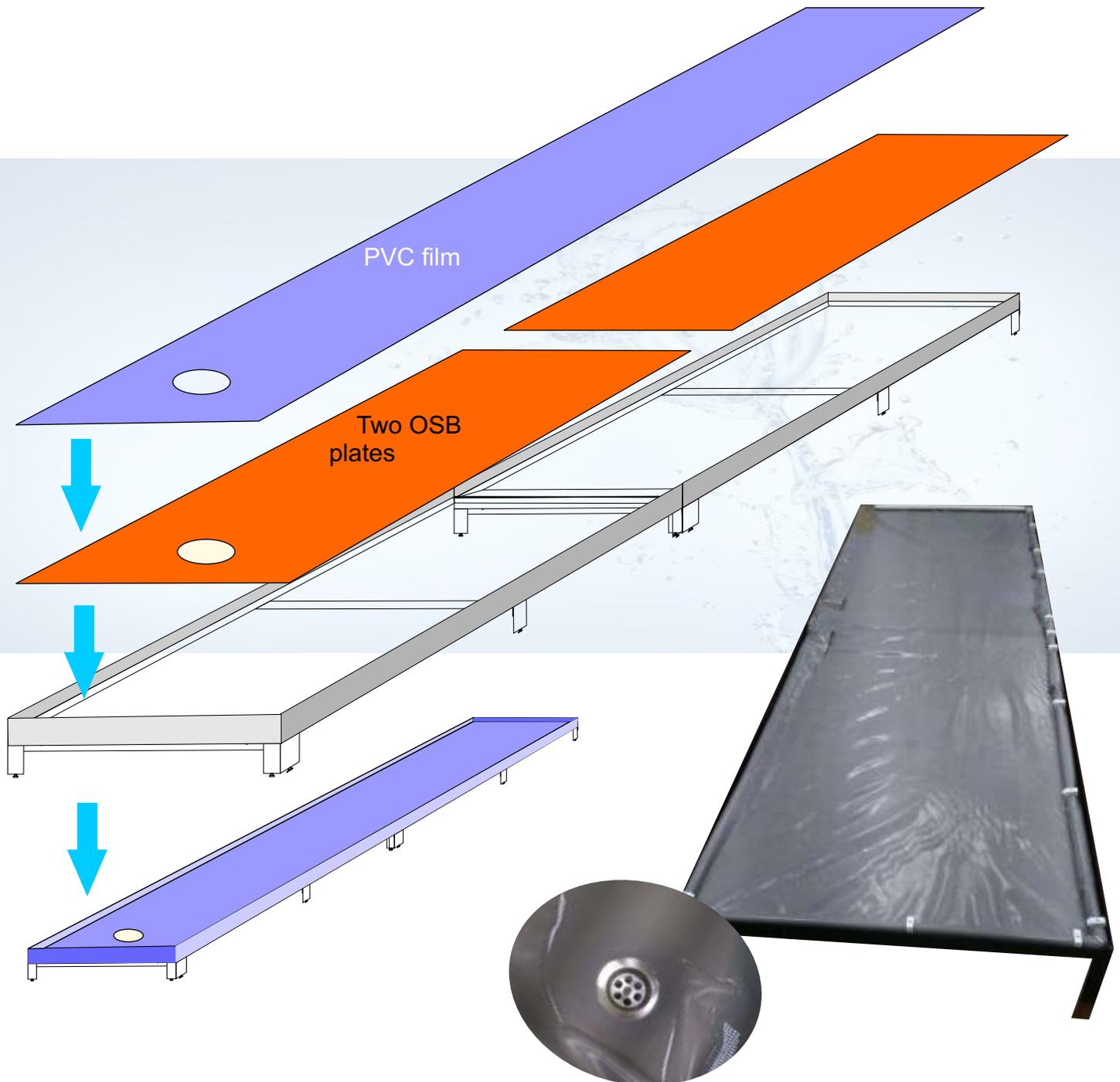
The upper part of the frame has a slope of 1° to ensure the flow of the mixture to the funnel. In the OSB plate, at the lower point, a round hole for the funnel is cutted. The fitting of the funnel and film is sealed.

In order to simplify transportation and installation, the Aeroponics basis is made of two parts, which are connected directly in the greenhouse.



## ASSEMBLY OF BASIS

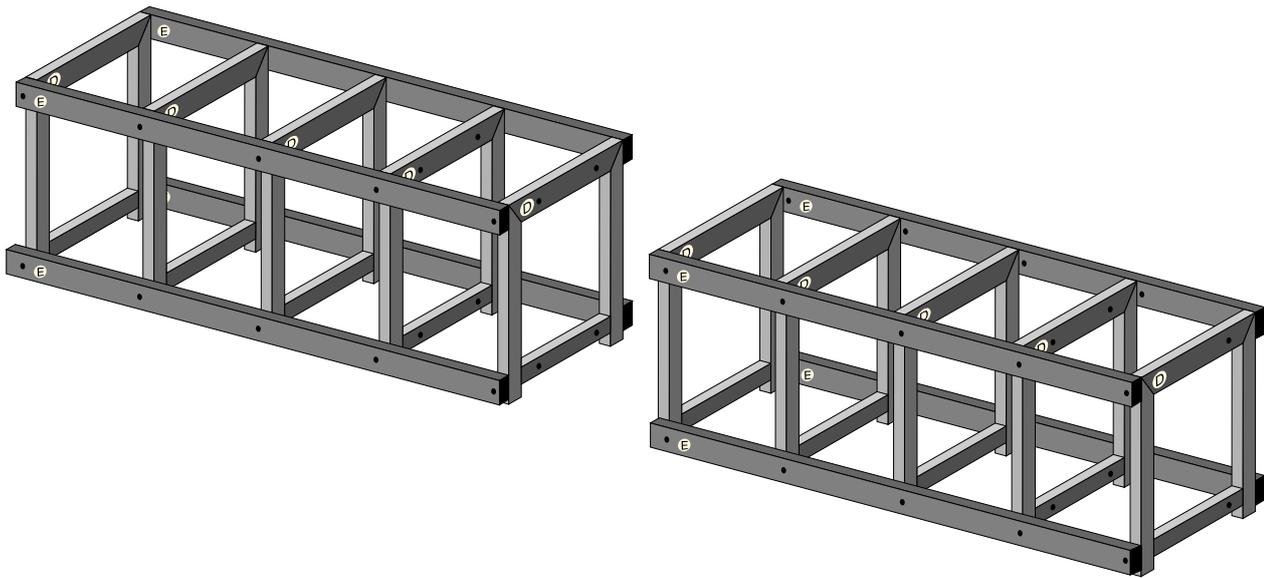
- Parts A and B are connected by two bolts. The adjustment screws compensate for floor defects. It must be ensured that the base plane has a slope of about  $1^\circ$ .
- OSB boards are placed inside the base. In the slab laid in PART A is made a hole for a funnel to drain the mixture.
- PVC film is laid on top of the plates. The edges of the film are wrapped around the vertical walls of the base and secured with clips.
- A hole is made in the film corresponding to the hole in the plate.



## HORIZONTAL CULTIVATION CHAMBER

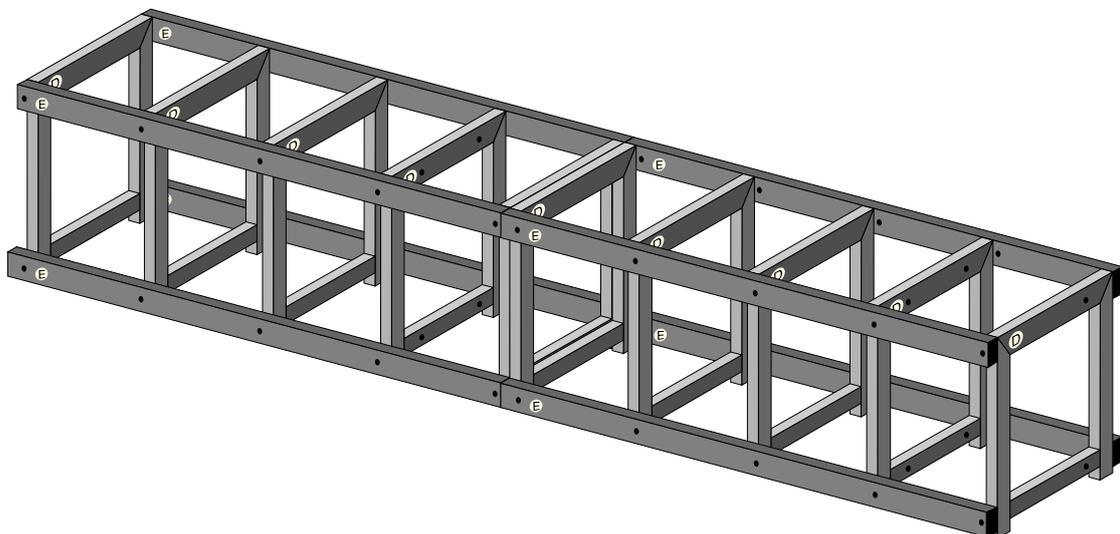
All materials of cultivation chamber must eliminate the possibility of corrosion. The housing of the Aeroponics is a frame made of stainless or aluminium rectangular pipe, to which panels of sheet PVC are attached. Holes for growing baskets are cut out in the top of PVC panel. The side walls of the housing are PVC doors that slide along aluminum rails. This provides easy access to the inside of the potato harvester.

The Aeroponics frame is divided into two identical parts for ease of transportation and assembly.



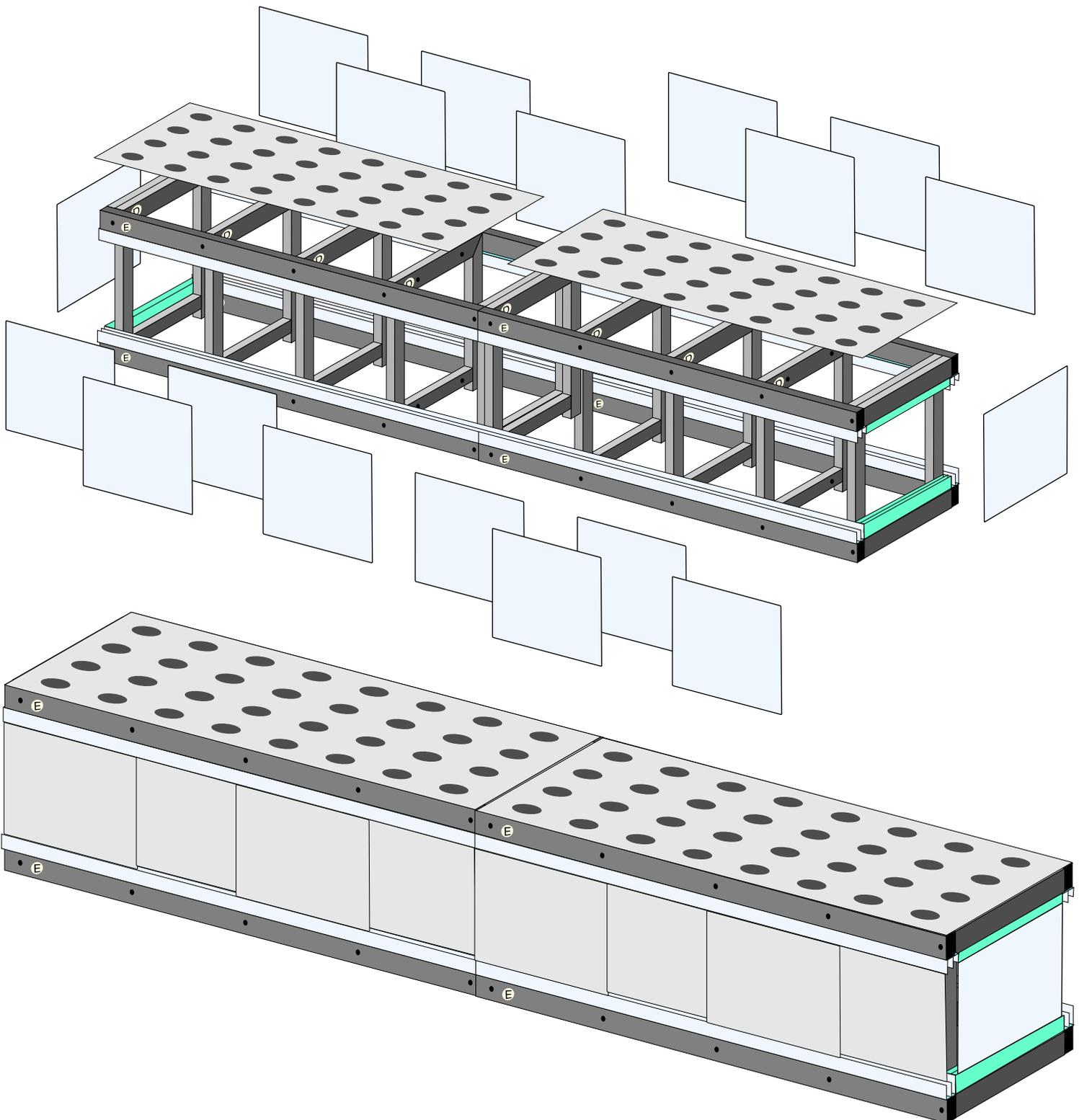
## ALUMINUM GUIDES

Parts E are the bases to which the aluminium guides are mounted. PVC doors move along these guides, which provides quick and easy access to the internal volume of the horizontal Aeroponics.



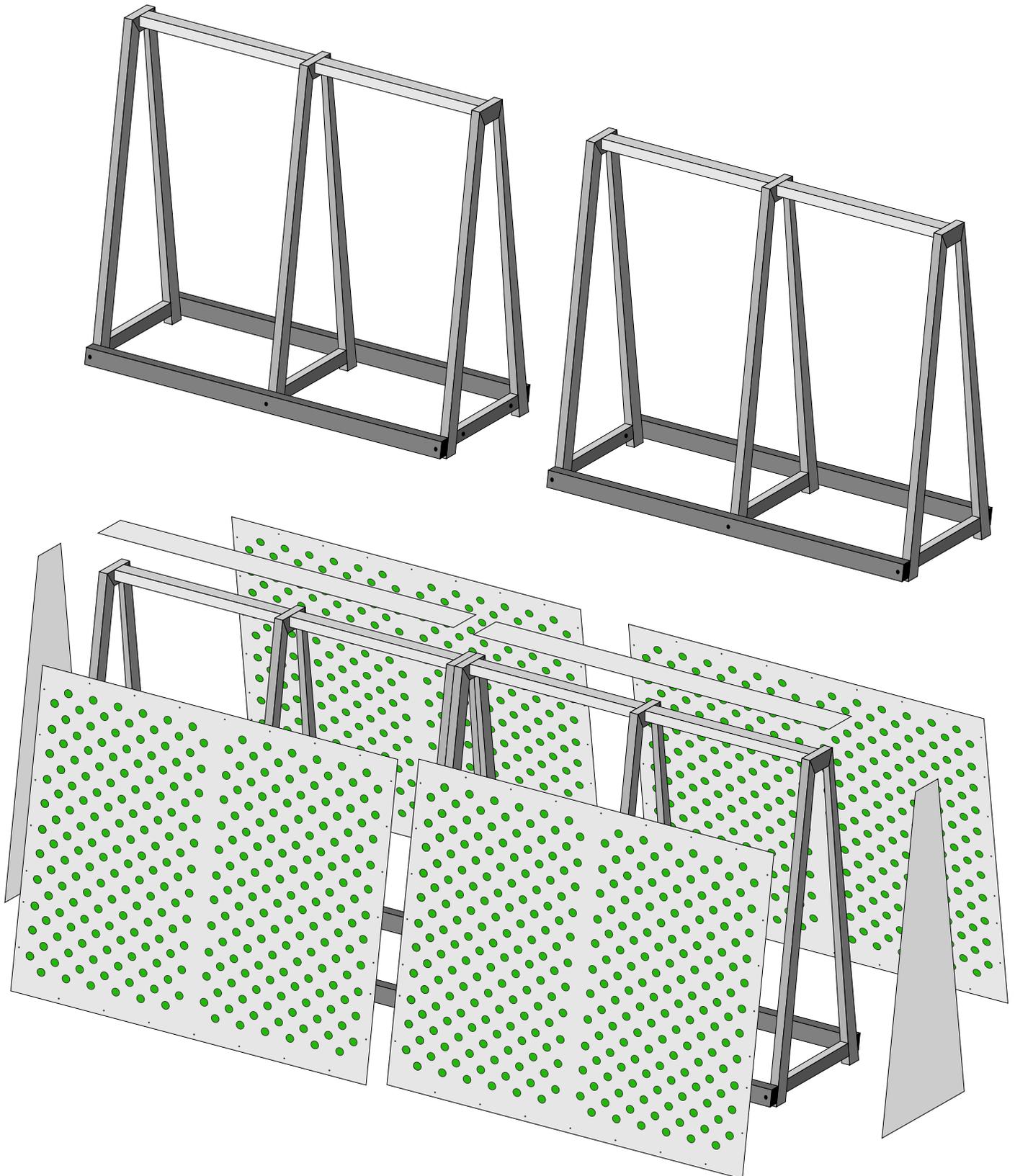
PVC PARTS

The top panel with holes for baskets - 2 pieces.  
 Sliding panels - 16 pieces. Fixed panels - 2 pieces.



VERTICAL (INCLINED) CULTIVATION CHAMBER

All materials of cultivation chamber must eliminate the possibility of corrosion. The housing of the Aeroponics is a frame made of stainless or aluminium rectangular pipe, to which panels of sheet PVC are attached. Holes for growing baskets are cut out in PVC panel. Side trapezoidal covers should be removable to provide access to the inside of Aeroponics during maintenance work.

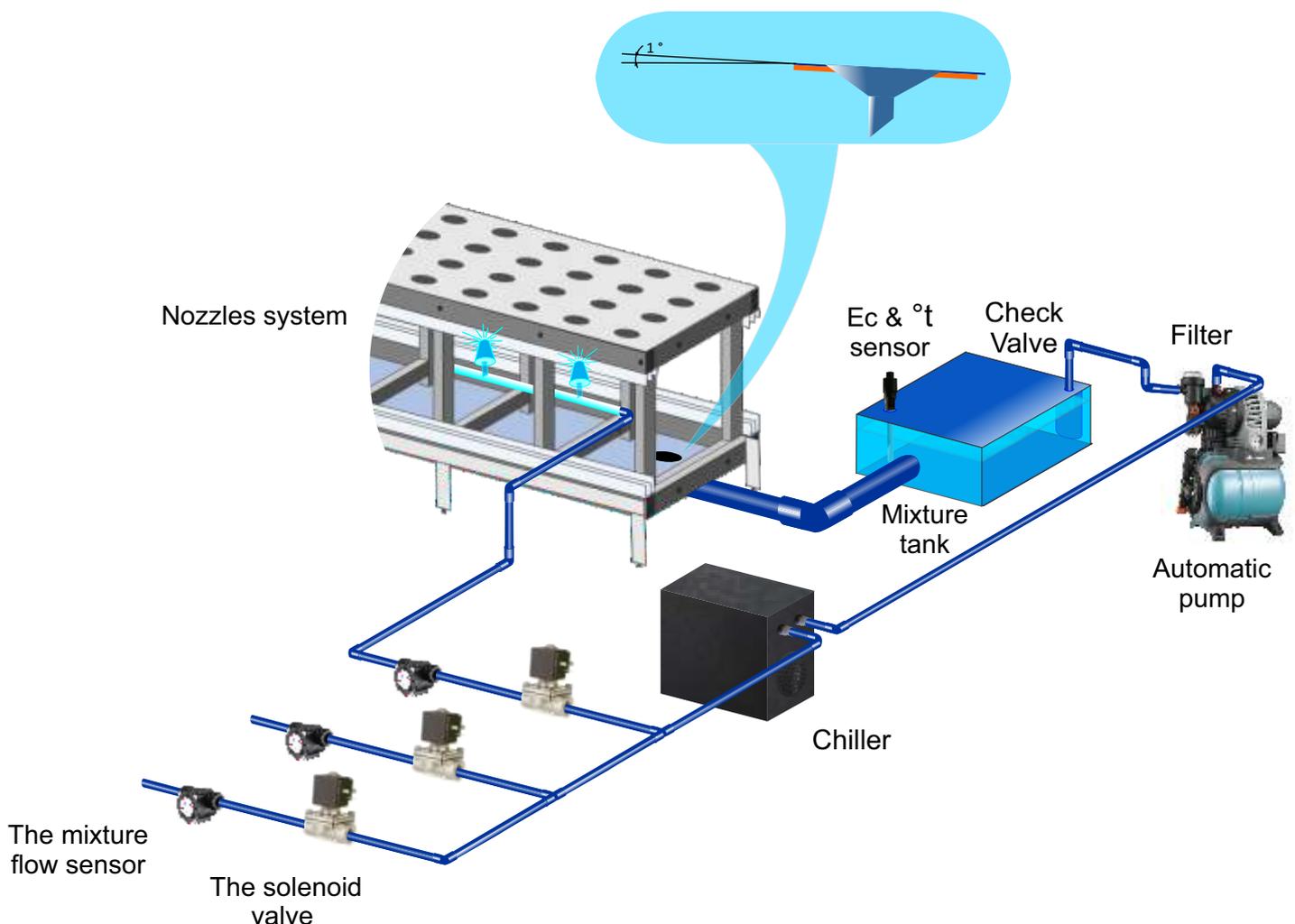


## SYSTEM OF FEEDING OF NUTRIENT MIXTURE

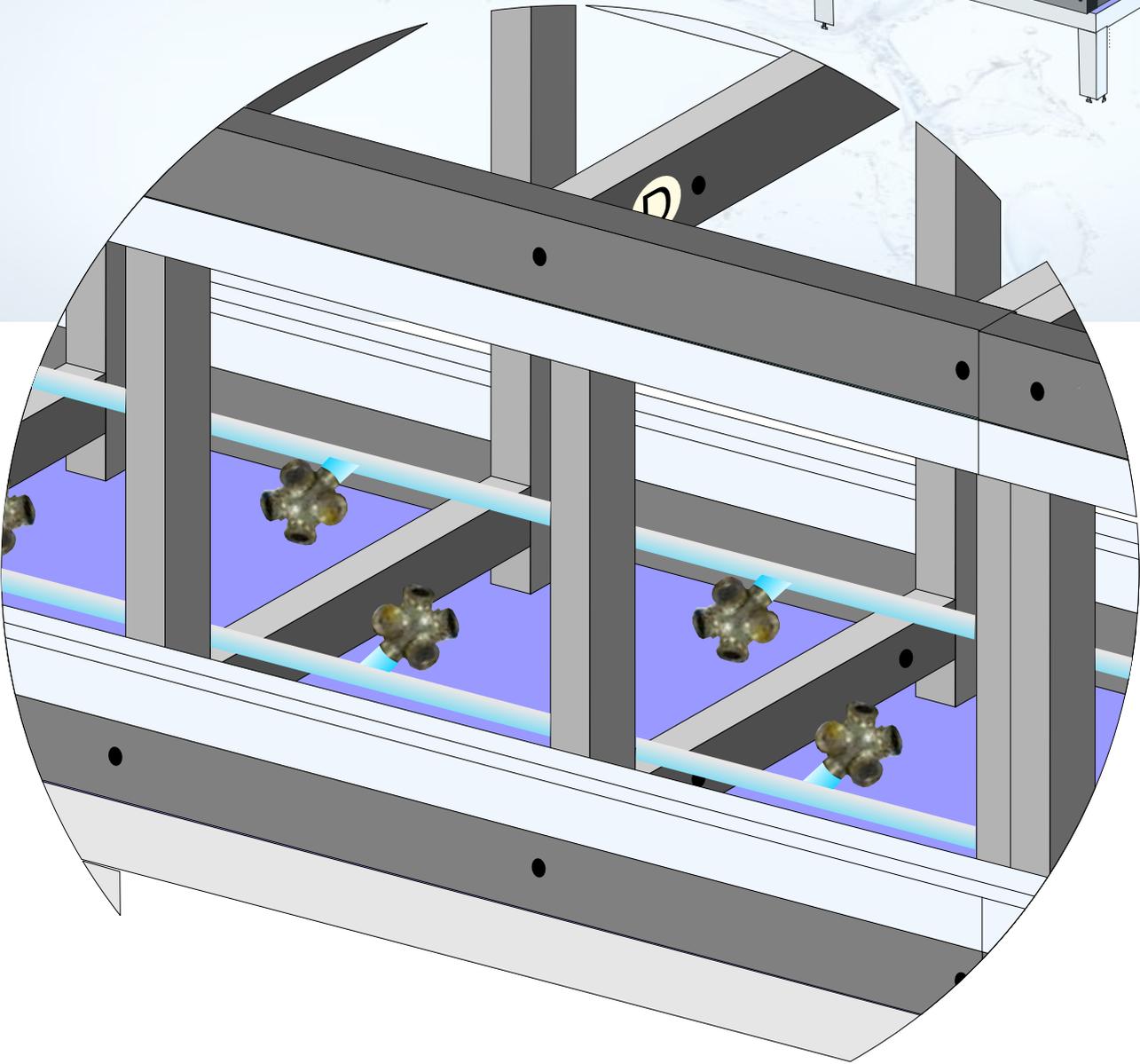
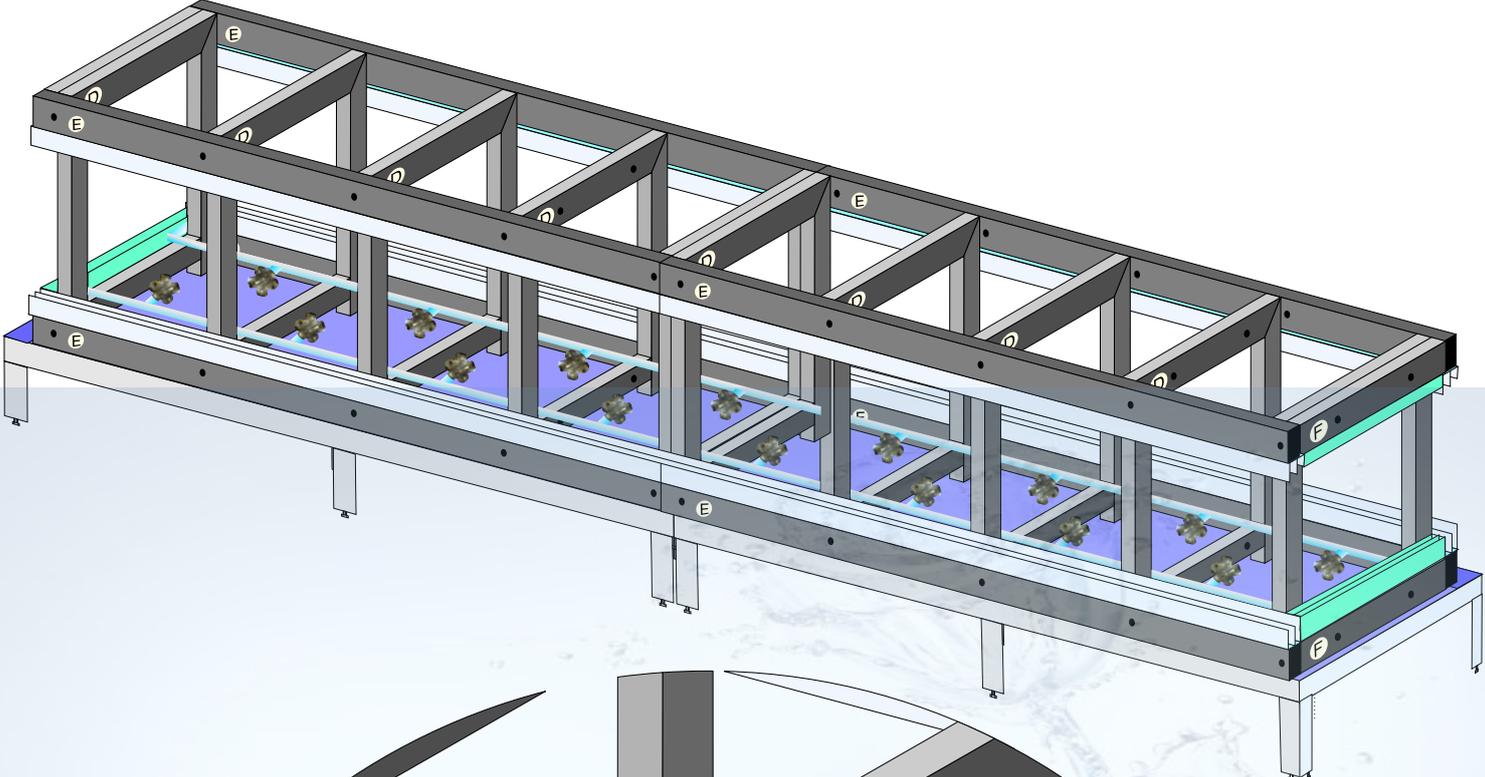
The SMART-SERVER gives commands to SMART-CONTROLLER for supplying the mixture. The feed system of the nutrient mixture in the Aeroponics forms a closed cycle. The pump automatically maintains high pressure at its outlet. When a signal is sent from the SMART-CONTROLLER the solenoid valve opens, the pump pumped out a part of the mixture from the tank and the feed mixture is supplied under pressure to the injectors. Fog is formed inside the cultivation chamber. A part of the nutrient mixture wets the roots of the plants and an excess amount of liquid condenses on the inner surface of the walls of the Aeroponics and enters the pallet. From the pallet, the nutrient mixture flows into the tank under the influence of gravity. An automatic pump draws the mixture from the tank and creates pressure in the pipeline. A filter is installed at the pump outlet. After the filter, it is advisable to install a chiller to automatically adjust the temperature of the nutrient mixture.

At the command of the SMART-CONTROLLER one of the solenoid valves opens and delivers the mixture to the appropriate Aeroponics. The mixture flow sensor monitors the amount of fluid entering the Aeroponics nozzle system. Information on the flow rate is processed by the SMART-SERVER if the nozzles become clogged, valve or pump malfunctions. An emergency message is sent to technical personnel.

To avoid bacterial infection of the mixture an ultraviolet lamps must be be installed. The lamp may irradiate flowing fluid or may be installed inside a solution tank.



The supply pipe is mounted from 1/2" or 3/4" plastic soldered pipe and the necessary fittings. Pipelines with nozzles are laid inside the Aeroponics. The number of nozzles should be selected so that the fog from the nutrient mixture uniformly fills the entire internal volume of the cultivation chamber.



# SMART AEROPONICS

MANAGEMENT SYSTEM

## SMART-AEROPONICS SERVER

### MAIN FUNCTIONS:

- Transmit to SMART-CONTROLLER (or controllers, in the case of centralized control of several Aeroponics) information of growing program. In the WEB-interface of the SMART-SERVER it is possible to program the feeding modes of the mixture during the all phases of vegetation period of the plants.
- Transmit to the SMART-CONTROLLER commands to turn on/off phytolamps. In the interface of the SMART-SERVER, it is possible to program the day-night mode during the whole vegetation period of the plants.
- Warning of personnel on the need to replace the mixture according to the schedule.
- Receiving from SMART-CONTROLLER and processing the following information:
  - *temperature and electrical conductivity of the nutrient mixture;*
  - *air temperature in the room;*
  - *volume of the mixture delivered to the injectors during the injection;*
  - *useful phytolamps voltage and power consumption;*
  - *the content of carbon dioxide in the air;*
  - *leaf hydrated rate.*
- Warning personnel about the output of growing parameters beyond the limits of acceptable values.



All information is sent between the SMART-CONTROLLER and the SMART-SERVER via Wi-Fi. Additional Wi-Fi router is needed. To adjust the modes of operation of Aeroponics, a convenient WEB interface is used. Remote monitoring of system operation via the Internet is possible. SMART-SERVER has HDD drive, therefore you can store information obtained during all phases of plant development for statistical recording.

<b>SMART-SERVER parameters</b>	<b>Description</b>
Interface	WEB-interface
Embedded Operation System	LINUX Debian
Number of management Aeroponics	99 maximum
Processor Model	Intel Core i5
Processor Main Frequency	Dual core 1.5 GHz/ 1.6 GHz
Memory Capacity	≥ 4GB DDR3L SO-DIMM
Hard Drive Capacity	120GB
Remote access	Via Internet
Local control and monitoring	Via Ethernet
Messages	by MESSAGES menu / by TELEGRAM group
Enclosure Type	Mini Desktop, Aluminium alloy
I/O Ports	2xHDMI, 2xLAN, 6xUSB, Mic In, Speak Out, DC in
LAN	2xRJ-45 port, Realtek RTL8111E 10/100/1000
Cooling Mode	Fanless Design
Voltage supply	12VDC
Power consumption	17W
Dimensions	155*127*48mm
Net weight	0.9kg

## SETUP OF THE SMART-SERVER

The SMART-SERVER uses the Linux Debian OS.

In order to be able to configure the server configuration on the SSH connection install the PuTTY program on your computer.

Indicate follow options into PuTTY menu:

IP address: 10.10.10.12

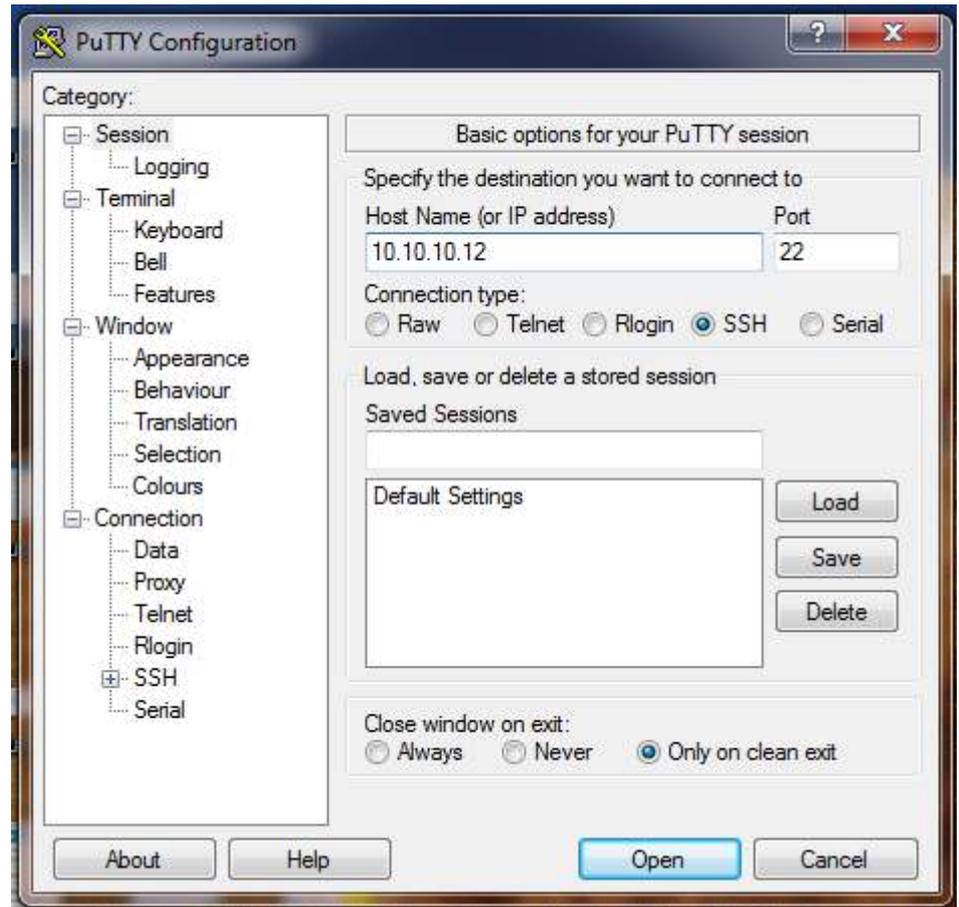
Port: 22

Connection type: SSH

Click OPEN key.

Login: **root**

Password: **aerponics**



It is mandatory to change the root password for confidential:

```
root@aerponics:~# passwd [ENTER]
```

```
root@aerponics:~# Enter new UNIX password:***** [ENTER]
```

```
root@aerponics:~# Retype new UNIX password:***** [ENTER]
```

You can connect to the SMART-SERVER locally via Ethernet connection or through a Wi-Fi router connected to the SMART-SERVER.

If you want to configure remote access to the SMART-SERVER to manage Aeroponics you need to contact your Internet provider to get a real IP address. Assign an IP address to the Wi-Fi router. Contact your system administrator to complete these steps. The system administrator must specify the appropriate DNS settings. If you wish, you can register a domain name by registering it at this address.

## LOG-IN menu

To enter the SMART-AEROPONICS program the following steps are required:

- In the local network, connect your computer or smartphone to the Wi-Fi network of the router connected to the SMART-SERVER via Ethernet. In the browser, enter the local IP address of the SMART-SERVER 10.10.10.12 (default) or the real address assigned to the router.
- For remote access, enter the real IP address provided by your Internet service provider or the domain name of your SMART-SERVER.

On the computer or smartphone screen, you can see the LOG-IN menu. Enter the default username and password (Login: **root**; Password: **aeroponics**) or your new username and password to enter the AEROPONICS LIST menu.



## AEROPONICS LIST menu

The menu shows all the Aeroponics connected to the SMART-SERVER. The menu can be used for general monitoring of the operation of an Aeroponics greenhouse. The “Unread messages” column indicates the number of unread messages in the system. The absence of messages means that the Aeroponics is operating normally.



The “Number” column shows all Aeroponics listed. Click the button to add a new Aeroponics to the list. Press the button with the Aeroponics number to go to the MONITORING menu, which displays detailed information about the current Aeroponics status.



In the upper left sector of the menu the current time and date are displayed.



The “Plant” column shows the plants that are grown in each Aeroponics. Press the button with the name of the plant to go to the MONITORING menu, which displays detailed information about the current Aeroponics status.



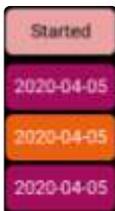
The “Phase” column shows the phases of plant growth. Press the appropriate button to go to the MONITORING menu, which displays detailed information on the calendar dates of the phases of plant growth.



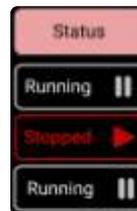
The “Program” column shows the programs selected for growing plants. Press the button with the program name to go to the CREATE NEW PROGRAM menu, which displays detailed information about the parameters of the current program.



The “Unread messages” column indicates the number of system messages that have not yet been read by the user. Press the appropriate button to go to the MESSAGES LIST menu which displays all system messages.



The “Started” column shows the starting dates for growing plants. Press the appropriate button to go to the MONITORING menu which displays detailed information on the calendar dates of the phases of plant growth.



The “Status” column indicates the current status of the Aeroponics. Press the appropriate button to start or stop the plant growing program. A program stop can be applied during plant maintenance.



The “Day” column shows the current days of plant growth. Press the appropriate button to go to the MONITORING menu which displays detailed information on the calendar dates of the phases of plant growth.



To delete an Aeroponics from the system, click on the button in the “Delete” column.

Be careful!

01 SMART-AEROPONICS MONITORING April 25, 2020 12:25

Settings Tomatoe Tomatoes Injigate Injigation 2.2 Start at 00:30 Leaf deaquectio...

Phyto Lamp 1480 41 TemperatunCO2 75 Water temperatunCO2 Working 0.0 Conductivity 2.2

Item	Start/End	Temp/CO2	Water/Conduct	Light
1	00:30-01:00	20.0/1000	18.0/100	100%
2	01:00-01:30	20.0/1000	18.0/100	100%
3	01:30-02:00	20.0/1000	18.0/100	100%

TROPHY Designed by TROPHY ELECTRONICS

12:25 April 25, 2020 SMART-AEROPONICS AEROPONICS LIST

Number	Program	Started	Unread messages	Status	Delete
1	Tomatoes	2020-04-05	7	Running	✖
2	Potato	2020-04-05	10	Stopped	✖
3	Potato	2020-04-05	41	Running	✖

02 SMART-AEROPONICS MONITORING April 25, 2020 12:25

Settings Tomatoe Tomatoes Injigate Injigation 2.2 Start at 00:30 Leaf deaquectio...

Phyto Lamp 1480 41 TemperatunCO2 75 Water temperatunCO2 Working 0.0 Conductivity 2.2

Item	Start/End	Temp/CO2	Water/Conduct	Light
1	00:30-01:00	20.0/1000	18.0/100	100%
2	01:00-01:30	20.0/1000	18.0/100	100%
3	01:30-02:00	20.0/1000	18.0/100	100%

04 SMART-AEROPONICS SETTINGS

GROWING PLANT: Tomatoe PROGRAM NAME: 02 Start

Item	Start/End	Temp/CO2	Water/Conduct	Light
1	00:30-01:00	20.0/1000	18.0/100	100%
2	01:00-01:30	20.0/1000	18.0/100	100%
3	01:30-02:00	20.0/1000	18.0/100	100%

SMART-AEROPONICS CREATE NEW PROGRAM

NEW PROGRAM: 00001 GROWING PLANT: Tomatoe

Item	Start/End	Temp/CO2	Water/Conduct	Light
1	00:30-01:00	20.0/1000	18.0/100	100%
2	01:00-01:30	20.0/1000	18.0/100	100%
3	01:30-02:00	20.0/1000	18.0/100	100%

SMART-AEROPONICS MESSAGES LIST

Item	Start/End	Temp/CO2	Water/Conduct	Light	Message	Read
1	00:30-01:00	20.0/1000	18.0/100	100%	High main...	✓
2	00:30-01:00	20.0/1000	18.0/100	100%	High main...	✓
3	00:30-01:00	20.0/1000	18.0/100	100%	High main...	✓

## MONITORING menu

AEROPONICS LIST menu --> AEROPONICS number button--> MONITORING

You can see the current operating parameters of the selected Aeroponics in the menu.

By pressing the ▲ ▼ buttons or by direct dialing you can enter into MONITORING menu of another Aeroponics.

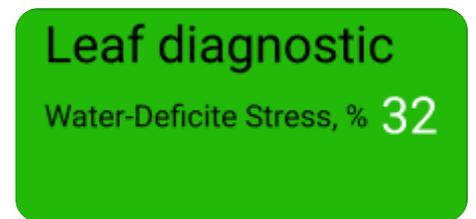
By clicking on the SETTING window you can enter into menu of the Aeroponics parameters setup.



The SETTINGS window displays:  
 - name of the plant being grown;  
 - name of the growing program;  
 - current phase.  
 Click on this window and enter the SETTINGS menu.



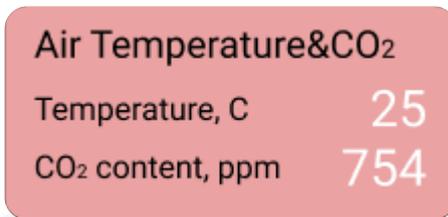
The IRRIGATE window displays:  
 - flow rate of the nutrient mixture during the last irrigation;  
 - Countdown to the next irrigation.



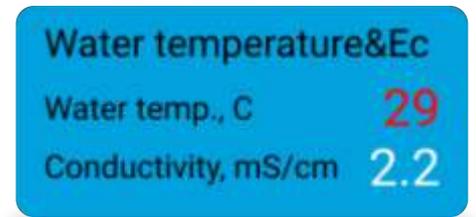
The LEAF DIAGNOSTIC window displays:  
 - the level of current Water-Deficite Stress of the controlled leaf.



The PHYTO LAMPS window displays:  
 - current power consumed by fitolamps;  
 - phytolamps voltage supply.



The AIR TEMPERATURE & CO2 window displays:  
 - air temperature;  
 - carbon dioxide content.



The WATER TEMPERATURE & Ec window displays:  
 - temperature of the nutrient mixture;  
 - electrical conductivity of the nutrient mixture.

Phases	Start of phase I	Start of phase II	Start of phase III	Finish
Date	March 10, 2020	April 10, 2020	April 30, 2020	June 09, 2020

This window displays the schedule of the phases of plant growth with calendar dates.



In this window a scale indicating the number of the current day of cultivation and the number of days of a full growing cycle is visible.

**TROPHY**  
Designed by TROPHY ELECTRONICS

12:25 April 25, 2020

### SMART-AEROPONICS AEROPONICS LIST

Number	Plant	Program	Started	Day	Phase	Control message	Status	Details
1	Tomatoes	Tomatoes	2020-04-05	T	1		Running	⏸
2	Tomatoes	Tomatoes	2020-04-04	T	2		Running	⏸
3	Tomatoes	Tomatoes	2020-04-03	T	3		Running	⏸

**02** 

AEROPONICS NUMBER

**01** 

AEROPONICS NUMBER

## SMART-AEROPONICS MONITORING

12:25 April 25, 2020

**Settings**

Plant: Tomatoes

Program: Tomatoes

Phase: 2

**Irrigate**

Consumption, l/s: 2.2

Start countdown: 00:30

**Leaf diagnostic**

Water-Deficite Stress, %: 32

**Phyto Lamps**

Consumption, W: 1450

Mains voltage, V: 223

**Air Temperature&CO<sub>2</sub>**

Temperature, C: 25

CO<sub>2</sub> content, ppm: 754

**Water temperature&Ec**

Water temp., C: 29

Conductivity, mS/cm: 2.2

Phases	Start of phase I	Start of phase II	Start of phase III	Finish
Date	March 10, 2020	April 10, 2020	April 30, 2020	June 09, 2020

45

190

**01** 

AEROPONICS NUMBER

### SMART-AEROPONICS SETTINGS

GROWING PLANT: Tomatoes | PROGRAM NAME: Search  **ADD NEW**

Parameter	Serial number of SMART-controller	Normal value	Alert when value is reached by	Alert when value is exceeded by
Water consumption (l/s)	1-1257000478	1.5	1	1
Water temperature (C)	2-1257000452	Programmed	5	6
Air temperature (C)		Programmed	0.5	0.5
Daytime air temperature (C)		22	6	12
Night air temperature (C)	3-1257000417	-18	-3	10
CO <sub>2</sub> content (ppm)		500	300	1000
Physiology growth (h)	4-1257000552	1900	1400	1550
Leaf wetness (h)	5-1257001235	70	30	20

## SETTINGS menu

AEROPONICS LIST -->  button --> SETTINGS --> Select the number of the Aeroponics

or

AEROPONICS LIST --> Aeronics number button --> MONITORING --> SETTINGS window --> SETTINGS menu

In the menu you can manage the configuration and operation parameters of the specified Aeroponics.



Indicate the serial numbers of the SMART-CONTROLLERS working with this AEROPONICS number.

Set the average values of the specified parameters and the limit values at which the SMART-SERVER will send alarm messages.

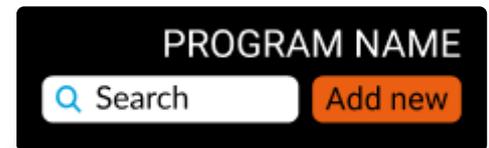
Please note that the optimal values of the nutrient solution parameters are set by the growing program, which you can choose from the list offered in the PROGRAM NAME window. If necessary, you can create your own program by pressing the ADD NEW button and going to the CREATE NEW PROGRAM menu.



By pressing the UP or DOWN buttons or by direct dialing of numbers (from 1 to 99) you can enter into SETTINGS menu of any Aeroponics.



The name of the plant being grown. This information helps the user to administer a large number of Aeroponics.



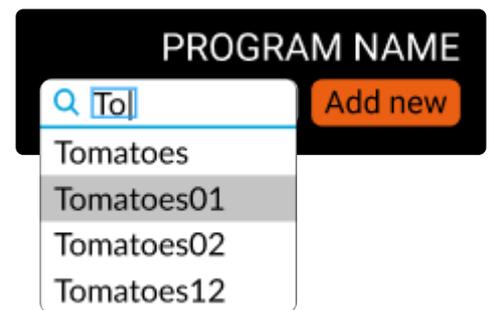
You can enter the name of the growing program in the SEARCH window and select the desired program from the list in the pop-up window. In addition, you can create a new program. To do this, press the ADD NEW button.



Return to AEROPONICS LIST



By pressing the SAVE button you save the changes of the settings of this Aeroponics. You can exit the menu without saving changes by pressing the CANCEL button.



<input checked="" type="checkbox"/>	Irrigate consumption, l/s	1-1257000478	1.5	1	1
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In the IRRIGATE CONSUMPTION window, specify:

- serial number of IRRIGATION or IRRIGATION-PLUS Wi-Fi Controller;
- the value of the normal flow rate of the nutrient mixture for one irrigation cycle. For example, in the MONITORING menu you can see this value.
- values of the minimum and maximum flow rates. Based on these values the SMART-SERVER will send messages about the accident in the event of a mixture leak or clogged nozzles.

You can deactivate the IRRIGATE CONSUMPTION window if another device controls the irrigation.

<input checked="" type="checkbox"/>	Water temperature, C	2-1257000452	Programmed	5	6
	Mixture Ec, uS/cm		Programmed	0.5	0.5

In the WATER TEMPERATURE / MIXTURE Ec window are specify:

- serial number of Water mixture Ec & Temperature Wi-Fi Controller or IRRIGATION-PLUS Wi-Fi Controller;
- maximum allowable changes in values. If the parameters go beyond the permissible limits the SMART SERVER will send alarm messages.

Please note that the normal values of temperature and conductivity of the nutrient mixture are set by the growing program.

You can deactivate the WATER TEMPERATURE / MIXTURE Ec window if you do not intend to monitor these parameters.

<input checked="" type="checkbox"/>	Daytime air temperature, C	3-1257000417	22	6	12
	Night air temperature, C		18	3	10
	CO2 content, ppm		500	300	1000

In the DAYTIME AIR TEMPERATURE / NIGHT AIR TEMPERATURE / CO2 CONTENT window are specify:

- serial number of Air °t & CO2 Wi-Fi Controller;
- normal values, maximum and minimum acceptable values. If the parameters go beyond the permissible limits the SMART-SERVER will send alarm messages.

You can deactivate the window if you do not intend to monitor these parameters.

<input checked="" type="checkbox"/>	Phytolamp power, W	4-1257000552	1500	1400	1550
-------------------------------------	--------------------	--------------	------	------	------

In the PHYTOLAMP POWER window, you must specify:

- serial number of Phyto Lamps Wi-Fi Controller;
- the normal value, the maximum and minimum allowable values of the power consumed by phytolamps. For example, in the MONITORING menu you can see the current power consumption. If the parameters go beyond the permissible limits the SMART-SERVER will send alarm messages.

You can deactivate the PHYTOLAMP POWER window if you do not intend to control the phytolamps and monitor the power and voltage.

<input checked="" type="checkbox"/>	Water-Deficite Stress, %	5-1257001235	30	20	40
-------------------------------------	--------------------------	--------------	----	----	----

Specify in the Water-Deficite Stress window:

- the serial number of the Leaf WDS Monitoring Wi-Fi Controller;
- normal value, maximum permissible value changes. If the parameters go beyond the permissible limits the SMART SERVER will send alarm messages.

You can deactivate the window if you do not intend to monitor the activity of the sheet.

01 AEROPONICS NUMBER

SMART-AEROPONICS MONITORING

12:25 April 25, 2020

Settings: Tomatoes Tomatoes 2

Irrigate: Consumption, l/s 2.2 Start countdown 00:30

Leaf diagnostic: Water Deficite Stress, % 32

Phyto Lamp: Consumption, W 1450 Matrix voltage, V 223

Air Temperature&CO2: Temperature, C 25 CO2 content, ppm 754

Water temperature&EC: Water temp, C 20 Conductivity, mS/cm 2.2

Phase	Start of phase I	Start of phase II	Start of phase III	Finish
Date	March 10, 2020	April 13, 2020	April 30, 2020	June 09, 2020

45

02 AEROPONICS NUMBER

01 AEROPONICS NUMBER

SMART-AEROPONICS SETTINGS

GROWING PLANT: Tomatoes (up to 10 symbols)

PROGRAM NAME: Search Add new

Parameter	Serial number of SMART-controller	Normal value	Alarm when value decreased by	Alarm when value increased by
Irrigate consumption, l/s	1-1257000478	1.5	1	1
Water temperature, C	2-1257000452	Programmed	5	6
Mixture Ec, mS/cm		Programmed	0.5	0.5
Daytime air temperature, C		22	6	12
Night air temperature, C	3-1257000417	18	3	10
CO2 content, ppm		500	300	1000
Phytolamp power, W	4-1257000552	1500	1400	1550
Water-Deficite Stress, %	5-1257001235	30	20	40

PROGRAM NAME

Search [To] Add new

- Tomatoes
- Tomatoes01
- Tomatoes02
- Tomatoes12

SMART-AEROPONICS

CREATE NEW PROGRAM

NEW PROGRAM NAME: Tomatoes12 (up to 10 symbols)

APPLY PROGRAM TEMPLATE: Search

Growing phase	Start	Day (hrs)	High (hrs)	EC (mS/cm)	Temp (C)	Light (W)	Water (l/s)	CO2 (ppm)	Deficit (%)	Leaf Stress (%)
Phase I	00:00	12:00	00:00	0.5	20	1500	1.5	500	3	30
Phase II	00:00	12:00	00:00	0.5	20	1500	1.5	500	3	30
Phase III										

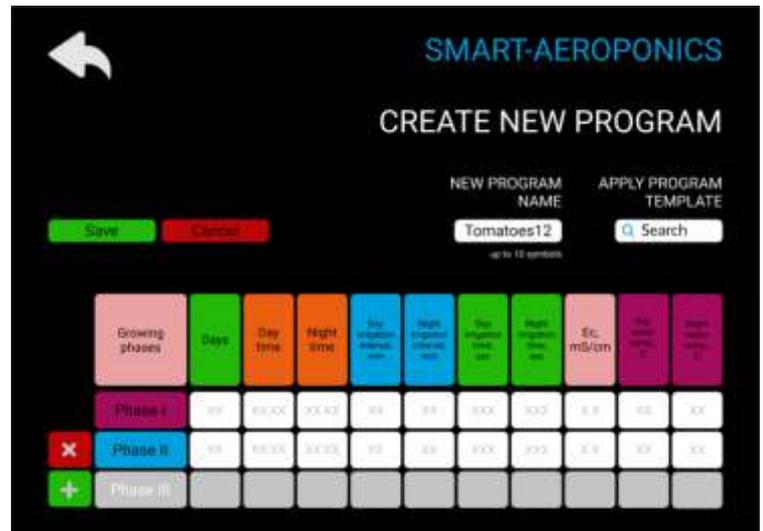
## CREATE NEW PROGRAM menu

AEROPONICS LIST --> button in the PROGRAM column --> CREATE NEW PROGRAM menu

or

AEROPONICS LIST --> Aeroponics number button --> MONITORING --> SETTINGS --> ADD NEW button --> CREATE NEW PROGRAM menu

In the menu you can create your own version of the growing program.



First of all, you need to enter a unique name for the new program in the NEW PROGRAM NAME window. Next, you can choose one of the options for creating a new program:

1. Using a template. Enter the name of the existing growing program in the SEARCH window and select the desired program from the list in the pop-up window. Change the program parameters and save the new program by pressing the SAVE button. Pressing the CANCEL button does not save the new program.
2. Without using a template. Enter the values of the parameters of the new growing program in the appropriate cells. Use the   buttons to select the number of plant growth phases (from 1 to 3). Save the new program by pressing the SAVE button. Pressing the CANCEL button does not save the new program.

## View the parameters of growing programs.

Enter the name of the existing growing program in the SEARCH window and select the desired program from the list in the pop-up window. Program parameters are displayed in the appropriate cells.

Growing phases	The number of phases of cultivation, from 1 to 3
Days	Total quantity of growing days
Day time	Beginning of the lighting period
Night time	The end of the lighting period
Day irrigation interval, min	Daily interval between irrigation, in minutes
Night irrigation interval, min	Night interval between irrigation, in minutes
Day irrigation time, s	Duration of daytime irrigation, in seconds
Night irrigation time, s	Duration of night irrigation, in seconds
Ec, mS/cm	Nutrient mixture Ec
Day water temp., C	Day temperature of nutrient mixture
Night water temp., C	Night temperature of nutrient mixture

04 AEROPONICS NUMBER

SMART-AEROPONICS SETTINGS

GROWING PLANT: Tomatoes

PROGRAM NAME: Search

Parameter	Serial number of plant - substrate	Rooting index	Water level (meters)	Water level (meters)
1-1257000478	1-1257000478	1.5	1	1
2-1257000492	2-1257000492	Programmed	3	0
3-1257000417	3-1257000417	Programmed	0.3	0.3
4-1257000553	4-1257000553	32	6	12
5-1257001235	5-1257001235	18	3	10
		300	300	1000
		1500	1400	1550
		70	30	20

SMART-AEROPONICS

## CREATE NEW PROGRAM

NEW PROGRAM NAME: Tomatoes12 (up to 10 symbols)

APPLY PROGRAM TEMPLATE: Search

Save Cancel

Growing phases	Days	Day time	Night time	Day irrigation interval, min	Night irrigation interval, min	Day irrigation time, sec	Night irrigation time, sec	Ec, mS/cm	Day water temp, C	Night water temp, C
Phase I	XX	XX:XX	XX:XX	XX	XX	XXX	XXX	X.X	XX	XX
Phase II	XX	XX:XX	XX:XX	XX	XX	XXX	XXX	X.X	XX	XX
Phase III										

SMART-AEROPONICS

## CREATE NEW PROGRAM

NEW PROGRAM NAME: Tomatoes

APPLY PROGRAM TEMPLATE: Tomatoes

Save Cancel

Growing phases	Days	Day time	Night time	Day irrigation interval, min	Night irrigation interval, min	Day irrigation time, sec	Night irrigation time, sec	Ec, mS/cm	Day water temp, C	Night water temp, C
Phase I	11	09:00	17:00	05	05	30	30	1.4	08	07
Phase II	10	09:00	17:00	05	05	40	40	1.4	08	07
Phase III	11	13:00	17:00	05	05	30	30	1.4	08	07

PROGRAM NAME

Search: To

Add new

- Tomatoes
- Tomatoes01
- Tomatoes02
- Tomatoes12

MESSAGES LIST menu

AEROPONICS LIST --> button in the UNREAD MESSAGES column --> MESSAGES LIST menu

In the menu you can view system messages. Unread messages are marked the  in the VIEWED column. Click on this sign to mark the message as read.

A  will appear in the message line.



Return to the AEROPONICS LIST menu



Select a number of page with messages



The number of unread messages and the total number of system messages

No.	Date, time	Aeroponics	Messages text	Viewed
1	2020-04-05 20:35	1	High water temperature	!

Number of message	Time and date the message was sent	Number of Aeroponics	Accident Report Text
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## SETUP OF THE TELEGRAM BOT

You have to make changes into configuration file /etc/aerponics.conf

```
root@aerponics:~# nano /etc/aerponics.conf
```

The screenshot shows the nano editor with the following configuration:

```

[mysql]
host = 127.0.0.1
username = aero
password = ponix

[aerponics]
logging interval = 15
uart = /dev/ttyUSB0
max running = 0

[bot]
token = 52818788[redacted]1n
admin chat id = 312[redacted]
send daily time = 10:00
    
```

Callouts explain the parameters:

- mysql parameters by default.** (points to the [mysql] section)
- Period of DATA recording into database (15 minutes)**  
**Connection USB port number (USB0 is default)**  
**Quantity of simultaneously opened irrigation valves**  
 ("0" is ignore of this control). (points to the [aerponics] section)
- TELEGRAM bot "token" number - see later.**  
**TELEGRAM chat ID - see later.**  
**Time of once a day message.** (points to the [bot] section)

Register your bot in the TELEGRAM, using the BotFather TELEGRAM BOT. Follow the instructions to receive a message containing the "token" number.

Indicate token number into the configuration file /etc/aerponics.conf (see previous page). Exit from nano editor with saving of file (Ctrl+X).

The screenshot shows a Telegram chat with BotFather. The messages include:

- "Done! Congratulations on your new bot. You will find it at t.me/[redacted].bot. You can now add a description, about section and profile picture for your bot. see /help for a list of commands. By the way, when you've finished creating your cool bot, ping our Bot Support if you want a better username for it. Just make sure the bot is fully operational before you do this."
- "Use this token to access the HTTP API: [redacted]10VXW0XK21nH20ddIBAdMkVBxU"
- "For a description of the Bot API, see this page: <https://core.telegram.org/bots/api>"

Additional text in the chat includes: "What can this bot do?", "BotFather is the one bot to rule them all. Use it to create new bot accounts and manage your existing bots.", "About Telegram bots: <https://core.telegram.org/bots>", "Bot API manual: <https://core.telegram.org/bots/api>", and "Contact @BotSupport if you have questions about the Bot API."

It is necessary to enable two services:

- [aerobot](#) for subscription management;
- [aerobot\\_sender](#) for sending of messages.

Specify the command to automatically start the services when the server boots:

```
root@aerponics:~# systemctl enable aerobot [ENTER]
```

```
root@aerponics:~# systemctl enable aerobot_sender [ENTER]
```

```
root@aerponics:~# systemctl start aerobot [ENTER]
```

```
root@aerponics:~# systemctl start aerobot_sender [ENTER]
```

Find the name of your bot in TELEGRAM contacts menu and get your Chat ID.



After that, you need to indicate Chat ID number to the configuration file `/etc/aerponics.conf`

```
root@aerponics:~# nano /etc/aerponics.conf [ENTER]
```

Restart aerobot service:

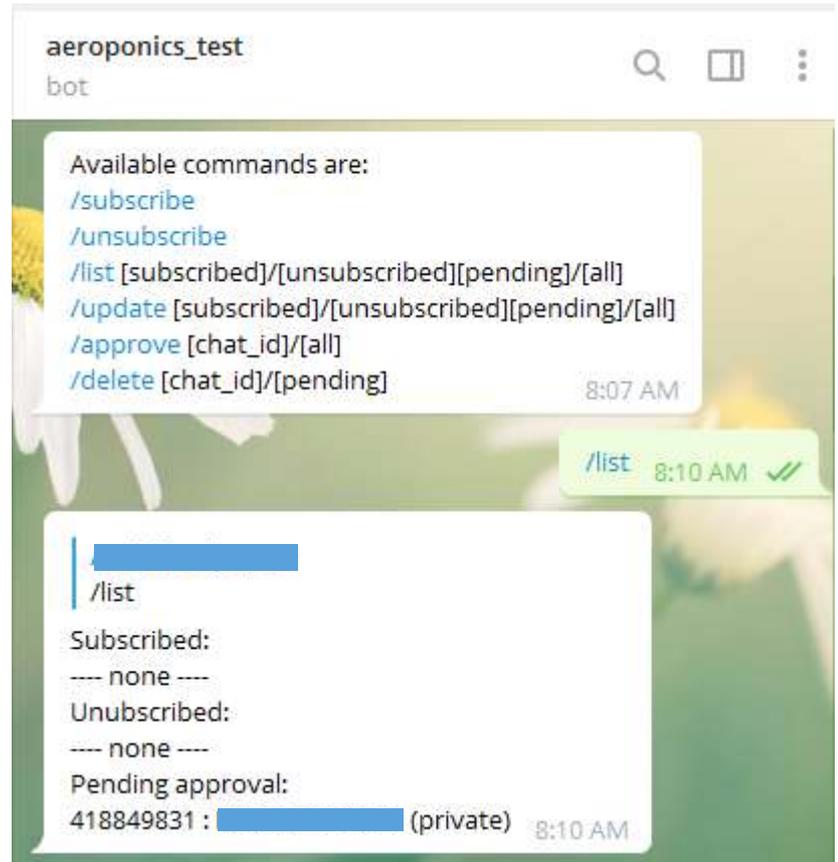
```
root@aerponics:~# systemctl restart aerobot [ENTER]
```

To exit the PuTTY program, press Ctrl+D.

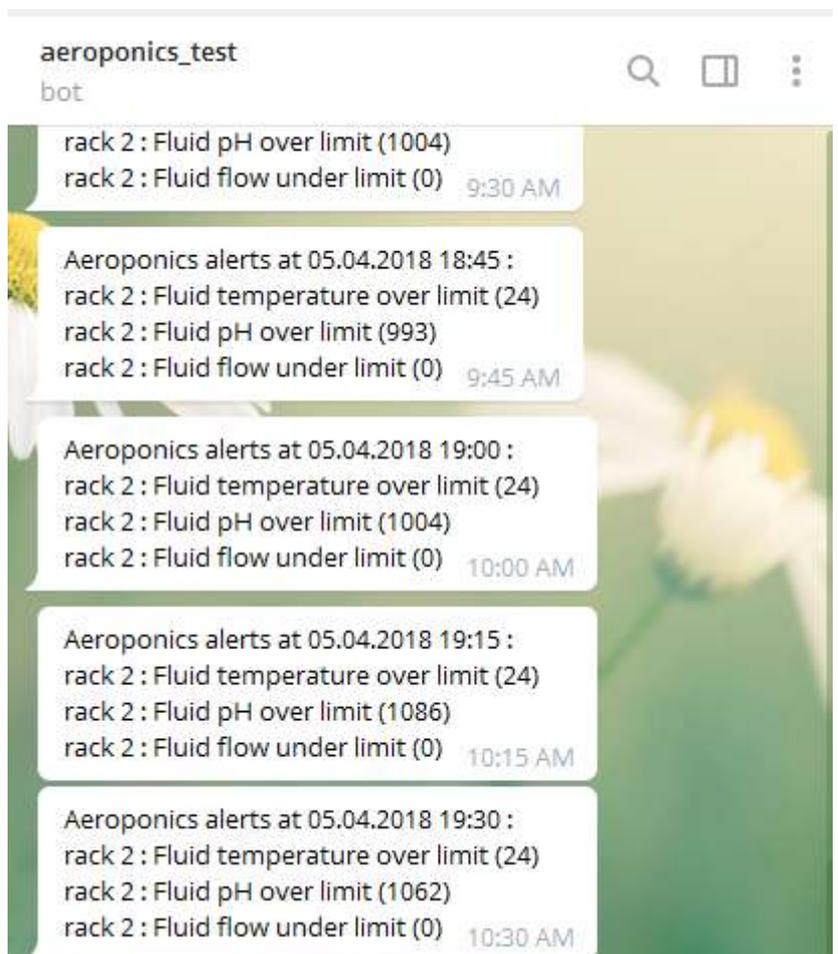
Congratulations! You have set up a service for sending out alarm messages to TELEGRAM account.

As a chat administrator, you have access to several functions:

- Allow users who sent the request to subscribe;
- refuse to subscribe;
- Display information about current subscribers and remote subscribers, information about subscription requests;
- get information about the chat;
- delete the chat.



In the event that any Aeroponics parameters is out of limits, the information will be sent every 15 minutes to the subscribers of the TELEGRAM chat until the problem is resolved.





## IRRIGATION WI-FI CONTROLLER

SOLENOID VALVE CONTROL  
& FLOW MONITORING

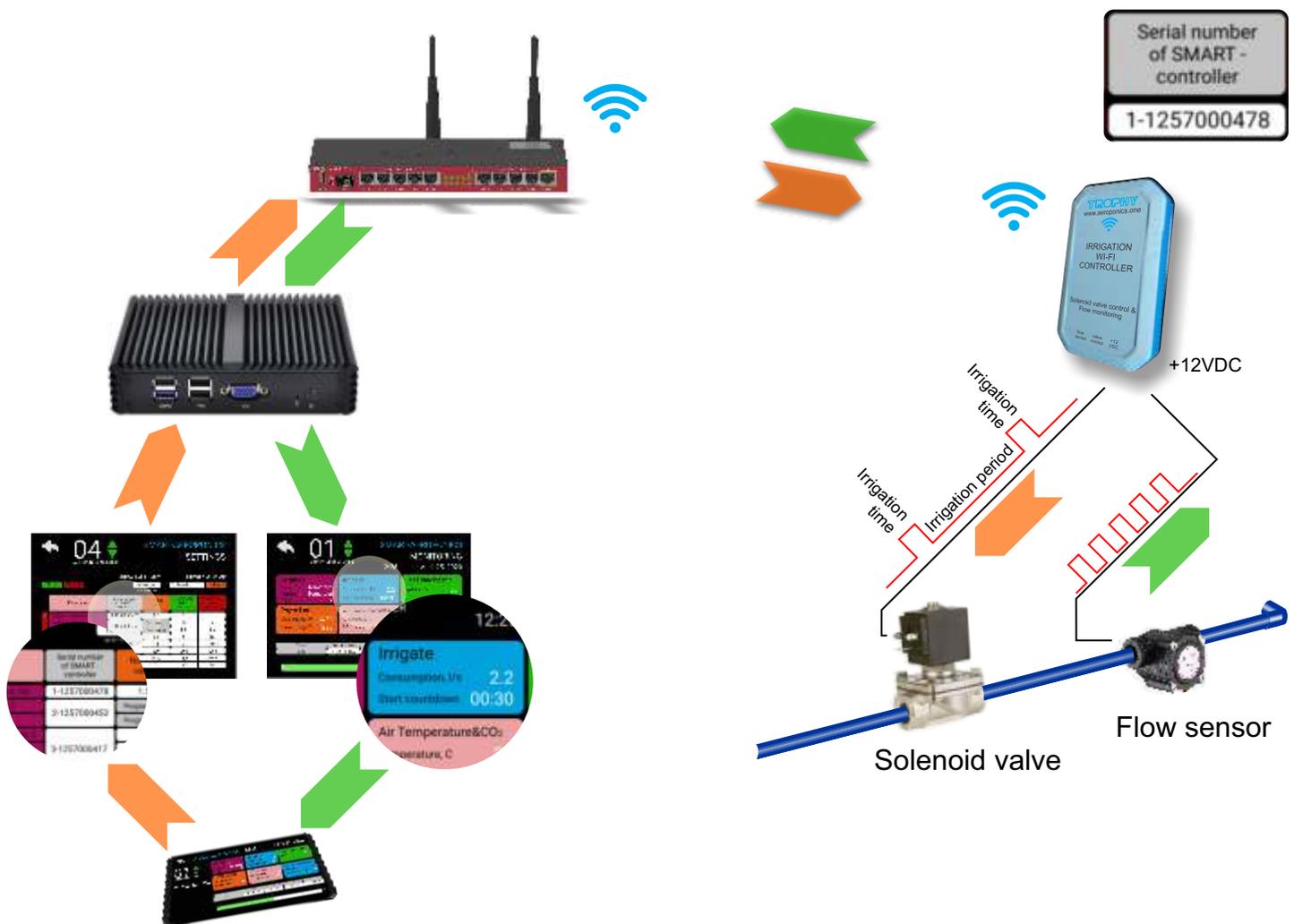
**SMART CONTROLLERS**

## IRRIGATION WI-FI CONTROLLER (SOLENOID VALVE CONTROL & FLOW MONITORING)

The SMART-CONTROLLER controls the solenoid valve through which the nutrient solution is supplied to the irrigation system. The period and duration of irrigation is set by the growing program that the user selected in the SETTINGS menu. The serial number of the SMART-CONTROLLER is registered in the same menu. Communication between the SMART-CONTROLLER and the SMART-SERVER is via Wi-Fi.

The SMART-CONTROLLER receives information about the irrigation schedule and works autonomously according to a given program until a new schedule is received. That is, even when the connection with the SMART-SERVER is interrupted there is no failure in the irrigation of plants.

The SMART-CONTROLLER receives data from the flow sensor and sends information about the current flow rate to the SMART-SERVER. The SMART Server analyzes this data and sends an alarm message to the user if the parameter exceeds the permissible limits. For example, an increased flow rate of the solution indicates a leak in the system and a reduced flow rate may be a sign of clogged nozzles. Information on the flow rate of the solution is displayed in the MONITORING menu too. The SMART-CONTROLLER is housed in a waterproof enclosure and is powered by 12V which makes it safe to use the device in rooms with high humidity.



## INSTALLATION OF SMART-CONTROLLER

Place the SMART-CONTROLLER near the solenoid valve and the flow sensor. Connect the two-wire cable from the DC voltage network of 12 Volts to the Controller. Connect valve control wires and flow sensor wires to the Controller too.

The SMART-CONTROLLER is made in a waterproof enclosure and can be operated in rooms with high humidity.

The SMART-CONTROLLER connects to the SMART-SERVER via Wi-Fi. The SMART-CONTROLLER is the Access Point to which the SMART-SERVER should connect.

Factory settings of Access Point:

Name: **smartcontroller**  
 Password: **smartcontroller**

Connect to an Access Point.  
 Change the password to confidential.



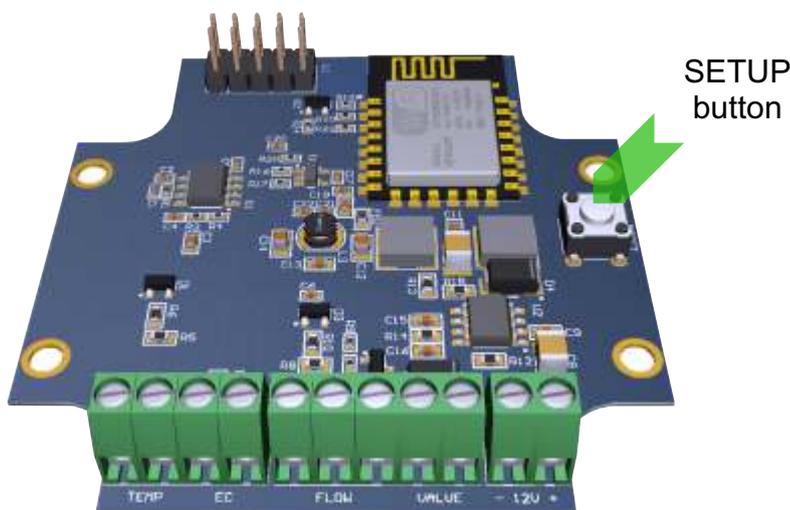
www.aeroponics.one



### IRRIGATION WI-FI CONTROLLER

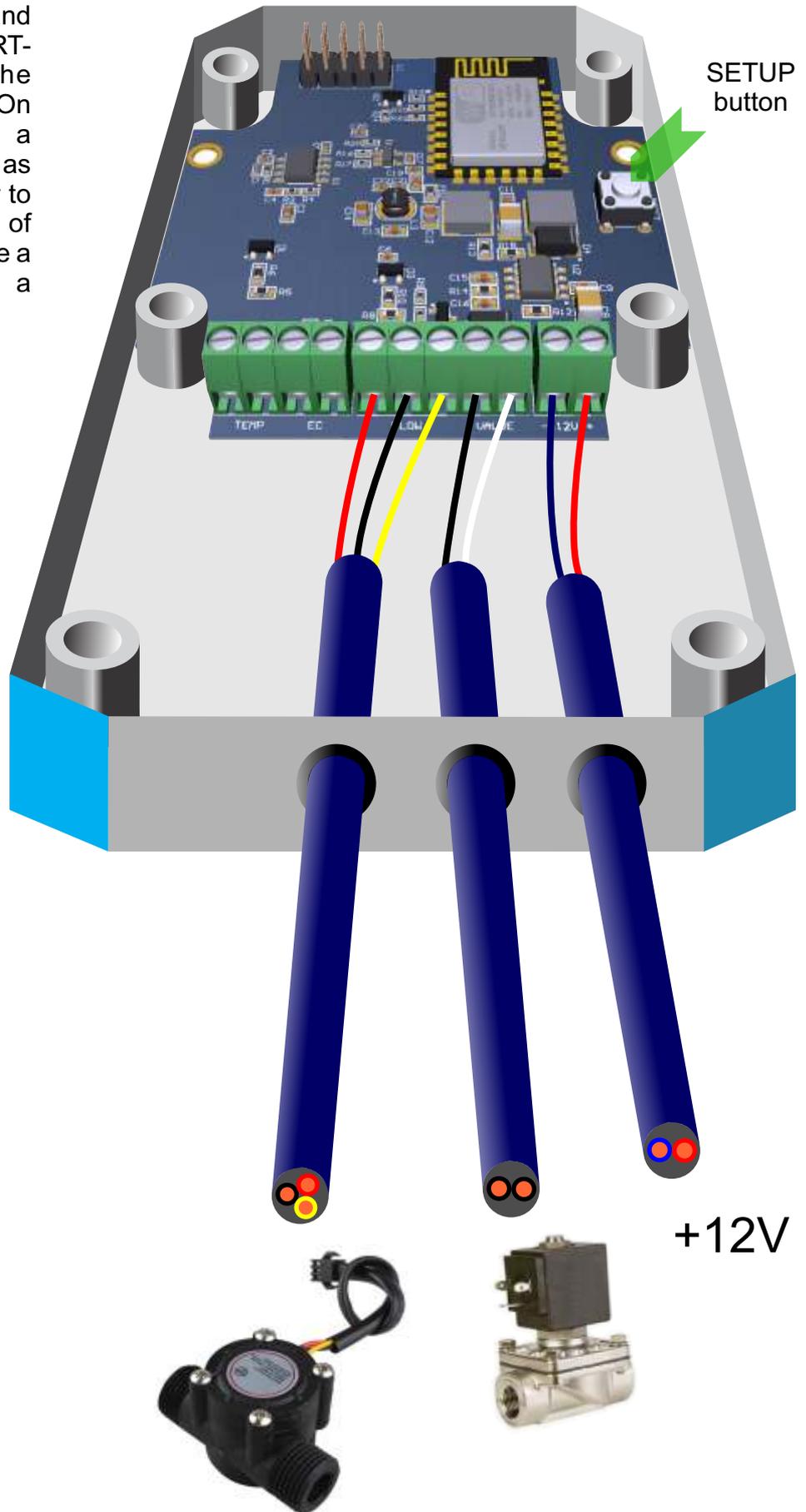
Solenoid valve control &  
Flow monitoring

flow sensor	valve control	+12 VDC
-------------	---------------	---------



If you forget the password, then you have the opportunity to restore the factory settings of the SMART-CONTROLLER. To do this, remove the Controller cover, connect the power and press the SETUP button for more than 3 seconds. After that you can use the factory password.

Unscrew the 6 fastening screws and remove the top cover of the SMART-CONTROLLER to connect the power cable and sensor wires. On the board are connectors with a screw clamp. Connect the wires as shown. Please note that in order to maintain the moisture resistance of the housing, the cables must have a circular cross section with a diameter of 6 mm.

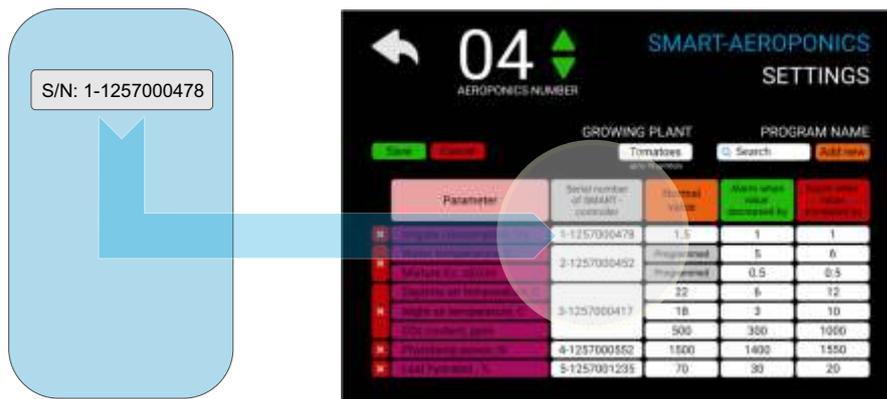


To connect the Controller to the network, it is enough to enter the serial number of the device in the SETTINGS menu of the corresponding Aeroponics. The Controller's serial number is indicated on a sticker located on the rear side of device.

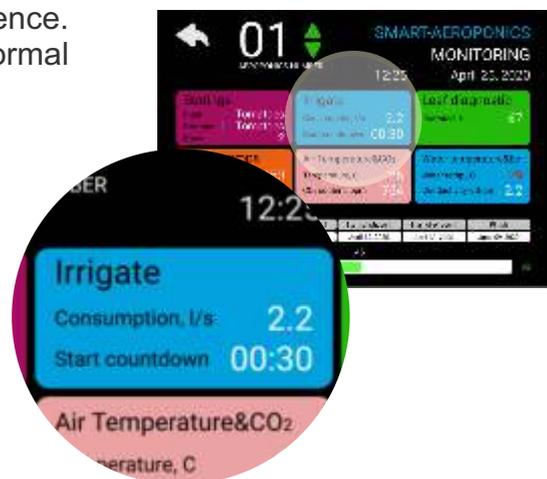
Enter to the SETTINGS menu.

AEROPONICS LIST --> Aeroponics number button -> MONITORING --> SETTINGS window --> SETTINGS

or AEROPONICS LIST -->  button --> SETTINGS --> Choice of Aeroponics number



Enter the serial number of the SMART-CONTROLLER in the IRRIGATE CONSUMPTION line. Enter the average flow rate of the nutrient mixture and the maximum permissible deviations. The flow rate of the nutrient mixture depends on many factors (system pressure, pipeline throughput, shape and number of nozzles). In the MONITORING menu, after each irrigation cycle, the actual value of the mixture consumption is displayed. You can enter this value in the NORMAL VALUE cell. Values of permissible deviations from the norm are specified on the basis of operating experience. First you can set the deviation range to 50% of the normal value.



<b>SMART-CONTROLLER parameters</b>	<b>Description</b>
Main function	Irrigation control; Consumption monitoring
Interface	Wi-Fi, support WPA/WPA2 security
Frequency Range	2.4GHz...2.5GHz (2400M...2483.5MHz)
Operation modes	STA/AP/STA+AP operation modes
Protocols	802.11 b/g/n; Integrated TCP/IP protocol stack
Certificates	FCC/CE/ROSH
Wi-Fi output power	+20dBm in 802.11b mode
Solenoid valve control port	Two wires line, 12V control level / up to 3A
Flow monitoring port	Three wires line, pulses method
Processor Model	ARM Cortex-M
Enclosure Type	Plastic, waterproof
Voltage supply	9...15VDC
Power consumption	up to 1W
Dimensions	125*77*20mm
Net weight	0.2kg
Operation temperature	0...60°C

## SOLENOID VALVE

Normally, the valve is closed. When 12VDC is applied to the two terminals, the valve opens and water can push through. The valve has a gasket arrangement inside, so there is a minimum pressure requirement of 0.02 Mpa. Also, mixture can only flow one direction.



SOLENOID VALVE parameters	Description
Main function	Open mixture flow
Solenoid valve control port	Two wires line, 12V control level / up to 3A
Working Pressure	0.02...0.8 Mpa
Enclosure Type	Plastic, 1/2"
Response time	≤ 0.15 sec (open); ≤ 0.3 sec (close)
Actuating voltage	12VDC
Voltage / Current	9V/240 mA; 10V/270 mA; 11V/300 mA; 12V/320 mA
Dimensions	3.3" x 1.69" x 2.24"
Net weight	0.2kg
Operation temperature	1...75°C

## FLOW SENSOR

The sensor is designed to monitor the flow rate of the nutrient solution during irrigation. The built-in Hall sensor emits pulses as the fluid flows through the blades of the device. SMART-CONTROLLER converts the number of pulses into units of fluid flow (liters per second)



FLOW SENSOR parameters	Description
Main function	Mixture consumption monitoring
Flow sensor control port	Three wires line, pulse method
Working Pressure	0...1.75 Mpa
Consumption range	1-30 l/min
Enclosure Type	Plastic, 1/2"
Working voltage range	5...18VDC
Maximum operating current	15 mA
Dimensions	60mm x 40mm x 40mm
Net weight	0.2kg
Operation temperature	1...80°C



MIXTURE  
Ec & TEMPERATURE  
Wi-Fi CONTROLLER

SMART CONTROLLERS

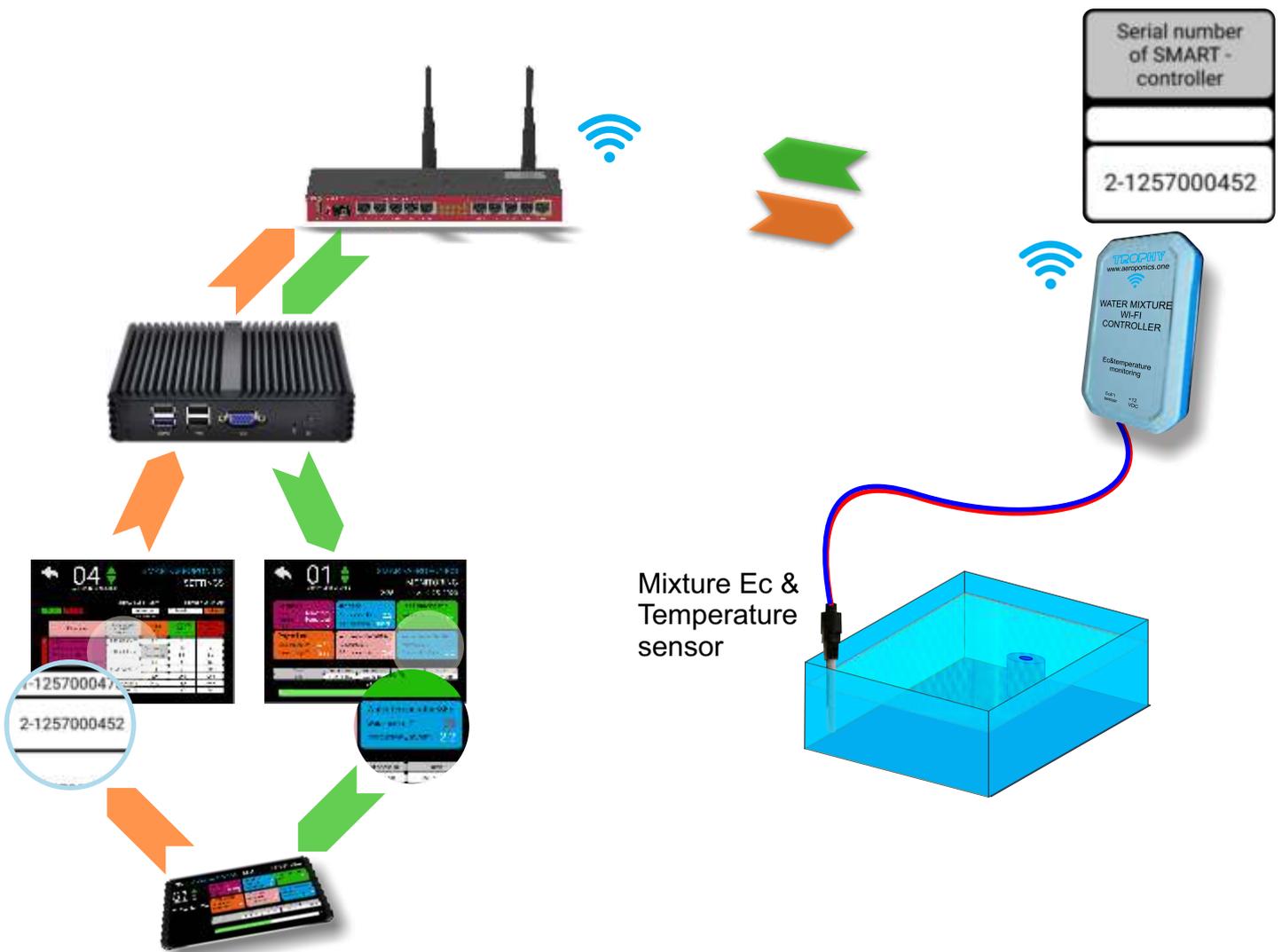
## MIXTURE Ec & TEMPERATURE WI-FI CONTROLLER

The SMART-CONTROLLER monitors the conductivity and temperature of the nutrient mixture.

Normal parameters of mixture Ec and temperature are set by the program that the user selected in the SETTINGS menu. The serial number of the SMART-CONTROLLER is registered in the same menu. Communication between the SMART-CONTROLLER and the SMART-SERVER is via Wi-Fi.

The SMART-CONTROLLER receives data from the Mixture Ec&Temperature sensor and sends information about the current values to the SMART-SERVER. The SMART-SERVER analyzes this data and sends to the user a message about the accident if the parameters go beyond the permissible limits. In addition, information on the conductivity and temperature of the mixture is displayed in the MONITORING menu.

The SMART-Controller is placed in a waterproof enclosure and is powered by 12V voltage, which allows safe use of the device in rooms with high humidity.



## INSTALLATION OF SMART-CONTROLLER

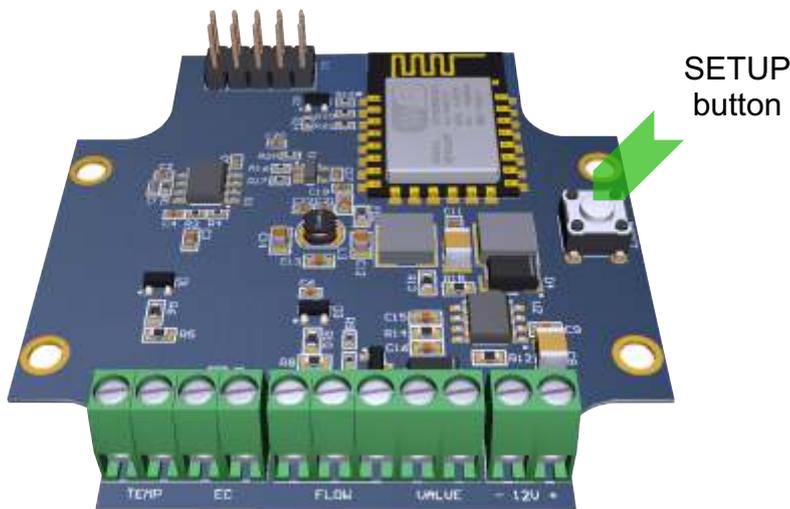
Place the SMART-CONTROLLER near the nutrition mixture tank. Connect the two-wire cable from the DC voltage network of 12 Volts to the Controller. Connect Ec&t sensor wires to the Controller too.

The SMART-CONTROLLER is housed in a waterproof case and can be operated in rooms with high humidity.

The SMART-CONTROLLER connects to the SMART-SERVER via Wi-Fi. The SMART-CONTROLLER is the Access Point to which the SMART-SERVER should connect.

Factory settings of Access Point:

Name: **smartcontroller**  
 Password: **smartcontroller**





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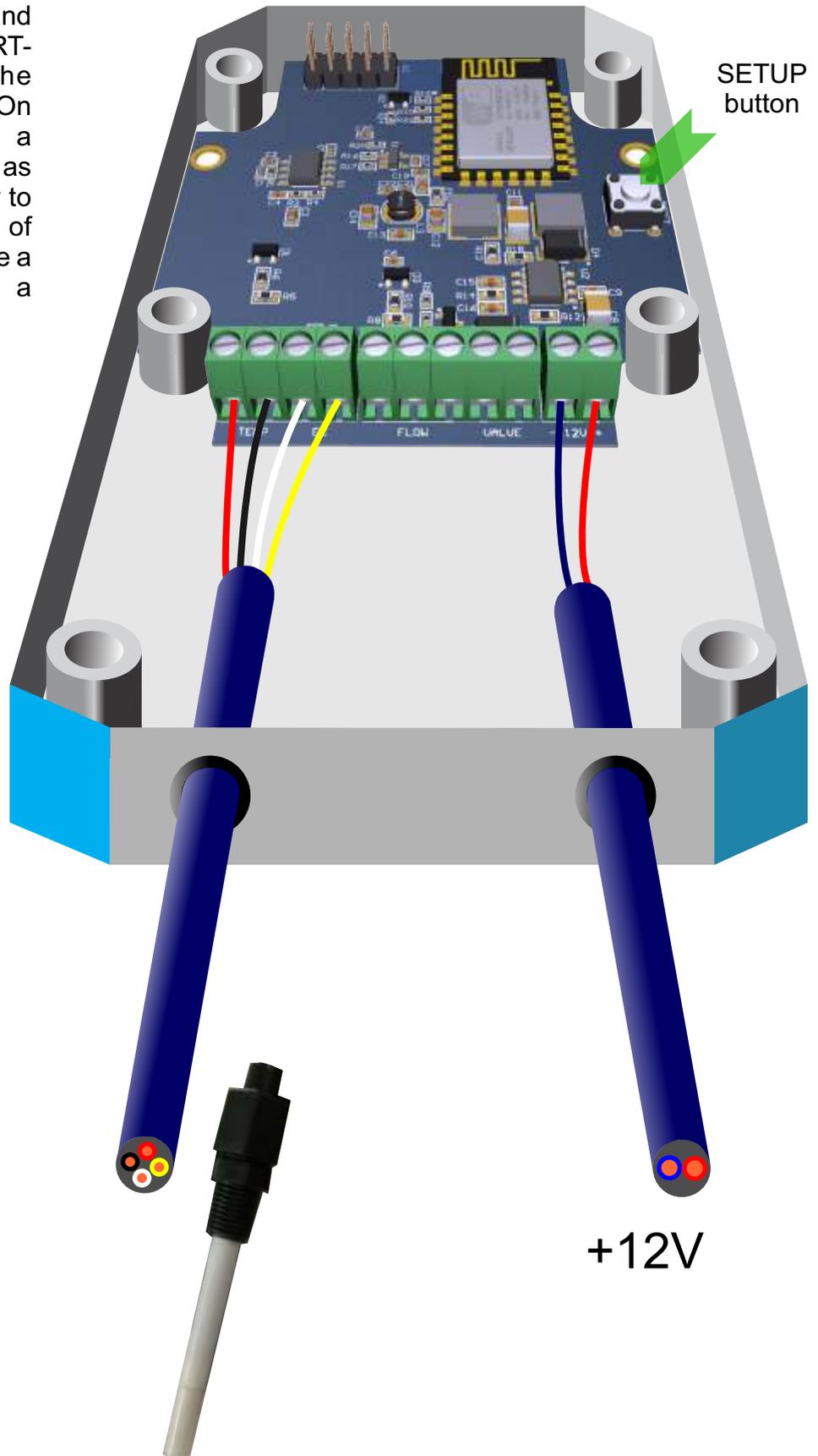
### WATER MIXTURE WI-FI CONTROLLER

Ec&temperature  
monitoring

Ec&t sensor	+12 VDC
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If you forget the password, then you have the opportunity to restore the factory settings of the SMART-CONTROLLER. To do this, remove the Controller cover, connect the power and press the SETUP button for more than 3 seconds. After that you can use the factory password.

Unscrew the 6 fastening screws and remove the top cover of the SMART-CONTROLLER to connect the power cable and sensor wires. On the board are connectors with a screw clamp. Connect the wires as shown. Please note that in order to maintain the moisture resistance of the housing, the cables must have a circular cross section with a diameter of 6 mm.

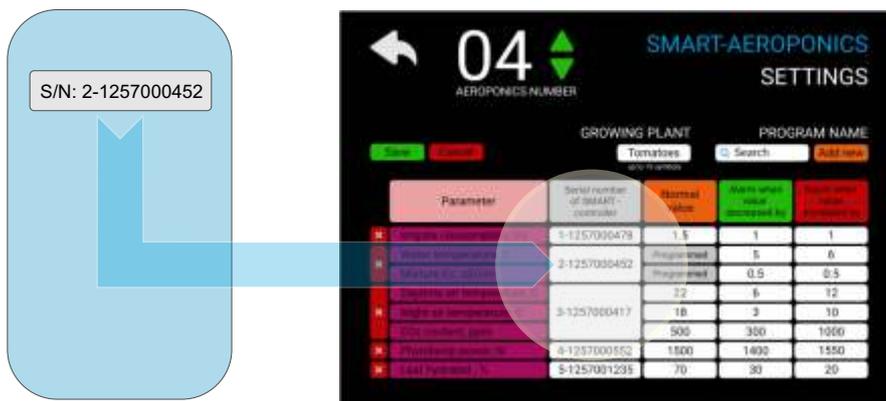


To connect the Controller to the network, it is enough to enter the serial number of the device in the SETTINGS menu of the corresponding Aeroponics. The Controller's serial number is indicated on a sticker located on the rear side of device.

Enter to the SETTINGS menu.

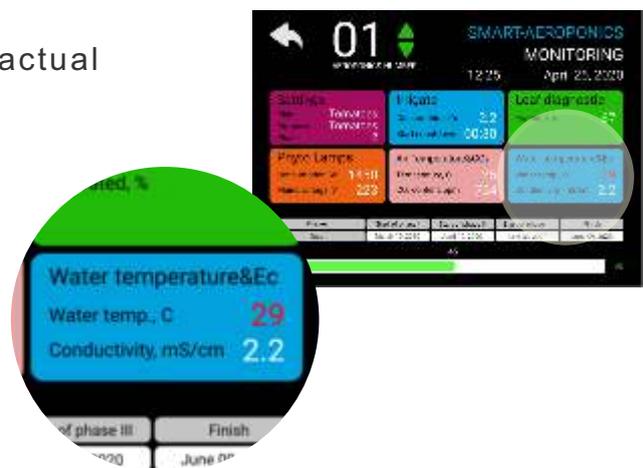
AEROPONICS LIST --> Aeroponics number button -> MONITORING --> SETTINGS window --> SETTINGS

or AEROPONICS LIST -->  button --> SETTINGS --> Choice of Aeroponics number



Enter the serial number of the SMART-CONTROLLER in the WATER TEMPERATURE & MIXTURE Ec line. The normal temperature and conductivity values are set by the growing program. The values of permissible deviations from the norm are specified based on operating experience. First you can set the temperature deviation to 5 degrees and the conductivity deviation to 0.5 mS/cm.

The MONITORING menu displays the actual temperature and conductivity.



<b>SMART-CONTROLLER parameters</b>	<b>Description</b>
Main function	Mixture Ec&Temperature monitoring
Interface	Wi-Fi, support WPA/WPA2 security
Frequency Range	2.4GHz...2.5GHz (2400M...2483.5MHz)
Operation modes	STA/AP/STA+AP operation modes
Protocols	802.11 b/g/n; Integrated TCP/IP protocol stack
Certificates	FCC/CE/ROSH
Wi-Fi output power	+20dBm in 802.11b mode
Mixture Ec&t monitoring port	Four wires line
Ec measuring range	0-10 mS/cm
Temperature measuring range	0...50°C
Processor Model	ARM Cortex-M
Enclosure Type	Plastic, waterproof
Voltage supply	9...15VDC
Power consumption	up to 1W
Dimensions	125*77*20mm
Net weight	0.2kg
Operation temperature	0...50°C

MIXTURE Ec & Temperature SENSOR

The sensor is designed to control the conductivity and temperature of the nutrient solution. The sensor is installed in the top cover of the solution container. The sensor electrodes must be constantly immersed in the solution.



Ec & °t SENSOR parameters	Description
Main function	Mixture Ec and °t monitoring
Mixture Ec&°t monitoring port	Four wires line: White (A) conductivity - input Yellow (V) conductivity - output Red NTC 10k thermistor - signal Black NTC - ground
Working Pressure	0...5 Mpa
Measurement range	0-2000 mS/cm
Thermal sensor type	NTC 10k
Structure of the electrode	Bipolar
Electrode material	316L steel
Enclosure Type	1/2 ", thread pitch NPT
Dimensions	60mm x 40mm x 40mm
Net weight	0.2kg
Operation temperature	0...50°C



## IRRIGATION-PLUS WI-FI CONTROLLER

SOLENOID VALVE CONTROL /  
FLOW MONITORING /  
NUTRIENT MIXTURE Ec & TEMPERATURE

# SMART CONTROLLERS

## IRRIGATION-PLUS WI-FI CONTROLLER (SOLENOID VALVE CONTROL / FLOW MONITORING / NUTRIENT MIXTURE EC & TEMPERATURE)

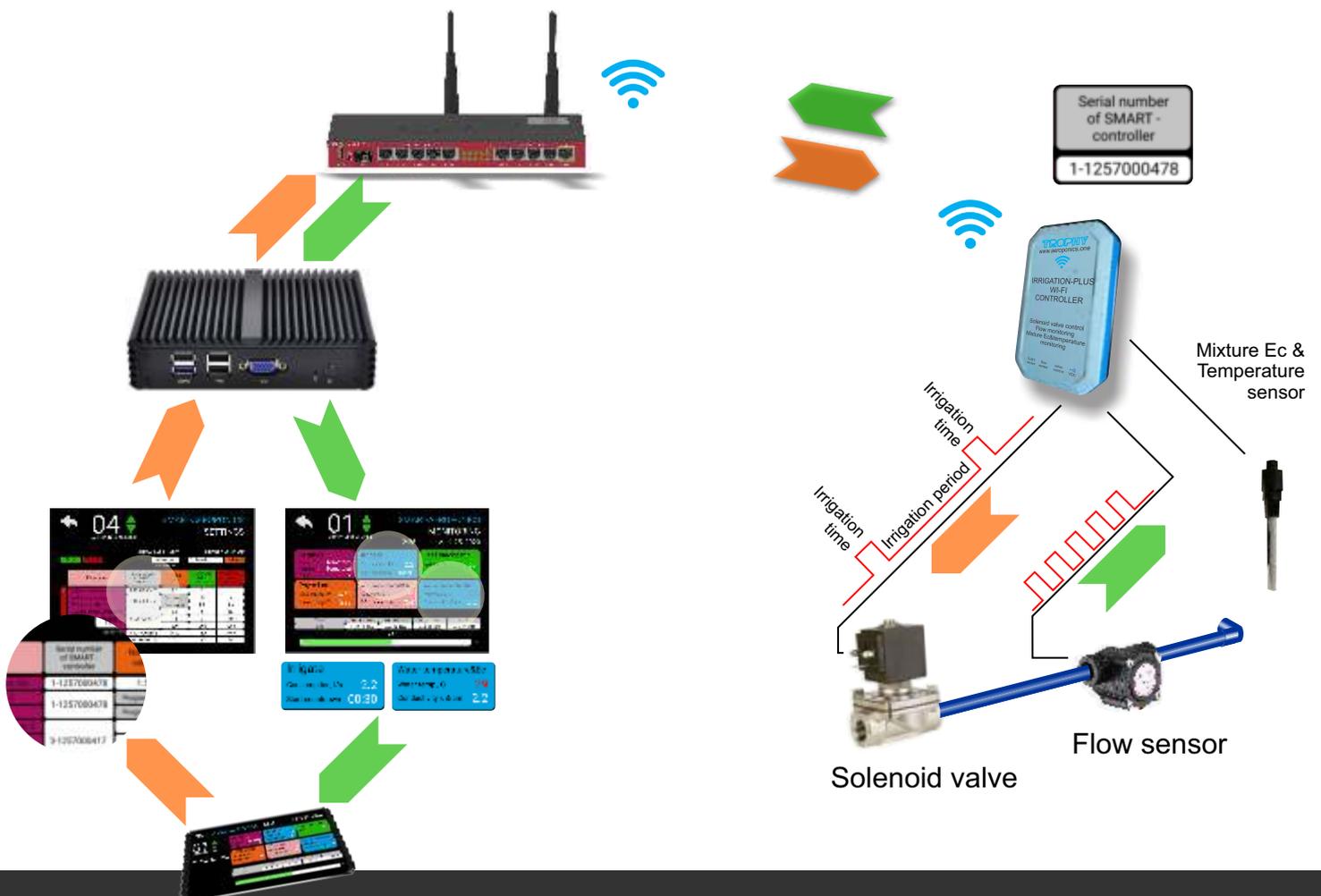
The SMART-CONTROLLER controls the solenoid valve through which the nutrient solution is supplied to the nozzles and monitors the conductivity and temperature of the nutrient solution.

The period and duration of irrigation, the normal parameters Ec and the solution temperature are set by the growing program that the user selected in the SETTINGS menu. In the same menu the IRRIGATE CONSUMPTION / WATER TEMPERATURE / MIXTURE Ec lines indicates the serial number of the SMART-CONTROLLER. Communication between the SMART-CONTROLLER and the SMART-SERVER is via Wi-Fi.

The SMART-CONTROLLER receives information about the irrigation schedule and works autonomously according to a given program until a new schedule is received. That is, even when the connection with the SMART-SERVER is interrupted there is no failure in the irrigation of plants.

The SMART-CONTROLLER receives data from the Mixture Conductivity/Temperature/Flow sensors and sends the current information to the SMART-SERVER. The SMART-SERVER analyzes this data and sends an alarm message to the user if the parameters go beyond the permissible limits. For example, an increased mixture flow rate indicates a leak in the system or a reduced flow rate may be a sign of clogged nozzles. In addition, all information is displayed in the MONITORING menu.

The SMART-CONTROLLER is housed in a waterproof enclosure and is powered by 12V which makes it safe to use the device in rooms with high humidity.



## INSTALLATION OF SMART-CONTROLLER

Place the SMART-CONTROLLER near the container with the nutrient mixture. Connect to the Controller the two-wire cable from the 12VDC voltage. Connect the wires of the Mixture conductivity and temperature sensor, the solenoid valve control wires and the flow sensor wires to the Controller (see the figure on the next page).

The SMART-CONTROLLER is made in a waterproof enclosure and can be operated in rooms with high humidity.

The SMART-CONTROLLER connects to the SMART-SERVER via Wi-Fi. The SMART-CONTROLLER is the Access Point to which the SMART-SERVER should connect.

Factory settings of Access Point:

Name: **smartcontroller**

Password: **smartcontroller**

Connect to an Access Point.

Change the password to confidential.

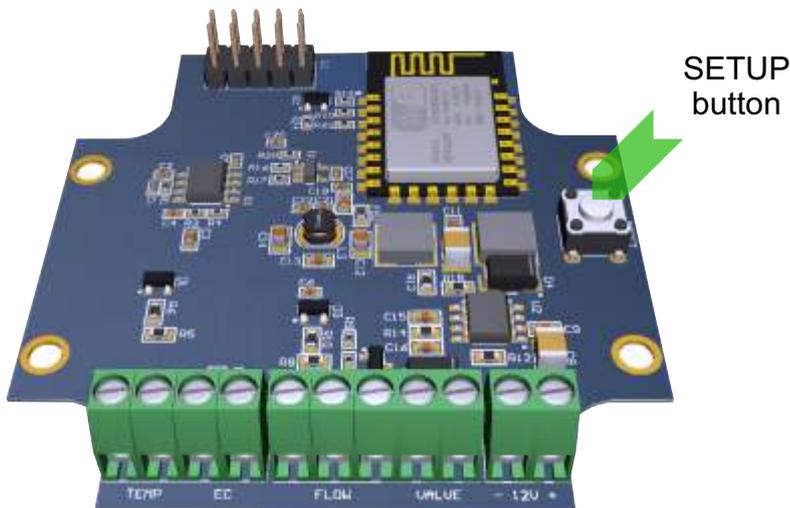
**TROPHY**  
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**IRRIGATION-PLUS  
WI-FI  
CONTROLLER**

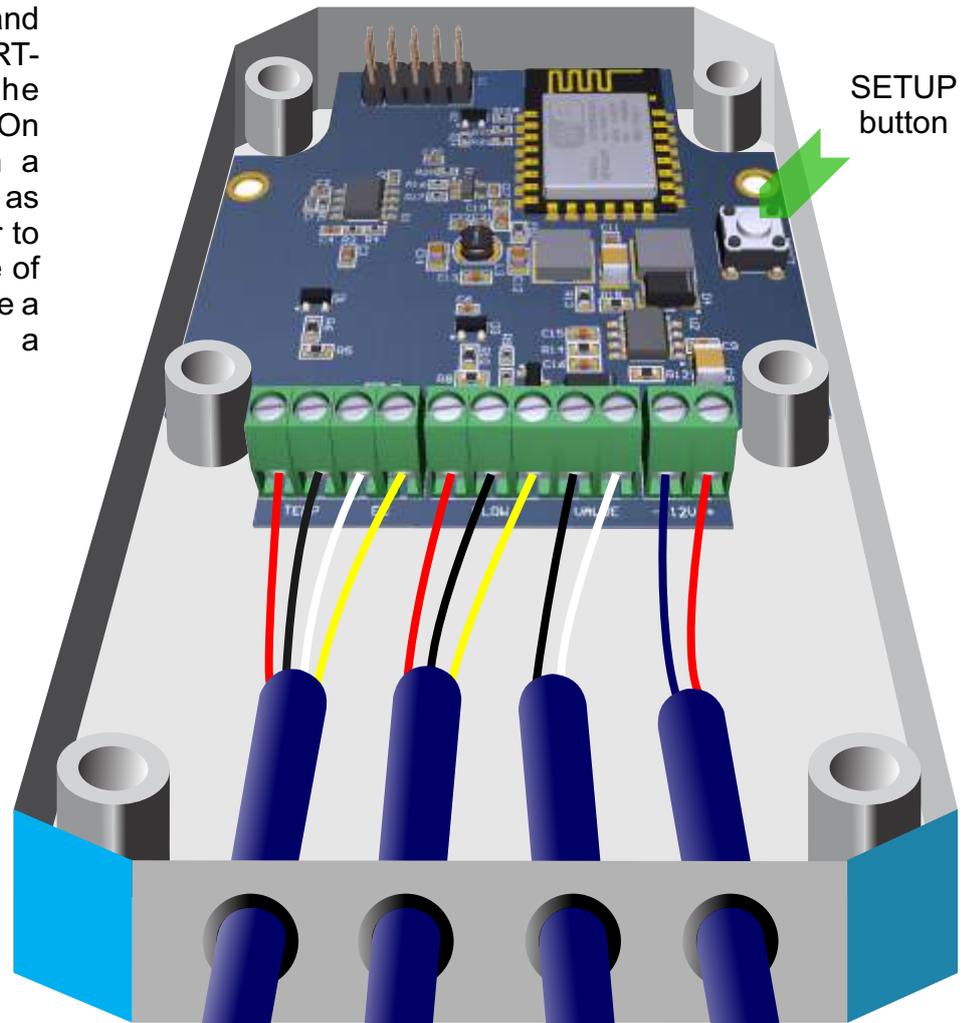
Solenoid valve control  
Flow monitoring  
Mixture Ec&temperature  
monitoring

Ec&t sensor	flow sensor	valve control	+12 VDC
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If you forget the password, then you have the opportunity to restore the factory settings of the SMART-CONTROLLER. To do this, remove the Controller cover, connect the power and press the SETUP button for more than 3 seconds. After that you can use the factory password.

Unscrew the 6 fastening screws and remove the top cover of the SMART-CONTROLLER to connect the power cable and sensor wires. On the board are connectors with a screw clamp. Connect the wires as shown. Please note that in order to maintain the moisture resistance of the housing, the cables must have a circular cross section with a diameter of 6 mm.



+12V

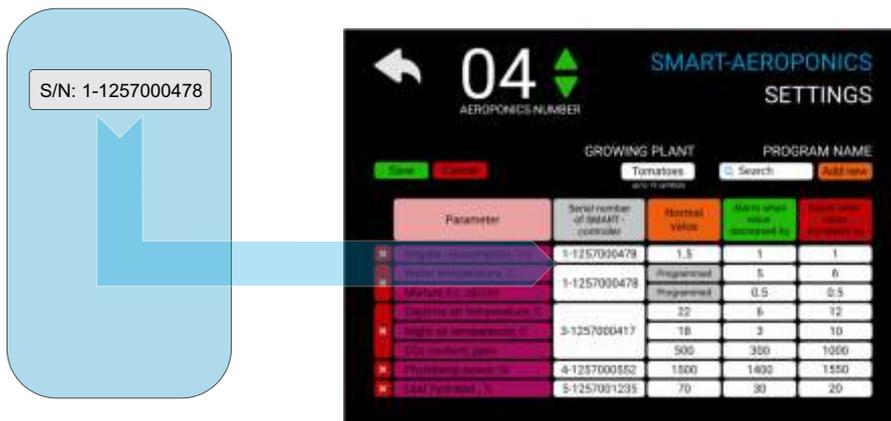


To connect the Controller to the network, it is enough to enter the serial number of the device in the SETTINGS menu of the corresponding Aeroponics. The Controller's serial number is located on a sticker located on the rear side of device.

Enter to the SETTINGS menu.

AEROPONICS LIST --> Aeroponics number button -> MONITORING --> SETTINGS window --> SETTINGS

or AEROPONICS LIST -->  button --> SETTINGS --> Choice of Aeroponics number



Enter the serial number of the SMART-CONTROLLER in the IRRIGATE CONSUMPTION and WATER TEMPERATURE & MIXTURE Ec lines. You do not need to enter normal values of temperature and conductivity, they are set by the growing program. Values of permissible deviations from the norm are adjusted based on operating experience. First you can set the temperature deviation to be 5 degrees and a conductivity deviation of 0.5 mS/cm.

The MONITORING menu displays the actual temperature and conductivity values.

Enter the average flow rate of the nutrient mixture and the maximum permissible deviations. The flow rate of the nutrient mixture depends on many factors (system pressure, pipeline throughput, shape and number of nozzles). The actual value of the mixture consumption is displayed in the MONITORING menu after each irrigation cycle. You can enter this value in the NORMAL VALUE cell. Values of permissible deviations from the norm are specified on the basis of operating experience. First you can set the deviation range to 50% of the normal value.

<b>SMART-CONTROLLER parameters</b>	<b>Description</b>
Main functions	Irrigation control; Mixture consumption, Ec and temperature monitoring
Interface	Wi-Fi, support WPA/WPA2 security
Frequency Range	2.4GHz...2.5GHz (2400M...2483.5MHz)
Operation modes	STA/AP/STA+AP operation modes
Protocols	802.11 b/g/n; Integrated TCP/IP protocol stack
Certificates	FCC/CE/ROSH
Wi-Fi output power	+20dBm in 802.11b mode
Solenoid valve control port	Two wires line, 12V control level / up to 3A
Flow monitoring port	Three wires line, pulses method
Mixture Ec&t monitoring port	<p>Four wires line</p> <p>White (A) conductivity - input            Yellow (V) conductivity - output            Red NTC 10k thermistor - signal            Black NTC - ground</p>
Ec measuring range	0-10 mS/cm
Temperature measuring range	0...50°C
Processor Model	ARM Cortex-M
Enclosure Type	Plastic, waterproof
Voltage supply	9...15VDC
Power consumption	up to 1W
Dimensions	125*77*20mm
Net weight	0.2kg
Operation temperature	0...50°C



AIR TEMPERATURE &  
CARBON DIOXIDE  
WI-FI CONTROLLER

SMART CONTROLLERS

## AIR TEMPERATURE & CO2 WI-FI CONTROLLER

The SMART-CONTROLLER monitors air temperature and carbon dioxide content.

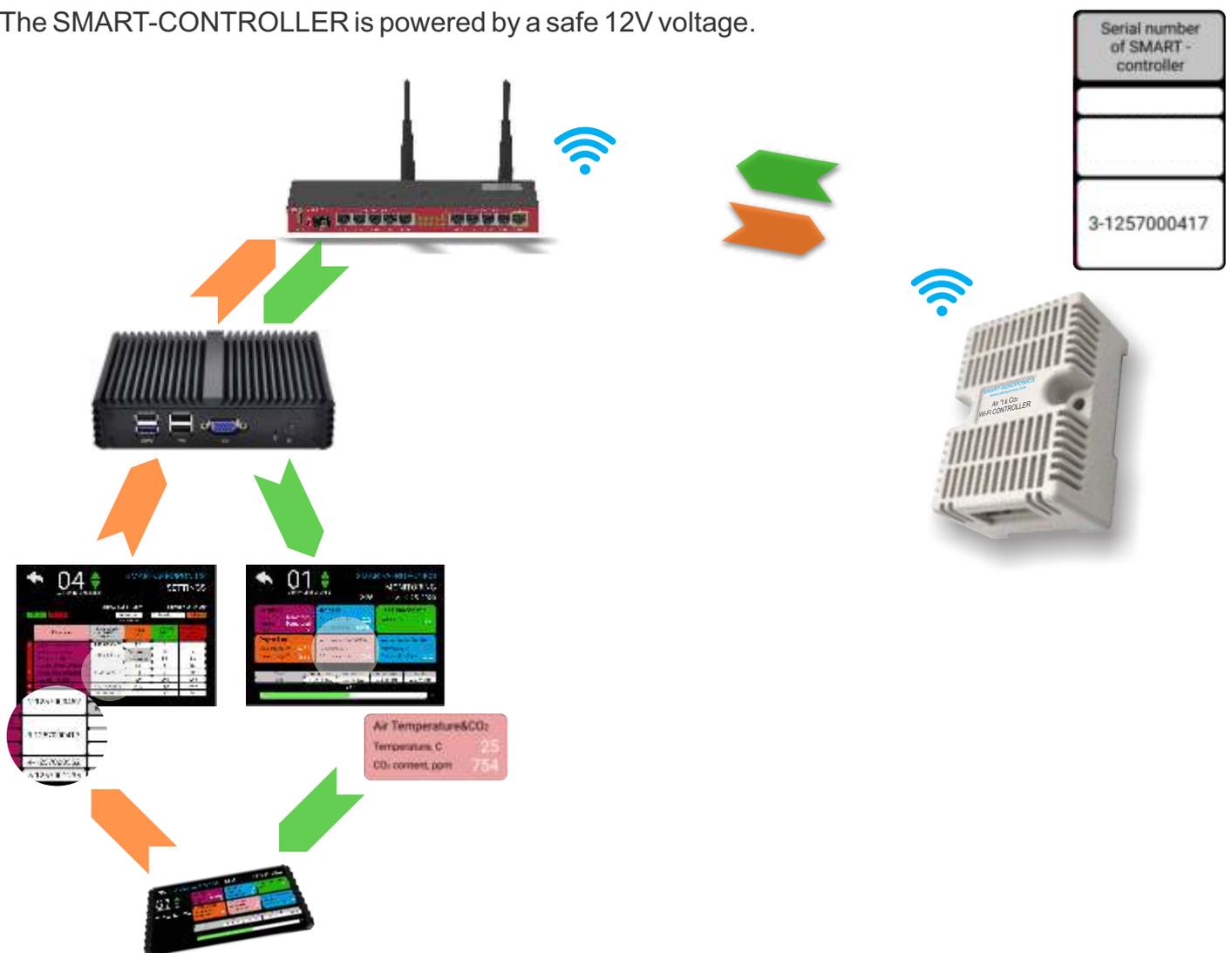
Normal parameters are set in the SETTINGS menu on the lines DAYTIME AIR TEMPERATURE / NIGHT AIR TEMPERATURE / CO2 CONTENT. The serial number of the SMART-CONTROLLER is also entered here. Communication between the SMART-CONTROLLER and the SMART-SERVER is via Wi-Fi.



The SMART-CONTROLLER receives data from Air temperature and carbon dioxide sensors and sends the current information to the SMART-SERVER. The sensors are located inside the SMART-CONTROLLER.

The SMART-SERVER analyzes this data and sends to the user a message about the accident if the parameters go beyond the permissible limits. In addition, all information is displayed in the MONITORING menu.

The SMART-CONTROLLER is powered by a safe 12V voltage.



## INSTALLATION OF SMART-CONTROLLER

Place the SMART-controller in the dry place. Connect to the Controller the two-wire cable from the 12VDC voltage.

The SMART-CONTROLLER is housed in a waterproof enclosure and can be operated in rooms with high humidity.

The SMART-CONTROLLER connects to the SMART-SERVER via Wi-Fi. The SMART-CONTROLLER is the Access Point to which the SMART-SERVER should connect.

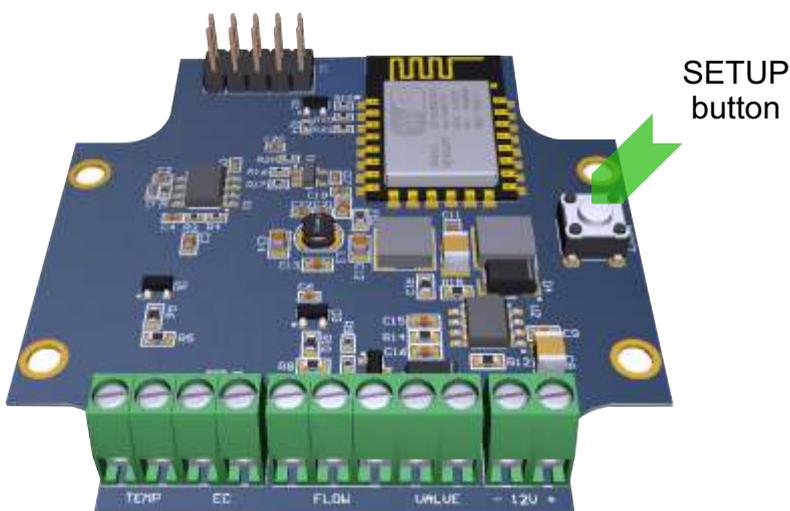
Factory settings of Access Point:

Name: **smartcontroller**

Password: **smartcontroller**

Connect to an Access Point.

Change the password to confidential.



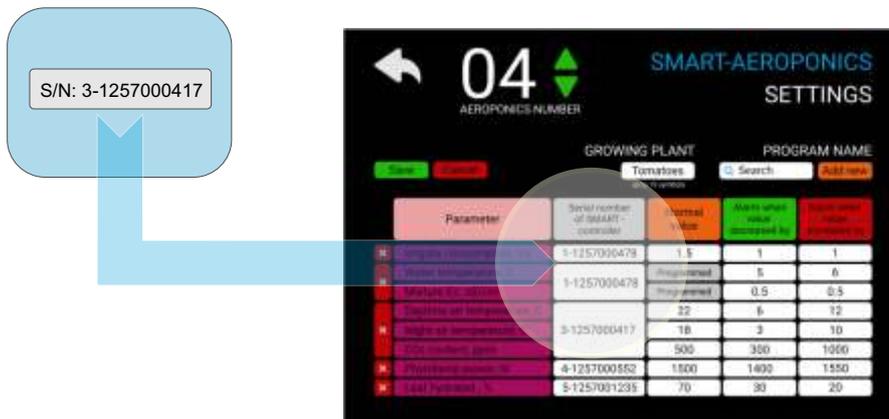
If you forget the password, then you have the opportunity to restore the factory settings of the SMART-CONTROLLER. To do this, remove the Controller cover, connect the power and press the SETUP button for more than 3 seconds. After that you can use the factory password.

To connect the Controller to the network, it is enough to enter the serial number of the device in the SETTINGS menu of the corresponding Aeroponics. The Controller's serial number is located on a sticker located on the rear side of device.

Enter to the SETTINGS menu.

AEROPONICS LIST --> Aeroponics number button -> MONITORING --> SETTINGS window --> SETTINGS

or AEROPONICS LIST -->  button --> SETTINGS --> Choice of Aeroponics number



Enter the serial number of the SMART-CONTROLLER in the DAYTIME AIR TEMPERATURE / NIGHT AIR TEMPERATURE / CO2 CONTENT lines. Normal values of temperature and carbon dioxide content should be indicated in the same lines. Values of permissible deviations from the norm are specified on the basis of operating experience. First you can set the temperature deviation to 5 degrees and the carbon deviation to -300 / + 1000ppm. The MONITORING menu displays the actual temperature and CO2 values.

<b>SMART-CONTROLLER parameters</b>	<b>Description</b>
Main functions	Air temperature and carbon dioxide level monitoring
Interface	Wi-Fi, support WPA/WPA2 security
Frequency Range	2.4GHz...2.5GHz (2400M...2483.5MHz)
Operation modes	STA/AP/STA+AP operation modes
Protocols	802.11 b/g/n; Integrated TCP/IP protocol stack
Certificates	FCC/CE/ROSH
Wi-Fi output power	+20dBm in 802.11b mode
Processor Model	ARM Cortex-M
Target gas	Carbon Dioxide
CO2 measuring range	0...2000ppm (0...+50°C)
Temperature measuring range	-20...+50°C
Enclosure Type	Plastic, no waterproof
Voltage supply	9...15VDC
Power consumption	up to 1W
Dimensions	65*45*28mm
Net weight	0.2kg



## PHYTO LAMPS WI-FI CONTROLLER

**SMART CONTROLLERS**

## PHYTO LAMPS WI-FI CONTROLLER

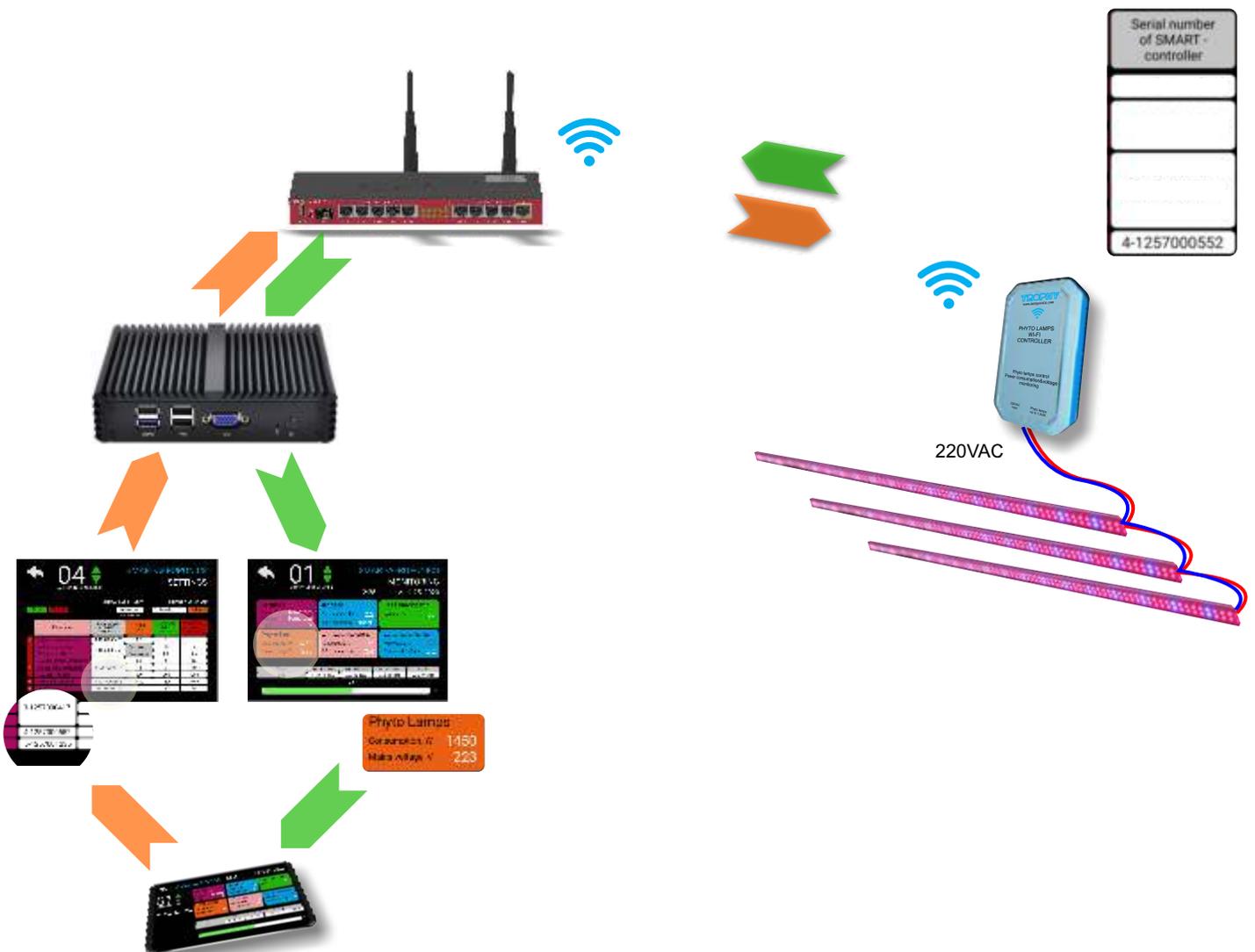
The SMART-CONTROLLER controls the phyto lamps and monitors the power consumption and lamp supply voltage.

Normal parameters are set in the SETTINGS menu on the PHYTOLAMP POWER line. The serial number of the SMART-CONTROLLER is also entered here. Communication between the SMART-CONTROLLER and the SMART-SERVER is via Wi-Fi.

The SMART-CONTROLLER receives commands from the SMART-SERVER to phytolamps turn on/off. The SMART-CONTROLLER sends information to the SMART-SERVER about the voltage and power consumed by the lamps. Sensors are located inside the SMART-CONTROLLER enclosure.

The SMART-SERVER analyzes this data and sends to the user a message about the accident if the parameters go beyond the permissible limits. In addition, all information is displayed in the MONITORING menu.

The SMART controller is powered by an alternating voltage of 230V. The sensor enclosure is waterproof.



## INSTALLATION OF SMART-CONTROLLER

Place the SMART-CONTROLLER near the phytolamp. Connect the two-wire cable from the 220 VAC network to the Controller. Connect the phytolamp 220-volt power cable to the Controller. The SMART-CONTROLLER is housed in a waterproof enclosure and can be operated in rooms with high humidity.

The SMART-CONTROLLER connects to the SMART-SERVER via Wi-Fi. The SMART-CONTROLLER is the Access Point to which the SMART-SERVER should connect.

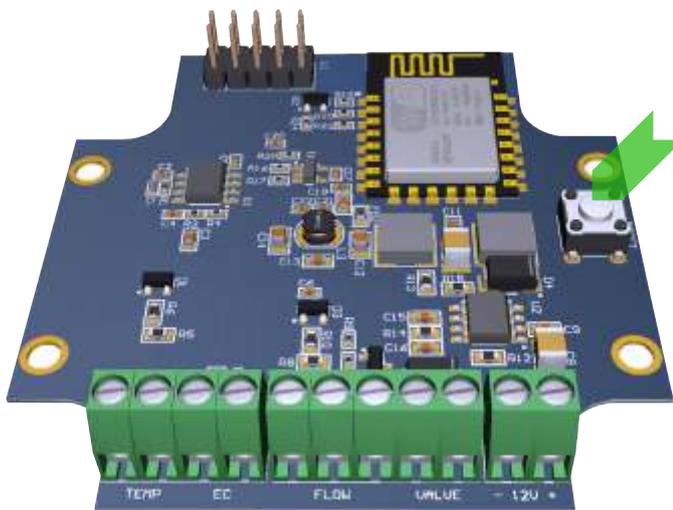
Factory settings of Access Point:

Name: **smartcontroller**

Password: **smartcontroller**

Connect to an Access Point.

Change the password to confidential.



SETUP  
button

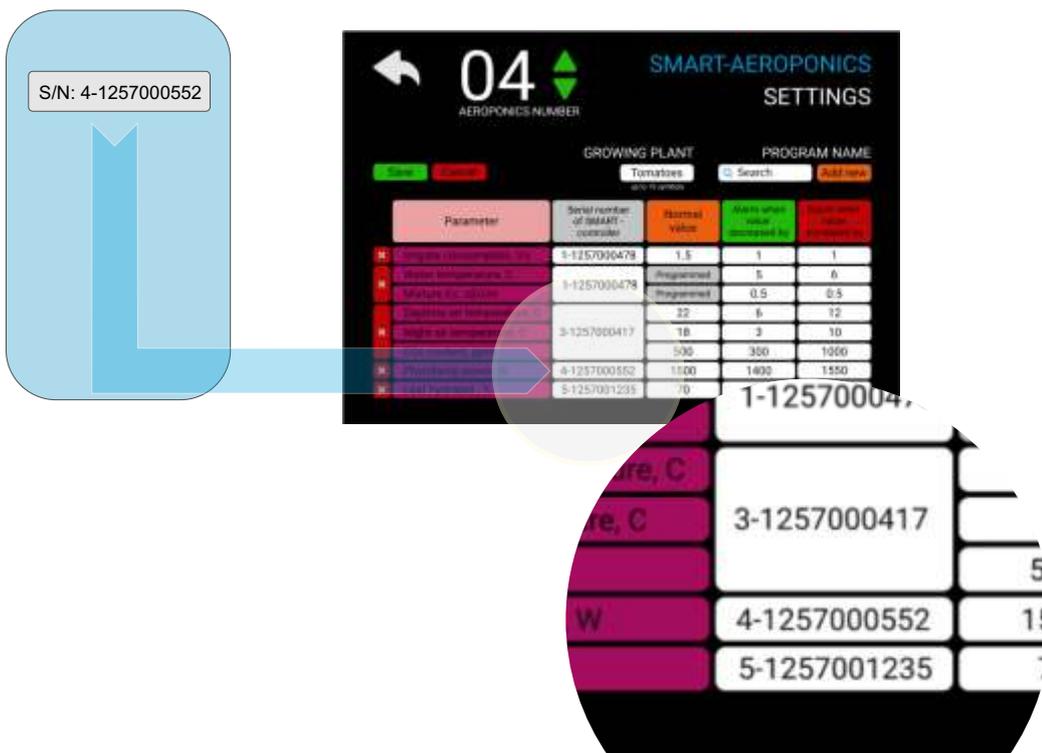
If you forget the password, then you have the opportunity to restore the factory settings of the SMART-CONTROLLER. To do this, remove the Controller cover, connect the power and press the SETUP button for more than 3 seconds. After that you can use the factory password.

To connect the Controller to the network, it is enough to enter the serial number of the device in the SETTINGS menu of the corresponding Aeroponics. The Controller's serial number is located on a sticker located on the rear side of device.

Enter to the SETTINGS menu.

AEROPONICS LIST --> Aeroponics number button -> MONITORING --> SETTINGS window --> SETTINGS

or AEROPONICS LIST -->  button --> SETTINGS --> Choice of Aeroponics number



Enter the serial number of the SMART-CONTROLLER in the PHYTOLAMP POWER line. Set the nominal power consumption. Values of permissible deviations from the norm are specified on the basis of operating experience. First you can set the deviation of the power +/- 10% of the nominal. The MONITORING menu displays the actual power consumption and supply voltage.

<b>SMART-CONTROLLER parameters</b>	<b>Description</b>
Main function	Phytolamps control / Power & Voltage monitoring
Interface	Wi-Fi, support WPA/WPA2 security
Frequency Range	2.4GHz...2.5GHz (2400M...2483.5MHz)
Operation modes	STA/AP/STA+AP operation modes
Protocols	802.11 b/g/n; Integrated TCP/IP protocol stack
Certificates	FCC/CE/ROSH
Wi-Fi output power	+20dBm in 802.11b mode
Phytolamp control port	Two wires line
Processor Model	ARM Cortex-M
Phytolamp consumption	0...2000W
Enclosure Type	Plastic, waterproof
Voltage supply	190...220VAC
Power consumption	up to 5W (+ Phytolamp consumption)
Dimensions	171*95*33mm
Net weight	0.3kg
Operation temperature	0...60°C



## LEAF WDS MONITORING WI-FI CONTROLLER

SMART CONTROLLERS

## LEAF WATER DEFICIT STRESS (WDS) MONITORING WI-FI CONTROLLER

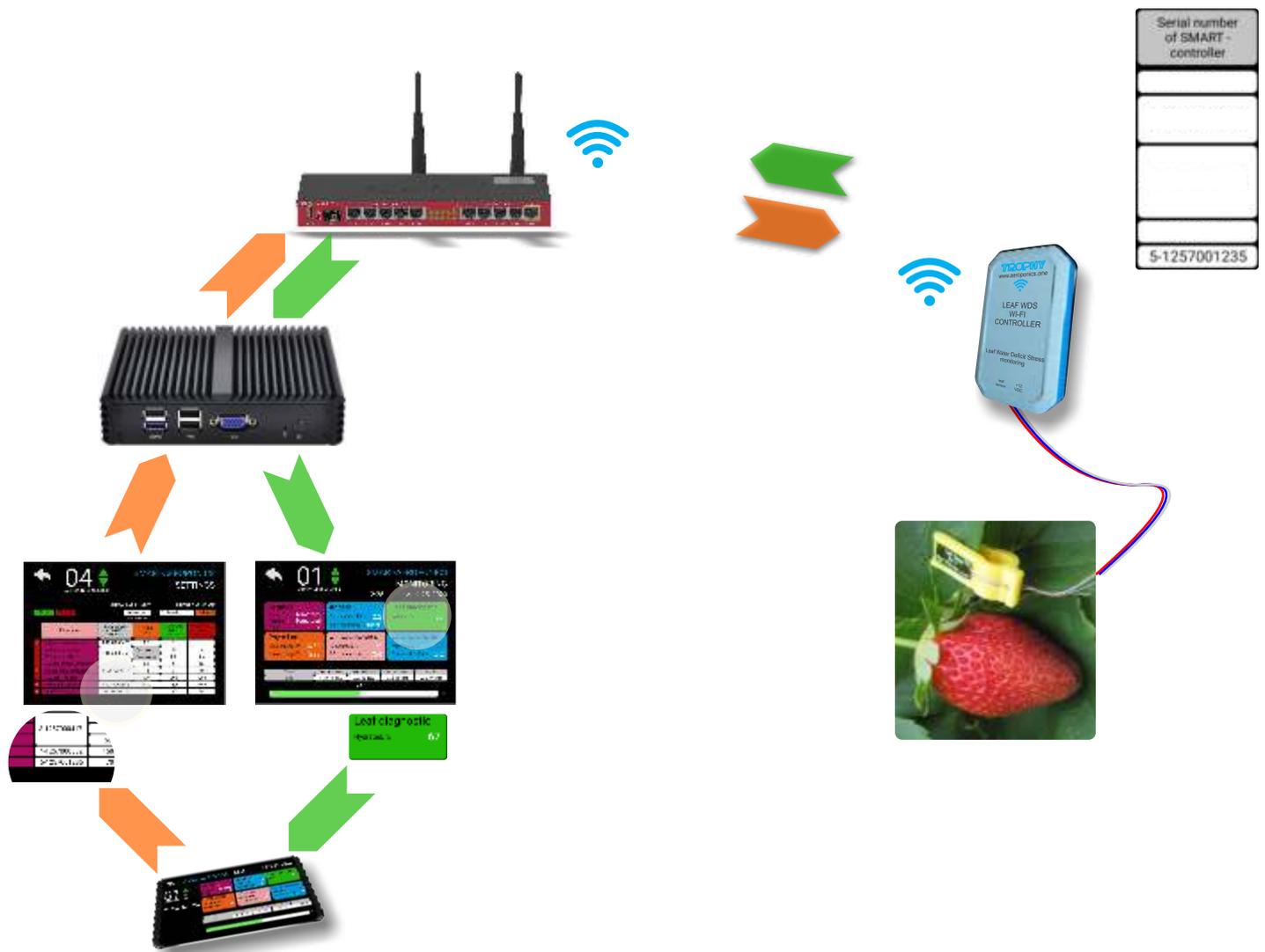
The SMART-CONTROLLER monitors leaf activity by measuring moisture deficiency.

The normal WDS value and tolerances are entered by the user in the SETTINGS menu. In the same menu, in the LEAF HYDRATED line, the serial number of the SMART-CONTROLLER is registered. Communication between the SMART-CONTROLLER and the SMART-SERVER is via Wi-Fi.

The SMART-CONTROLLER receives data from the Leaf sensor and sends the current information to the SMART-SERVER. The SMART-SERVER analyzes this data and sends to the user a message about the accident if the parameters go beyond the permissible limits. For example, a low level of WDS indicates an insufficient intensity of plant irrigation.

In addition, all information is displayed in the MONITORING menu.

The SMART-CONTROLLER is housed in a waterproof enclosure and is powered by 12V which makes it safe to use the device in rooms with high humidity.



## INSTALLATION OF SMART-CONTROLLER

Place the SMART-CONTROLLER near the leaf being analyzed. Connect a two-wire cable from the DC voltage network of 12 V to the Controller. Connect the wires of the Leaf sensor to the controller.

The SMART-CONTROLLER is housed in a waterproof enclosure and can be operated in rooms with high humidity.

The SMART-CONTROLLER connects to the SMART-SERVER via Wi-Fi. The SMART-CONTROLLER is the Access Point to which the SMART-SERVER should connect.

Factory settings of Access Point:

Name: **smartcontroller**  
 Password: **smartcontroller**

Connect to an Access Point.  
 Change the password to confidential.



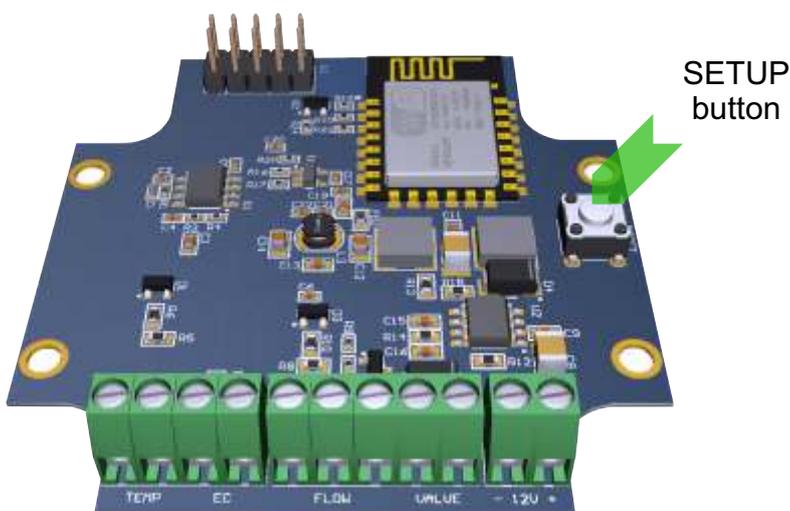
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### LEAF WDS WI-FI CONTROLLER

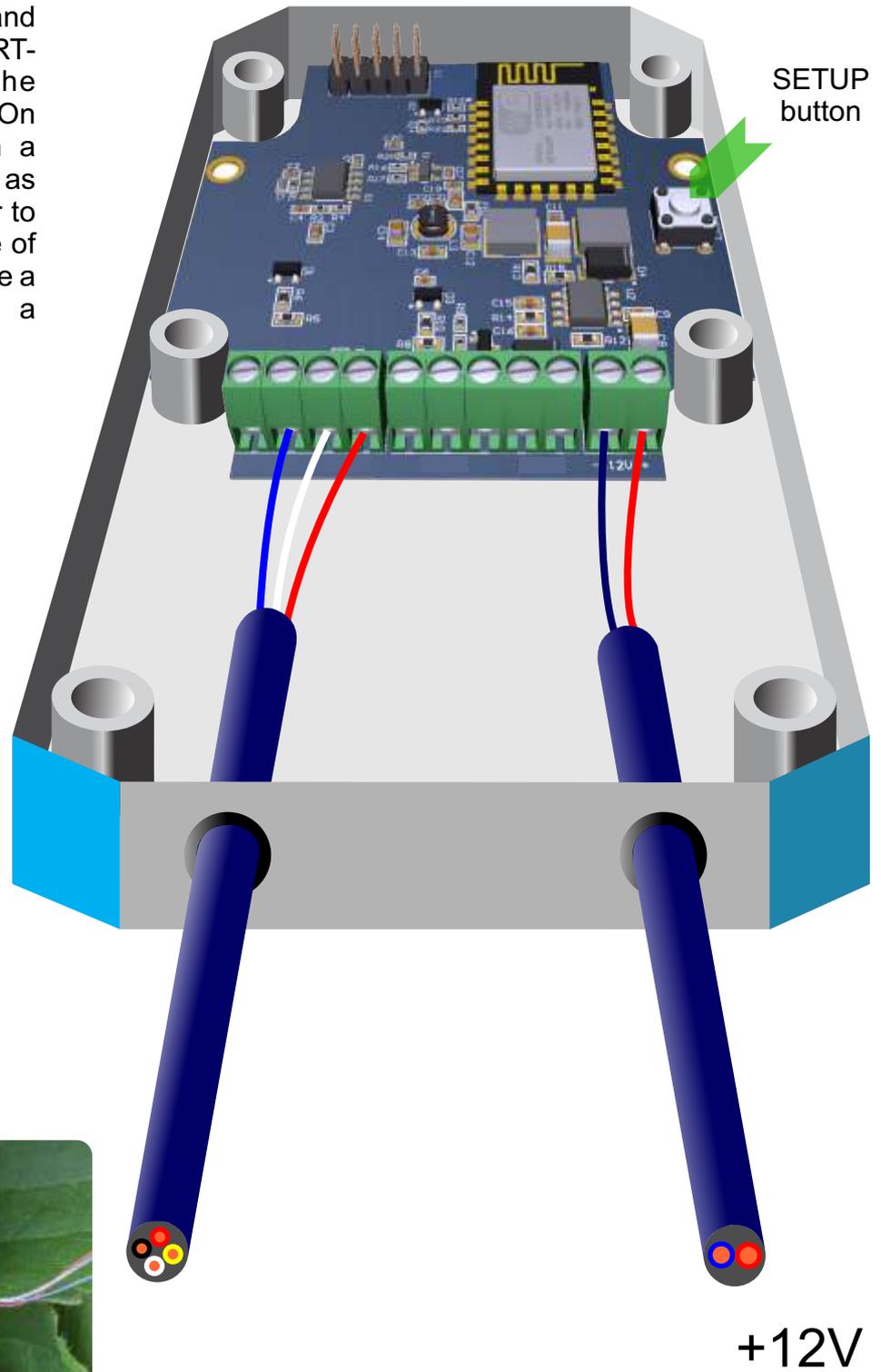
Leaf Water Deficit Stress  
monitoring

leaf sensor	+12 VDC
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If you forget the password, then you have the opportunity to restore the factory settings of the SMART-CONTROLLER. To do this, remove the Controller cover, connect the power and press the SETUP button for more than 3 seconds. After that you can use the factory password.

Unscrew the 6 fastening screws and remove the top cover of the SMART-CONTROLLER to connect the power cable and sensor wires. On the board are connectors with a screw clamp. Connect the wires as shown. Please note that in order to maintain the moisture resistance of the housing, the cables must have a circular cross section with a diameter of 6 mm.



To connect the Controller to the network, it is enough to enter the serial number of the device in the SETTINGS menu of the corresponding Aeroponics. The Controller's serial number is located on a sticker located on the rear side of device.

Enter to the SETTINGS menu.

AEROPONICS LIST --> Aeroponics number button -> MONITORING --> SETTINGS window --> SETTINGS

or AEROPONICS LIST -->  button --> SETTINGS --> Choice of Aeroponics number

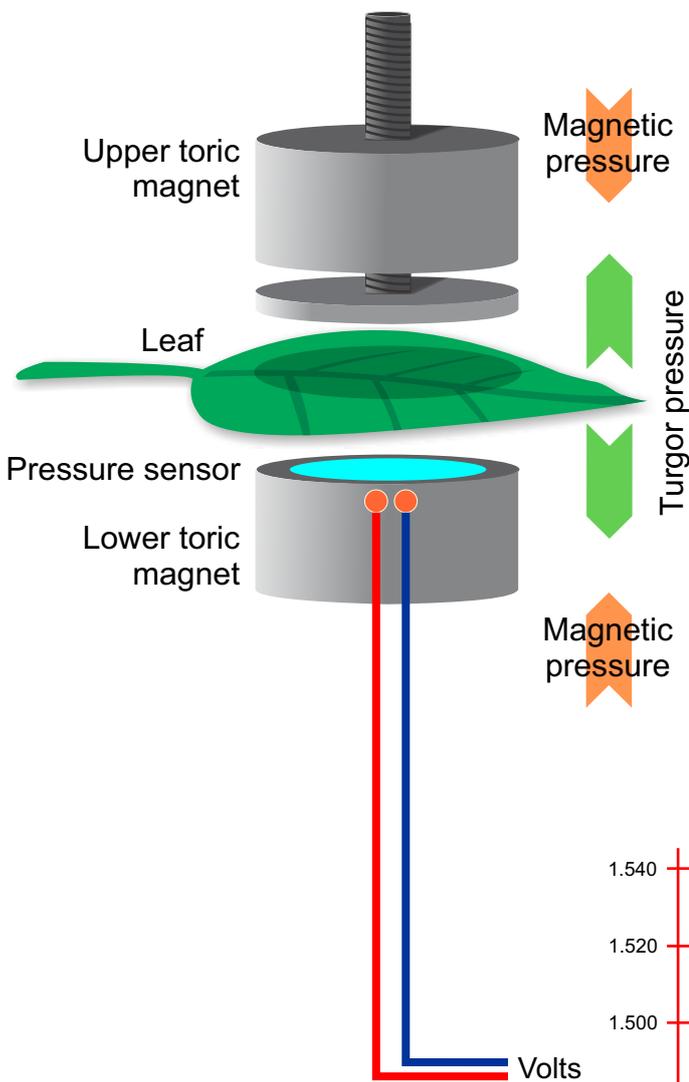


Enter the serial number of the SMART-CONTROLLER in the WATER-DEFICITE STRESS line. The normal hydration value of the leaf and the values of permissible deviations from the norm are specified based on operating experience. First you can set the WDS value to 30%, and the deviation from the norm +/- 20%.

The actual WDS level is displayed in the MONITORING menu.

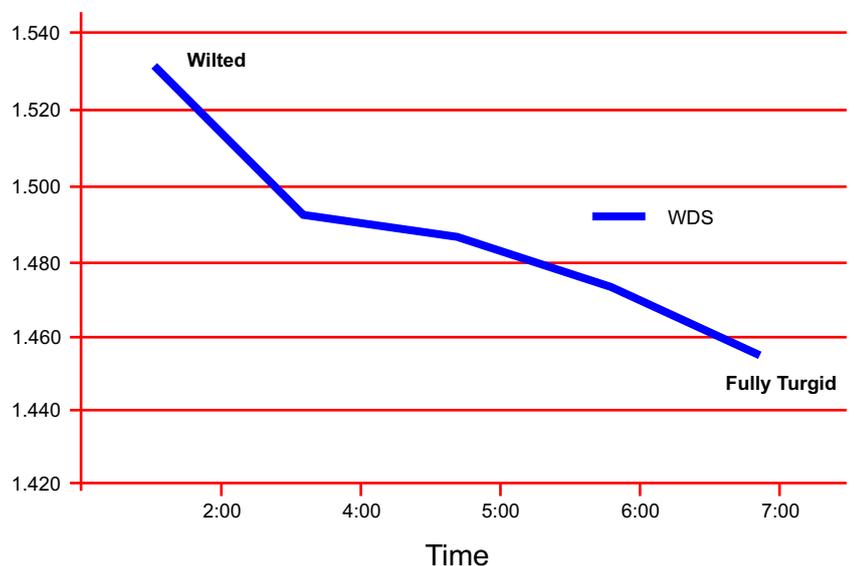
LEAF SENSOR

Leaf sensor indicates water deficit stress (WDS) by measuring the turgor pressure of a leaf, which decreases dramatically at the onset of leaf dehydration. Early detection of impending water deficit stress in plants can be used as an input parameter for precision irrigation control by allowing plants to communicate water requirements directly to humans and/or electronic interfaces.



When the plant was extremely wilted the WDS was near 100%. As the plant became more turgid the WDS was reduced to the 0% point when plant became Fully Turgid.

Turgid voltage diagram

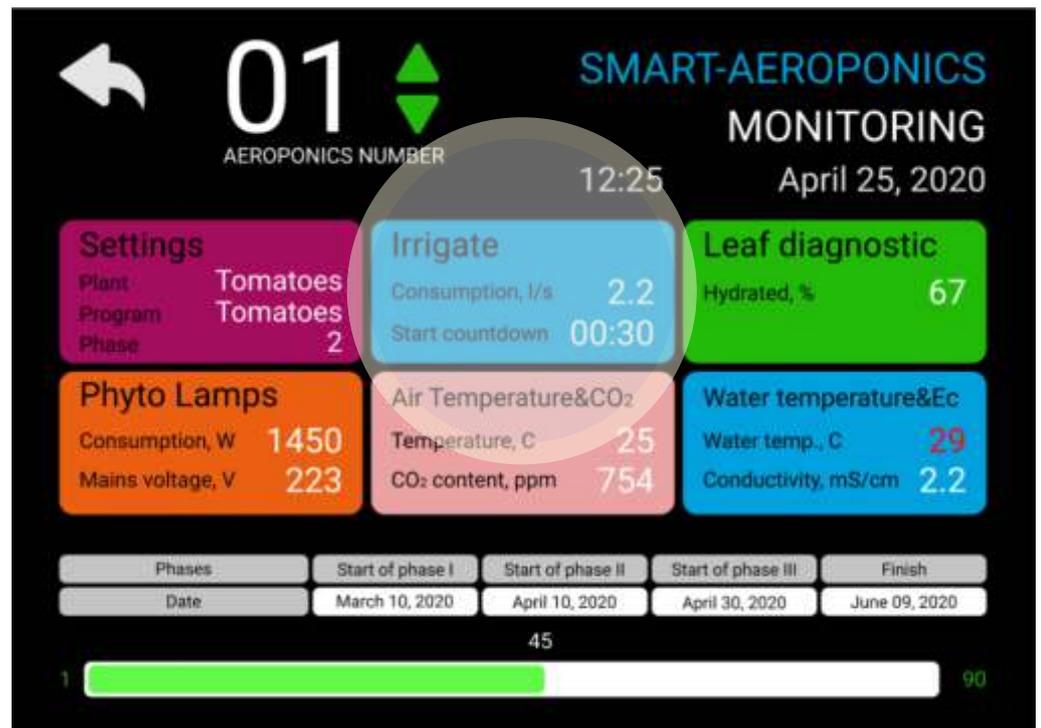


<b>SMART-CONTROLLER parameters</b>	<b>Description</b>
Main functions	Water deficit stress level monitoring
Interface	Wi-Fi, support WPA/WPA2 security
Frequency Range	2.4GHz...2.5GHz (2400M...2483.5MHz)
Operation modes	STA/AP/STA+AP operation modes
Protocols	802.11 b/g/n; Integrated TCP/IP protocol stack
Certificates	FCC/CE/ROSH
Wi-Fi output power	+20dBm in 802.11b mode
Processor Model	ARM Cortex-M
Leaf diagnostic port	Three wires line
Analog input range	1.45...2.0 VDC
Output voltage	3.3 VDC
Measuring range	0...100% of WDS (Water Deficit Stress)
Enclosure Type	Plastic, waterproof
Voltage supply	9...15VDC
Power consumption	up to 1W
Dimensions	65*45*28mm
Net weight	0.2kg

SMART

AEROPONICS

GROWING TECHNOLOGY



# IRRIGATION

GROWING TECHNOLOGY

## DURATION AND PERIOD OF FEEDING OF NUTRIENT MIXTURE

The frequency and duration of the feeding of the mixture depends on the following factors:

- species of the plant;
- phases of plant development;
- temperature and humidity of air;
- illumination;
- the volume of the cultivation chamber of the Aeroponics;
- Concentrations of the nutrient mixture.

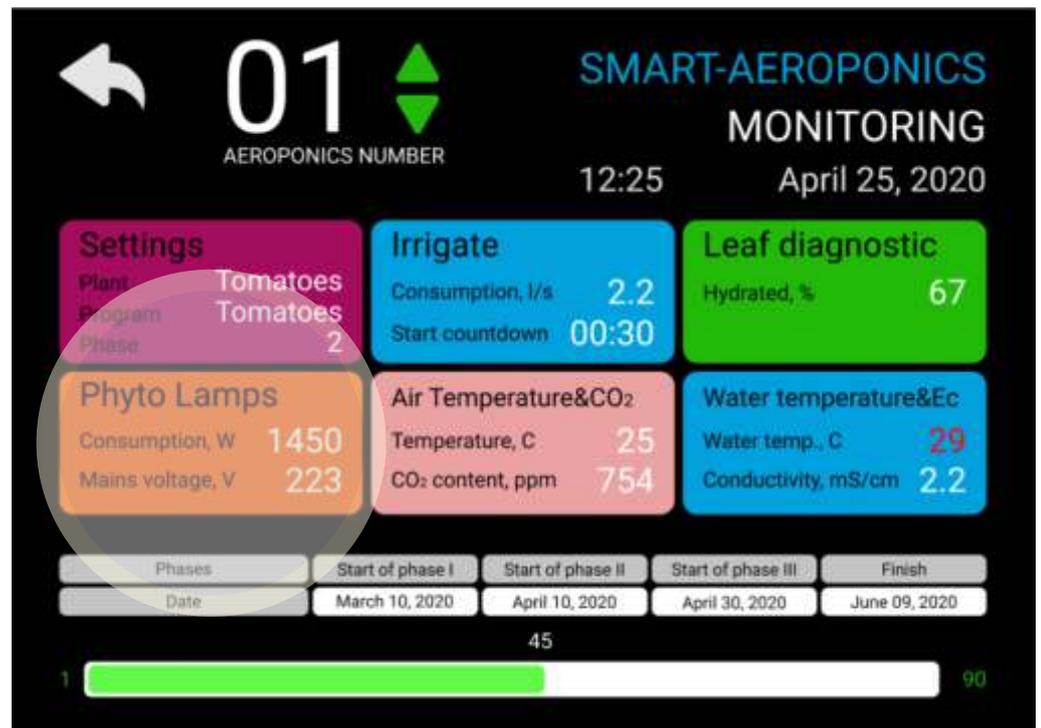
The timer is usually set to a specific "cycle". As an example, it can be installed only for 30 seconds to spray the nutrient mixture every 5 minutes. Thus, the cycle will be 30 seconds every 5 minutes around the clock.

How often do you need to spray the mixture in a Aeroponic system? The simplest answer is timely, long enough to root roots, but not so long that they choke. That's why it's useful to use a SMART-SERVER that gives flexibility in the settings.

If the roots seem to dry up between watering, increase the frequency that you watering them. If they seem very wet, shorten the watering time and see what happens. You can always increase or decrease it again. Each farmer quickly finds out what is best for his situation. Plants are very adaptable, but do not over do it. In principle, the roots simply need sufficient moisture so that they can absorb enough mixture to support the plant foliage. Large plants require more moisture (because they have much more foliage to support). Plants growing in dry conditions use more water than those that grow in wetter conditions.

SMART-SERVER allows you to set the cyclicity of watering depending on the time of year and time of day (daily highs and lows). Just gather statistics about the moisture content of the roots. You will probably want to try setting different timer settings to find what works best for local conditions. Watering at night (during the hours of darkness) is usually not required, because plants suck water only during light periods. But, it is recommended to water several times a night to keep the roots moist.

The SMART-Aeroponics includes a flow sensor for the mixture. In normal operation, the flow rate of the mixture will correspond to the duration of the electrical valve. In the event of an accident in the system (leakage of the mixture or the obstruction of a part of the injectors), the volume of the consumed mixture will accordingly increase or decrease. SMART-SERVER, in this case, will give the operator information about the accident.



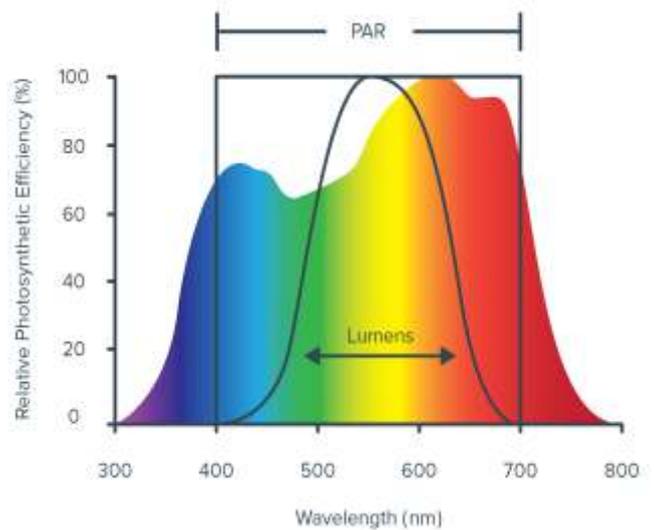
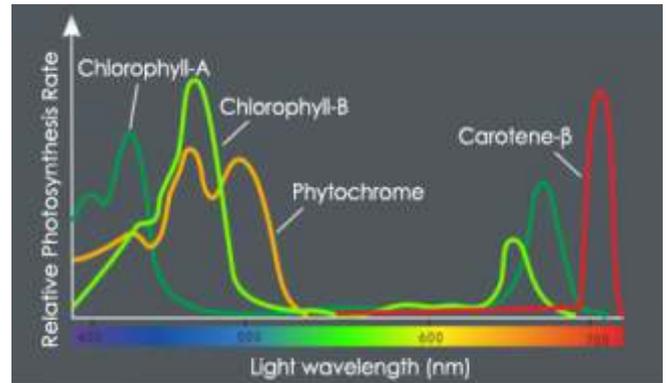
# PLANT LIGHTING

GROWING TECHNOLOGY

## CONTROL OF PLANT LIGHTING

The light period is the time during which the plant is illuminated during the day. Influences, mainly, on flowering. By adjusting the light period, you can influence the flowering period.

Under the influence of light in plants, a photochemical reaction occurs. Light reacts with chlorophyll types a and b, as well as beta-carotene. Chlorophyll A and B are responsible for photosynthesis. Photosynthetically active radiation (Photosynthetically active radiation, PAR) is radiation in the spectrum from 400 to 700nm which is used by photosynthesizing organisms in the process of photosynthesis. PAR is also absorbed by other photosynthetic pigments, for example, carotenoids beta-carotene, zeaxanthin, lycopene and lutein. But not all the light spectrum is equally absorbed by the plants. The best absorption of light by the plant occurs in the blue spectrum (440-460 nanometers, in red (650-670nm) and in far red (730-740nm).



For the PAR measurement, the Photo Dynamic Photon Flow Density (PPFD, Photosynthetic Photon Flux Density) is used. Measured in  $\mu\text{mol} / \text{m}^2\text{s}$  (micromole per square meter per second). The parameter PPFD can be measured in a certain range of wavelengths. For example, in assessing the quality of a luminaire, PPFD of the red spectrum: PPFD R (600 ~ 700 nm) can be measured and have a value of, for example,  $200 \mu\text{mol} / \text{m}^2\text{s}$ . In this case, the characteristics of the luminaire will be: PPFD R (600 ~ 700nm)  $203.32 \mu\text{mol} / \text{m}^2\text{s}$ .

Equally the PPFD in the blue and far red spectrum can also be measured. The total PPFD and will be a Useful Light Stream. To measure the amount of PAR, you must use a Quantum Sensor.

It is necessary to know that at different stages of plant development and for different plants, it is necessary to establish the optimum amount of useful light flux. The configuration and intensity of lighting devices should be selected to uniformly distribute light throughout the growing area. To determine the hourly PAR, you can use the following calculation:

$$\text{PAR per hour} = \left( \frac{100 \mu\text{mol}}{\text{m}^2\text{s}} \right) \left( \frac{60\text{s}}{\text{min}} \right) \left( \frac{60\text{min}}{1\text{hour}} \right) \left( \frac{1\text{mol}}{1 \times 10^6 \mu\text{mol}} \right) = 0,36 \frac{\text{mol}}{\text{m}^2\text{hour}}$$

Summarize the hourly PAR values for the daily PAR value.



# TEMPERATURE

GROWING TECHNOLOGY

## MONITORING OF AIR TEMPERATURE & NUTRITION MIXTURE TEMPERATURE

Temperature controls the growth rate of plants. As a rule, with increasing temperature, chemical processes proceed faster. Most of the chemical processes in plants are regulated by enzymes, which in turn operate in narrow temperature ranges. Above and below these temperature ranges, the activity of enzymes begins to weaken and, as a result, chemical processes slow down or stop. At this point, the plants are exposed to stress, growth is inhibited, and, eventually, the plant can die. The ambient temperature should be maintained at optimal levels for rapid and successful maturation.

Why is the temperature of the nutrient mixture important? Plants grow in nature in the soil, and the earth is a natural insulator of heat. This is the environment in which the roots live naturally. When roots are exposed to conditions outside their comfort zone, it becomes stress for the plant.

The optimum temperature of the mixture may vary slightly depending on the plant species and is between 20 and 24 degrees Celsius. You do not need to worry if the temperature of the nutrient mixture is slightly outside this range. After all, the term "optimal" means only the most favorable conditions. You need to start worrying if the temperature of the mixture reaches 27 degrees Celsius or falls below 16 degrees Celsius.

The high temperature of the mixture can cause the thermal stress of the aeroponic plants, and the extremely high temperature will cause the plant to close the roots and go into survival mode. Some of the symptoms include: wilting, forcing the plants to stop fruiting; drop in colors; soft and / or brown spots on existing fruits; low levels of dissolved oxygen; roots become black and die.

You need to buy a chiller for cooling the nutrient mixture. It is necessary to choose from a line of chillers for sea water. A large number of models are on the market.



The SMART-AEROPONICS has a temperature sensor for the nutrient mixture (combined with a conductivity meter for the mixture). If the temperature falls outside the normal range, the operator receives an alarm message.

The SMART-AEROPONICS makes measurements of air temperature indoors. If the air temperature falls outside the normal range, the controller sends a message to the operator. In turn, the operator must take measures for cooling (airing or conditioning) or heating the room.

For leaf surfaces, a non-destructive infrared thermometer is an economical tool for measuring leaf temperature. Measurement of the temperature of several places can show whether the photosynthetic plant is active, since it is difficult to determine whether photosynthesis stopped. Photosynthetic plants will have leaf stomata open for absorbing CO<sub>2</sub>, and open stomata will cool the leaf surface, so the plants are photosynthetic if the leaf surface is several degrees below the actual air temperature. If the surface of the leaf has the same temperature or slightly higher than the air temperature, then the stomata are probably closed to preserve water. This problem is much more common than many farmers think.

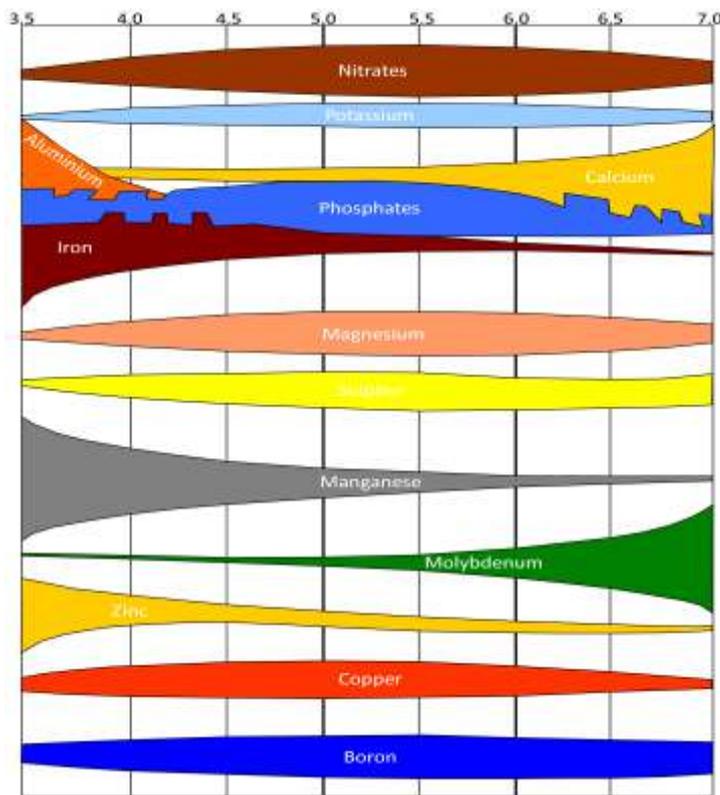
pH level

GROWING TECHNOLOGY

pH CONTROL

The pH of the nutrient mixture is a measure of the concentration of hydrogen ions. PH of the mixture can be in the range from 0 to 14. The neutral solution has a pH of 7. That is, there is an equal amount of hydrogen ions (H +) and hydroxide ions (OH-). Mixture in the pH range from 0 to 6.9 are considered acidic and have a high concentration of H +. Solutions with a pH of 7.1 to 14 are alkaline and have a high concentration of OH-.

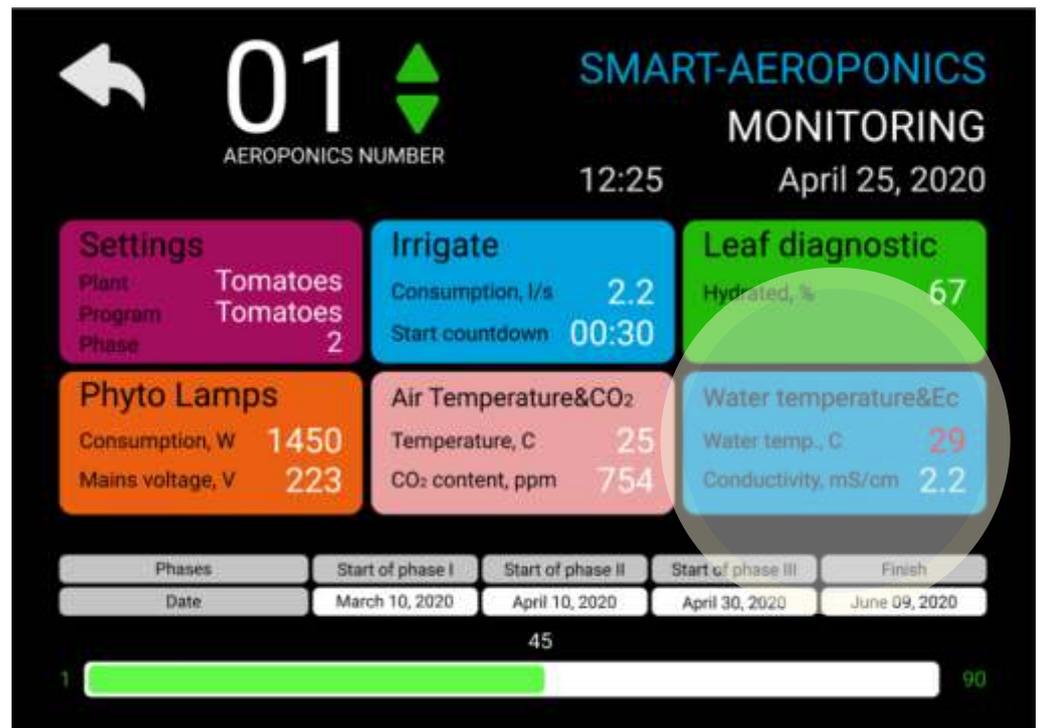
Mixture PH is important, as it controls the availability of fertilizer salts. Disadvantages of the assimilation of nutrients by plants can occur in ranges above or below the allowable value. Sources of water with a pH of more than eight are questionable for Aeroponics.



All plants on Aeroponics are grown at a weakly acid pH, regardless of the pH they prefer in the ground. In practice, this value should be below 6.5. What is the ideal pH value? Unfortunately, such a value does not exist. As can be seen from the table, nutrients are not assimilated by plants at the same pH value. Therefore, it is necessary to allow the pH to vary within acceptable limits. Due to the tendency of pH to increase, it is necessary to prepare the initial mixture with pH = 5.5. When pH reaches 6.5, it is necessary to take steps to lower the pH, but gradually, no more than 0.5 units per day.

SMART-Аэропоника не оборудована автоматическим датчиком уровня pH. Поэтому, в обязанности персонала должна входить процедура ежедневной проверки pH питательного раствора. Прибор должен калиброваться ежедневно.

В случае выхода значения за допустимые пределы необходимо добавлять в емкость с раствором соответствующее количество кислоты (для понижения значения) или щелочи ( для повышения значения). Если уровень pH раствора склонен к постоянному смещению, то это может быть связано с истощением питательного раствора. В этом случае, требуется замена раствора.



# ELECTRICAL CONDUCTIVITY

GROWING TECHNOLOGY

MONITORING OF ELECTRICAL CONDUCTIVITY OF A NUTRIENT MIXTURE

Electrical conductivity (Ec) is a measure of dissolved salts in mixture. The more salt content, the more Ec and vice versa. The Ec is expressed in miliSiemens per centimeter (mS/cm). Nutrients are absorbed by the plant, the level of the Ec is gradually decreasing, since less salt becomes in the solution. On the other hand, the Ec of the mixture increases when water is removed from the mixture through the processes of evaporation and transpiration. If the Ec of mixture increases, it can be lowered by adding pure water, for example reverse osmosis water. If the Ec decreases, it can be increased by adding a small amount of a concentrated fertilizers into the nutrient mixture. When monitoring the Ec concentration, be sure to subtract the baseline Ec of the source water from the level measured by the sensor.

If you intend to use tap drinking water to prepare the mixture, it must be remembered that this water is treated with chlorine. Chlorine and sodium are elements that significantly increase the electrical conductivity of water. When tap water is used to irrigate plants grown on a regular substrate, chlorine is usually harmless because it reacts with organic compounds to form chlorides that are not harmful to plants. In Aeroponics, chlorine is readily available to plants and can be harmful if it is present in concentrations of more than two parts per million (ppm). The tips of the roots will be burned. Therefore, tap water must be defended in an open container for at least 24 hours. It is useful to conduct a chemical analysis of water, even if the Ec and pH values fall within acceptable levels.

The level of electrical conductivity affects the morphology of the plant, the quantity and quality of the final product. This parameter varies the most from the variety of plants. The table shows the allowed intervals of the Ec level, depending on the phase of development of plants.

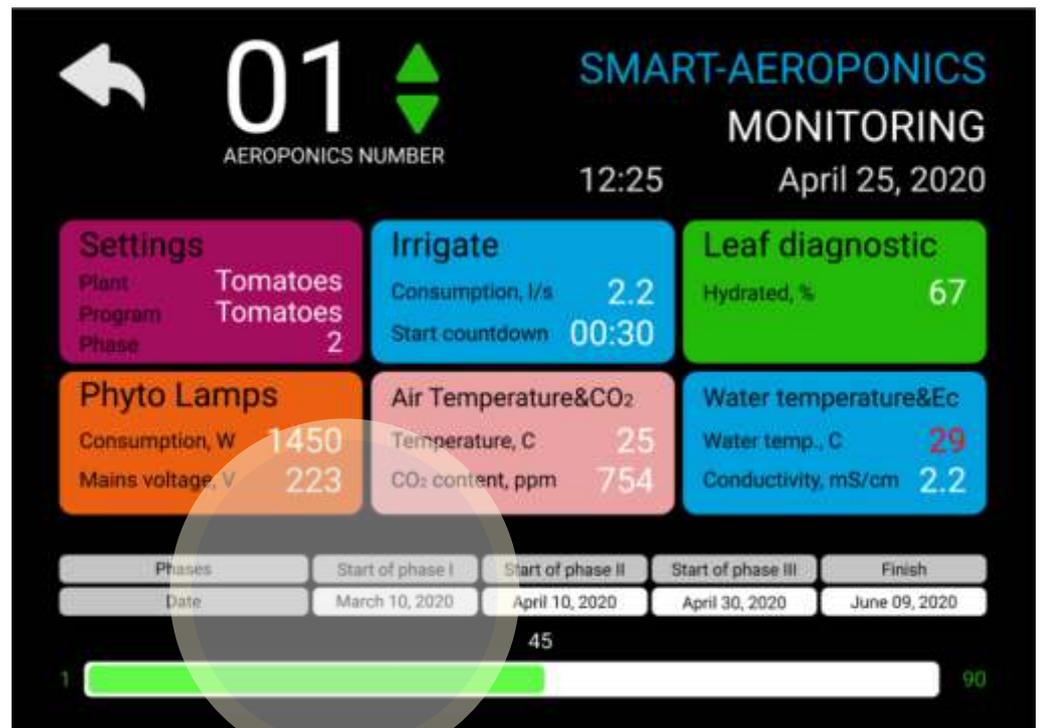
Electrical conductivity (Åc), mS/ñi	Stage of development of plants
0,2 – 0,4	Cuttings
0,8 – 1,2	Young rooted plants
1,6 – 1,8	Vegetation period
1,8 – 2,2	Flowering and fruiting
2,4 – 2,6	The latest stage

It should be noted that the table shows the total electrical conductivity, taking into account the conductivity of the water used for the mixture. Often, the conductivity of water exceeds the limits allowed for cuttings. In this case, it is necessary to use deionized water obtained by reverse osmosis.

The electrical conductivity must be adjusted in accordance with the temperature of the greenhouse. As the temperature rises, plants need to absorb more water. Plants should be helped by maintaining conductivity at a low level or even below the recommended level. The energy movement created by the absorption of water will bring nutrients and roots into contact. The plant will not suffer from lack of nutrition. On the contrary, if the room is cold, it is necessary to raise the conductivity to the upper value of the scale. A small transpiration and a decrease in absorption will require a more saturated mixture in order for the plants to receive all the necessary elements.

In addition, it should be borne in mind that the Ec of the same mixture changes with temperature. Below are the values of the electrical conductivity of a standard KCl (\*) 0.01 D mixture at different temperatures.

Temp. °C	KCl (*) 0.01 D mS/sm
15	1.142
16	1.168
17	1.194
18	1.220
19	1.247
20	1.273
21	1.300
22	1.327
23	1.354
24	1.381
25	1.409
26	1.436
27	1.464
28	1.491
29	1.519
30	1.547
31	1.575
32	1.603
33	1.632
34	1.660
35	1.688



# NUTRIENT MIXTURE

GROWING TECHNOLOGY

NUTRIENT MIXTURE

A growing environment will not be able to produce anything on its own. If you place the plants in an Aeroponics and will watering them with plain water, the plants will die from nutrient deficiencies. Water simply helps maintain the weight of plants, as well as the moisture and oxygen required by the roots. Nutrients necessary for plants are provided with a nutrient mixture during watering and moistening.

Every plant and even every variety or hybrid has optimal nutritional requirements. The composition of the mixture also depends on the chemical quality of the water.

**Preparation of the mixture.** When we add nutrients to the water, the Ec rises. In general, we should have Ec no higher than 2.0 mS/cm if we want to avoid problems with phytotoxicity. In Aeroponics, nutrient sources are water-soluble fertilizers that can be found on the market. It is inadmissible to use fertilizers containing sodium (Na) or chlorine (Cl). There are some fertilizers that increase the Ec by a larger amount than others. Plants need macronutrients: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and trace elements: iron (Fe), sulfur (S), manganese (Mn), copper (Cu) , zinc (Zn), boron (B), molybdenum (Mo) for normal growth. These elements should be easily dissolved in water so that plants can absorb them through their root system. In Aeroponics, only previously tested fertilizers should be used!

The concentration of macronutrients is usually expressed as milimol/liter or miliequivalent/liter (me/l). This can also be expressed in grams/liter (g/l) or as a percentage of N, P205 and K20. The concentration of microelements is expressed in milligrams/liter (mg/l) or in parts per million (ppm). It is useful to know some chemical terms (mole, equivalent) for the preparation of nutrients. Molecular weight is the sum of the atomic weight in grams of atoms that are part of the chemical formula of the compound. An equivalent number is obtained by dividing the weight of the compound in grams by its equivalent weight. The equivalent weight is calculated by dividing the molecular weight by its valence. One miliequivalent is 1/1000 of one equivalent.

Using the information in the table we can calculate the equivalent masses of potassium nitrate (118), ammonium nitrate (80), potassium phosphate (136.1) and potassium sulfate (87.2). These values can also be expressed in g/l.

Plants with a pronounced vegetative period, followed by periods of flowering and fruiting, require a completely different diet at different stages. In Aeroponics this is just a simple procedure of emptying and pouring a reservoir with a nutrient mixture.

Nutrient	Concentration (mg/l)
N	200
P	95
K	180
Ca	280
S	100
Fe	4
Mg	50
Cu	0.05
Mn	0.5
Zn	0.05
Mo	0.05
B	0.5

Cardinal changes in the composition of the nutrient mixture is one of the reasons why flowering and fruiting are accelerating. On the other hand, if you need to get a lush growth of green mass, you must use mixtures with a rich nitrogen supply.

In addition to the replacement of the nutrient mixture in connection with the transition of plants to another phase of development, there is a need to replace the mixture due to the excessive accumulation of certain elements. How often should this be done?

A reasonable average time is 15 days.

In the intervals between substitutions, there are three possible behavior scenarios for the mixture:

1. The best. Plants absorb nutrients and water, pH and conductivity levels remain stable. It is necessary to replenish the mixture with water, corrected for pH, and the appropriate amount of nutrients.
2. The surrounding temperature is high and plants will absorb more water than nutrients and the conductivity of the mixture will increase. This can lead to the death of plants. Intervention is necessary! Add water with the corrected pH. Knowing in advance about the seasonal increase in temperature, you can start work with a mixture with a low conductivity. Thus, when the mixture is concentrated, it will reach the optimum level of salinity.
3. With a decrease in temperature, plants will consume not so much water as dissolved salts. In this case, the amount of water will not change much, but the supply of nutrients will be depleted. Conductivity will decrease. In a cold climate, conductivity is increased by adding a small amount of nutrients to the mixture.

Plants need to receive all macro and microelements, but at different stages of development some elements are more necessary than others. Cuttings and young seedlings are needed in both nitrogen and potassium for leaf growth, and in phosphorus for the development of roots. Therefore, an equal mix of nutrients sets a good balance at this stage. Later, during vegetative growth, emphasis is placed on nitrogen and potassium. At the stage of flowering and fruiting the plant needs, mainly in phosphorus, as well as in magnesium and sulfur.

Choosing a nutrient brand is the key to success! Since the roots are directly in contact with the elements in the mixture, the salts must be clean. The substances must be 100% soluble in order to avoid clogging the injectors.

To prepare the mixture it is necessary to dissolve in the prepared water the manufacturer's recommended amount of WATER-SOLUBLE NPK FERTILIZER WITH MICROELEMENTS.

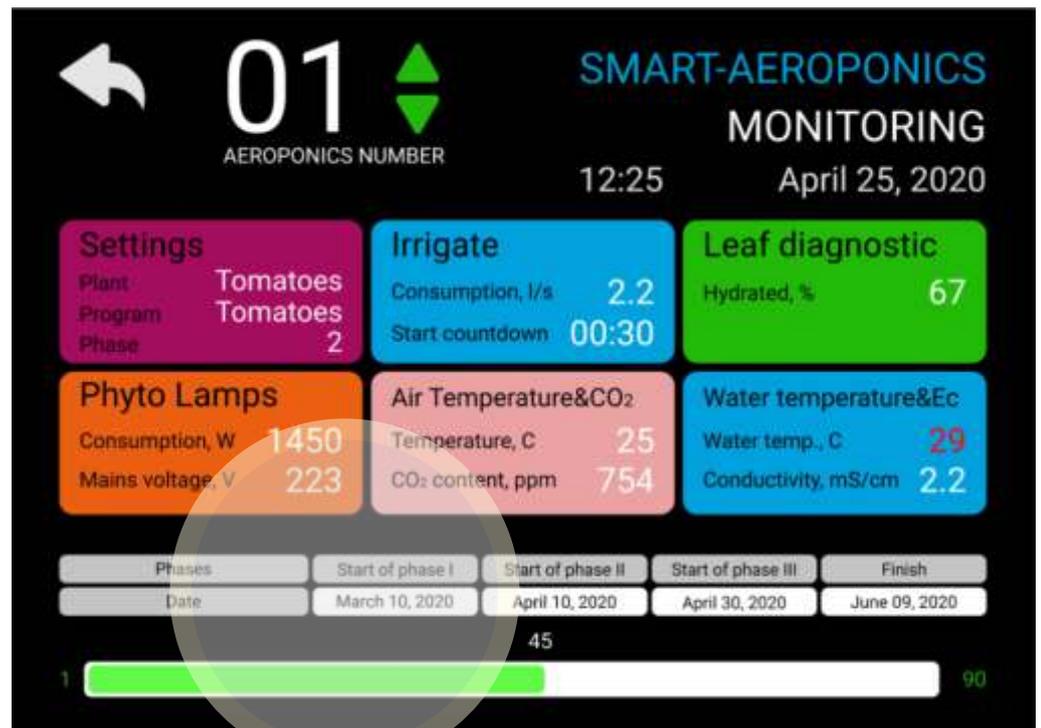
N - Nitrogen, N, Nitrogen

P - Phosphorus, P<sub>2</sub>O<sub>5</sub>, Phosphorus

K - Potassium, K<sub>2</sub>O, Potassium

As you can see, phosphorus and potassium are indicated in the formula in the form of oxides. To obtain correct information about the phosphorus content, multiply P<sub>2</sub>O<sub>5</sub> by 0.436. To obtain correct information on the potassium content, multiply K<sub>2</sub>O by 0.830.

When the manufacturer claims that the fertilizer contains secondary nutrients (calcium, magnesium, sulfur), their percentage should be indicated on the packaging. The same requirement applies to the content of trace elements.



# RECOMMENDATIONS FOR PLANTS GROWING

GROWING TECHNOLOGY

## RECOMMENDATIONS FOR PLANT GROWING

Sow plants better in a classical way - in trays or pots, maintaining a sufficient moisture and temperature above 22 Celsius degrees. To simplify the transplantation of young seedlings into an airborne installation, use a substrate that is easily washed from the root felt. Avoid the usual soil is difficult to wash off. Wait until the young seedling has two sets of true leaves (but not three). Carefully remove the sprout from the substrate and rinse the root felt with water. Place the sprout in a new medium, for example, wrap it with a thin sponge around the root neck of the plant and set it in the landing basket. The sponge should be moistened with a nutrient mixture. The landing basket is installed in one of the apertures of the aeroponics. The nutrient mixture must be checked regularly for Ec and pH. The temperature of the mixture should be optimal for a given plant species.

Later, when plants develop abundant foliage, the intake of nutrients increases.

Nutrient mixtures can be replaced at each stage of vegetation.

## RECOMMENDATIONS FOR CARE AT SMART-AEROPONICS

The strainer requires regular maintenance and cleaning (every month). At the end of the season, it is necessary to carry out cleaning and disinfection of pallets, pipes, nozzles and landing baskets. Salts tend to accumulate in filters and injectors. A weak acid, such as acetic acid or a dilute concentration of sulfuric acid, is effective in removing salts. 2% solution of Ca or Na hypochlorite should be passed through the system with the pump for 15 minutes, after which two or three cycles of pumping with clean water should be carried out as a rinse.

## POTATO GROWING IN AEROPONICS

Aeroponic methods optimize root aeration, which is the main factor leading to higher yields compared to classical methods of growing potatoes. Aeroponics can produce up to 10 times more yield, faster and at a lower price than conventional cultivation methods. Research conducted The International Potato Center (CIP) indicates that using this technology produces at least 80 tubers from a single plant. Harvesting in aeroponics is very convenient, clean and allows you to better control the size of the tubers by sequential cleaning. Removing dominant large tubers allows the initiation of new tubers, as well as the growth of existing tubers that can subsequently be harvested.



This technology has proven effective in producing disease-free seed potatoes. Plants also grow much faster with less water than other types of cultivation.



Aeroponics effectively uses the space of the greenhouse and air humidity to optimize the development of roots, tubers and foliage. Aeroponic systems allow the manufacturer to precisely control the nutritional and water regimes of the root zone and environmental conditions. There is also full access to the roots throughout the life of the plant.

According to the International Potato Center, most growers in developing countries do not use quality seeds due to high costs and lack of access. As a result, there is a high demand for cost-effective methods for producing quality seeds.

Aspects affecting growth, tuber initiation and yield.

#### Temperature

High temperature inhibit tuberization. Short day length and low temperature, especially at night, improve the initiation of tubers, increase the number of formed tubers.

Raising day or night temperatures above the optimum level dramatically reduces tuber productivity and high night temperature are considered more destructive. However, the reaction to temperature differs from one variety to another.

#### Photoperiod and light intensity

Potato originated in the Andes of South America, where it is cultivated at an altitude of 2000 to 4000 m above sea level in a region characterized by short daylight hours, high light intensity, cool temperatures and relatively high humidity. With long days, vegetative growth will be favorable, but tubers will eventually form three to five weeks later than plants growing on short days.

Light intensity has a direct effect on photosynthesis, which in turn affects the storage of nutrients.

#### Nitrogen

Nitrogen (N) is the most difficult to control nutrient, but the most crucial for potato quality. Nitrogen is necessary for the synthesis and production of protein. Nitrogen is an important component of chlorophyll, cell walls, amino acids and enzymes. Potatoes are more responsive to nitrogen compared to other nutrients. Increased doses of nitrogen can lead to excessive vegetative growth and delayed tuber maturation. Nitrogen is mobile in a growing plant, so its deficiency is manifested in older leaves in the first place.

In aeroponic greenhouses, the maximum possible level of control over the nitrogen content is achieved by changing the composition and concentration of the nutrient mixture.

#### Calcium

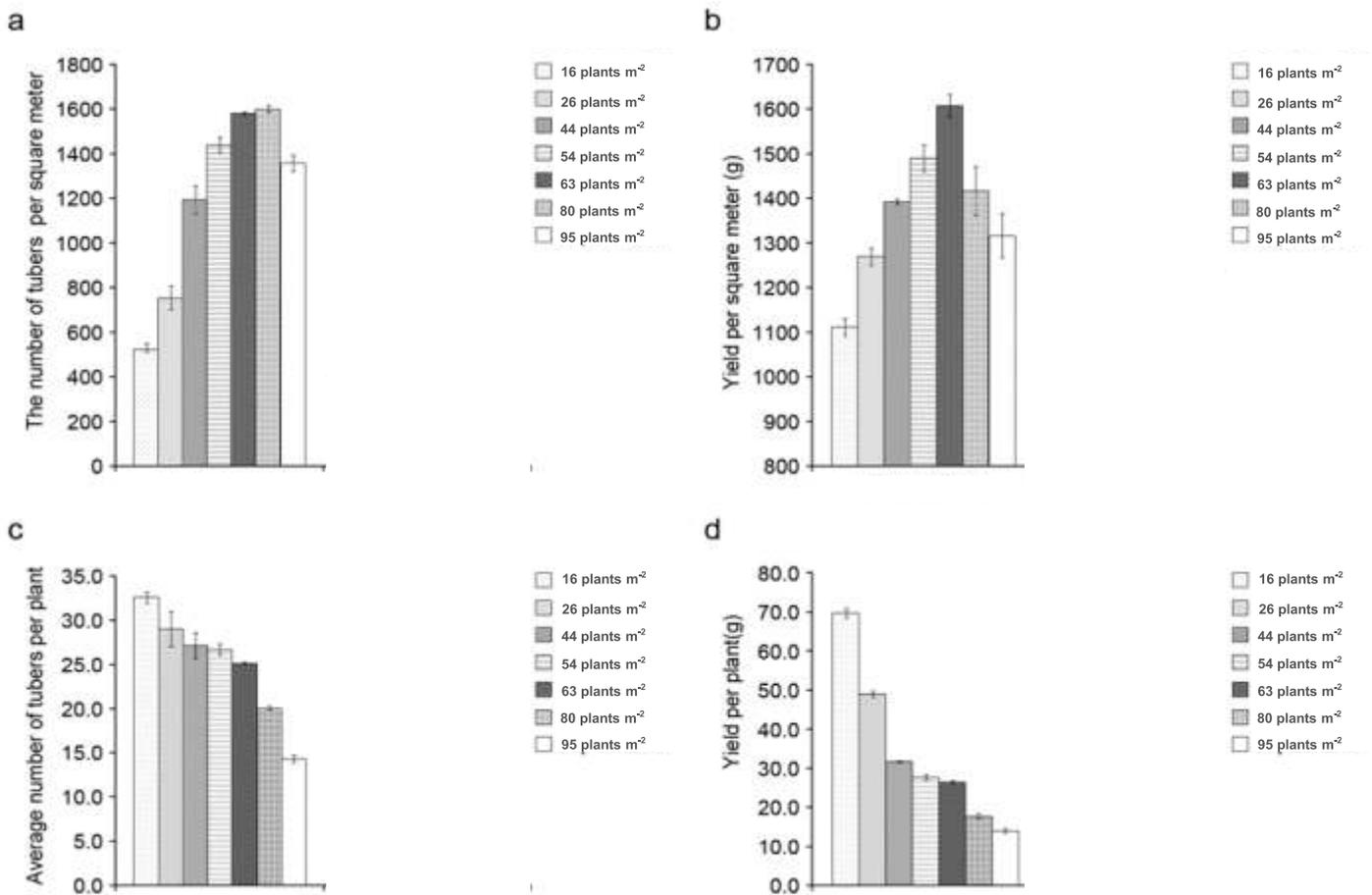
Calcium (Ca) is an important nutrient with many functions, such as strengthening cell walls, maintaining membrane stability and cell integrity. With insufficient intake of Ca in the plant, most crops produce lower yields, and the fruits during storage can be of poor quality and more susceptible to diseases and mechanical damage. Calcium is required at the tips of the stolons to initiate the tubers. Calcium stimulates the absorption of phosphorus and potassium at certain ranges of ion concentrations in nutrients. Ca appears to play the most important role in determining the susceptibility of tubers to cell damage. Despite the importance of Ca in the plant, a high concentration of this element has a inhibitory effect on the absorption of magnesium, which may be associated with a decrease in cell permeability.

Calcium deficiency can first be observed in the growing tips and the youngest leaves. These organs become deformed and chlorotic, at a late stage, necrosis spreads to the entire surface of the leaf. Affected foliage become soft due to dissolution of the cell walls.

When oxygen in the root zone is in a favorable concentration more tubers are produced, so potato plants will have more efficient and longer roots with more stolons and can produce more and more tubers. Harvesting in aeroponics is convenient, clean and provides excellent size control for sequential harvesting. The number and timing of non-destructive harvesting are key factors in optimizing the production of mini-tubers.

The tables below show the effect of planting density on the number of tubers and yield.

- a) the number of tubers per sq.m .;
- b) crop per sq.m .;
- c) the number of tubers per plant;
- d) crop yield.



Given this information we will calculate the following planting density of potatoes in an aeroponics:

- 64 plants per sq.m. for growing micro-tubers
- 16 plants per sq.m. for growing young potatoes for sale

## TOMATO GROWING IN AEROPONICS

Currently, there are tomato seeds on the market adapted for growing in Aeroponics, mainly hybrid varieties:

Gavrosh - early ripening (80-85 days from germination to fruiting) and 45-60 days when grown in Aeroponics stunted 40-50 cm. The plant is standard, does not require garter and pinching. Planting pattern is 30\*50 cm. The optimum temperature of the substrate or soil for germination is 26-29. It is not affected by late blight due to its high precocity, it gives the whole crop in 2 weeks. Harvest from one plant is from 1 to 1.5 kg. Fruits are round in shape, weighing up to 50 gr. Very sweet.

F1 Friend - precocious (90-95 days from germination to fruiting) and 55-70 days when grown in Aeroponics, stunted up to 70 cm. Planting pattern 40\*50 cm. Plants form 2-3 stems in the protected and open ground. Resistant to viruses and diseases. Good plant productivity. Harvest from one plant from 3.5 to 4 kg.

Alaska - precocious (90-95 days from germination to fruiting) and 55-70 days when grown in Aeroponics, stunted up to 70 cm. Planting scheme 40\*50 cm. Grow without the formation of bushes. Resistant to viruses and diseases. Good plant productivity. Harvest from one plant from 3 to 3.5 kg.

Bon Appeti - early ripe (90-100 days), 55-75 day when grown in Aeroponics, stunted up to 70 cm. It belongs to the group of carpal tomatoes. Planting 40\*60 cm. Mandatory garter plants. The plant is tall, unusually productive. Resistant to viruses and diseases. The mass of the fruit is 80-100g. Productivity of one plant is 5 kg.

Further we will consider this particular hybrid as the most effective for greenhouse cultivation.

At different stages of tomato growth are used various compositions of the nutrient mixture which is fed to the nozzles of the Aeroponics.

### pH (Acidity of the nutrient mixture)

The pH of the nutrient mixture for tomatoes should be between 6.0 and 6.3. In Aeroponics, the pH level must be monitored every day. For precise adjustment of the pH level there are various kinds of mixtures, powders and other formulations specifically designed for this purpose. Be sure to use gloves, respiratory and eye protection when using chemicals.

### EC (electrical conductivity)

The concentration of the nutrient mixture is measured by its electrical conductivity (EC), which determines the ability of the solution to conduct electricity. In an Aeroponics, conductivity is constantly monitored, which is expressed in units of milliSiemens/cm (mS/cm).

The nutrient mixture may have an EC from 1.5 to 3.0 mS/cm depending on the amount of each element. Some time after using the nutrient mixture, the EC will begin to fall, as the elements in the mixture are consumed by plants. When the EC decreases below an acceptable level you must completely replace the mixture. But nevertheless, the best mixture is to completely change the mixture every 3 to 4 weeks since plants consume elements in different quantities and some of them may not be enough while EC will be normal. We must discourage any possible shortage of substances otherwise the yield may be greatly reduced. Aeroponics is an exact science, but with experience and after some experiments you will find many advantages in comparison with the method of growing plants in the soil.

The optimal daylight hours are 12-16 hours. At least 8-10 hours a day.

Tomatoes are very sensitive and demanding on lighting. Abrupt transitions from low to high light levels are very harmful. At low light, the plant stretches, forms thin stems, the leaves become light and small, the inflorescence is laid above the 10th leaf. Inflorescences in conditions of low light intensity have few buds and flowers, fruits are not tied.

### How to plant tomatoes properly

Tomato seedlings are usually transplanted from corks into larger cubes on days 14-18 from the time of sowing the seeds. By this time, the seedlings develop the first full leaves, the ovary of the following appears. Prior to this, corks are placed in loose rows in a box for growing seedlings. Plants need space around.

A very important feature when growing tomato seedlings, which few beginner gardeners know about: briquettes with seedlings should be stacked on their sides for 7-8 days from the start of cultivation. This is done in order to get strong and strong plants with a powerful root system.

Once in a horizontal position, the seedlings bend up and form the adventitious roots at the base of the stem. During transplantation in mineral wool, briquettes are turned 180 degrees or laid on the other side. Such shock therapy pushes plants to develop additional roots that will sprout through the mineral wool, strengthening the plant, and subsequently help to easily survive the adaptation period of transplantation into the Aeroponics. Blocks are placed in pallets in a checkerboard pattern.

After 10-12 days, about three sets of leaves will appear, and the seedlings will be ready to land in the Aeroponics.

## CULTIVATION OF CUCUMBERS IN AEROPONICS

Cucumbers, by their nature, are climbing plants. The tied cucumbers produce much better quality fruits. Before sowing seeds, it is necessary to saturate the corks in the cassettes with a nutrient mixture with the following parameters: EC 2.0 mS, pH 5.2. Place one cucumber seed in the cork hole and sprinkle vermiculite on top. Cover with transparent polyethylene for 2-3 days and keep at a temperature of 23-25 ° C. After about 7 days when the plant is ready for planting place it in the landing basket of the Aeroponics.



Maintain the parameters of the nutrient mixture within: pH 5.5-6.2; Ec 2.2-2.7.

A very important point in the cultivation of cucumbers is the change in ambient temperature with the division into night and day (19-20°C and 21-22°C, respectively). On sunny days, it is recommended to raise the temperature to 24-25°C but maintain humidity within 70-80%.

Ideal conditions for a rich harvest are: temperature from 20 to 27 degrees, humidity about 75 percent. At low humidity, cucumbers will lose weight and become dry, and at temperatures below +15 (and above +42) they simply stop growing and die.

During the growing season (shoot growth before fruiting) it is necessary to ensure that the lower part of the shoot (up to the fifth leaf) does not have an ovary, otherwise the growth of the upper part will stop. All stalks are artificially chopped until the first cucumber ripens.

If with the usual method of growing cucumbers ripen within 50 days then in Aeroponics this period decreases to 43 days.

Cucumber is a photophilous plant for a short day (10-12 hours). If the day lasts longer the periods of flowering and fruiting are delayed and the plant grows prematurely and gives a smaller yield. With insufficient lighting cucumbers grow poorly, they shed ovaries and become more susceptible to disease.

To get a good crop you need to build a good support. When the stalk of the cucumber reaches about 30 centimeters in length and 4-6 true leaves appear on it you need to start tying it up. Before that time the cucumber does not need support but at a later date with the garter you can easily break the stem.

Typically, the distance between plants is 30 to 50 cm in which case they will not overlap much. Be sure to pinch stems longer than 2 meters, otherwise they will begin to obscure the cucumbers with grown shoots, as a result of which the crop may decrease significantly.

When preparing a nutrient solution it is necessary to take into account that in the earliest period cucumber consumes no more than 10% of all nutrients, up to 20% when organizing roots and the remaining 70% is used during active growth with continuous fruiting. Therefore, the Ec should not exceed 1.0 with a gradual increase to 2.5-3.0.