

METHOD OF AUTOMATIC IRRIGATION AND CONTROL OF THE ROOT SYSTEM OF GROWING HYDROPONIC GREEN FORAGE

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Abstract

Due to the lack of fodder base in agriculture, especially in animal husbandry, it became necessary to use various other methods for growing and further providing it. One of these systems is more optimal hydroponic system of growing green fodder indoors. Due to the fact that in hydroponic technology the root system in the production of green fodder is the main part, for its fruitful development, systems for the use of irrigation automation were considered: a system of drip and aeroponic irrigation systems, as well as automation tools, namely the operation of a timer (electronic time relay), which are used when the pump is running with a time delay.

Key words: hydroponic method, green fodder, root system, types of plant watering, automation equipment, timers (electronic time relay).

Introduction. At present, with the increasing needs of the population in agricultural products, it became necessary to create conditions for the development of animal husbandry. And this means, in turn, the development of the food base. Today, due to the decrease in agricultural land, the food base for providing animals with green fodder has sharply decreased. Therefore, in this case, the hydroponic method of producing green fodder can be used as an alternative method for providing a forage base [1,2,3].

The development of hydroponics is associated with an increasing interest in "small farms", where plants can be grown in a small area, this is an ideal water saving solution and where many crops can be harvested per year [3-6].

The hydroponic method of growing green fodder is without soil growing plants. When growing them, one of its main properties is the root system of plants. With the help of the root system, plants nourish themselves with water, as well as the necessary nutrients [7,8,9].

Statement of a question. Development of a growing system for a hydroponic green fodder production system. Its essence is as follows: Fresh hydroponic green food is suitable for feeding almost all animal species [10]. In the production of hydroponic green fodder, it is necessary to provide three main conditions for the requirement of plants: provide the roots with a balanced supply of fresh water and nutrients in a timely manner; - provide air exchange between nutrients and roots; - constantly protect the roots from drying out.

As a nutrient medium for plants in hydroponics, a special solution acts, containing all the compounds necessary for the plant to develop fully. Since the root system is the main part in the production of hydroponic green fodder, we will consider various methods of automated plant watering [11,12].

Research methods. Drip irrigation systems are becoming more and more popular. They allow you to create in a short time and at low cost an irrigation system for both traditional land cultivation and for hydroponic installations such as drip irrigation.

The research used the method of automatic control of irrigation, lighting control, as well as temperature control in greenhouse conditions for growing hydroponic green fodder.

An analysis of a number of scientific sources [4-6] confirms that, in practice, many developers deal with various types of hydroponic systems. In general, they can be divided into two main groups: "Passive" and "Active". In "Passive" systems, the nutrient solution is not subjected to any mechanical action and is delivered to the roots due

to capillary forces. Such systems are called wick systems. All "Active" systems, one way or another, require the circulation of the nutrient fluid, which is achieved using pumps [13].

Most of them need a parallel aeration system (oxygenation of the nutrient solution). There are hundreds of modifications to hydroponic systems, but they are all variations (or combinations) of six basic types:

1. Wick system
2. Deep water culture system (floating platform method)
3. System of periodic flooding
4. Nutrient Layer Technique
5. Drip irrigation system
6. Aeroponics

Let's consider several types of the method of watering plants in a hydroponic system. The drip irrigation method is the most common hydroponic technology. This method of watering works extremely simply - a timer-controlled pump, a nutrient solution is fed directly to the substrate, directly under the base of the plants, along the main line through tubes. This method of drip irrigation can be reversible and non-reversible [14].

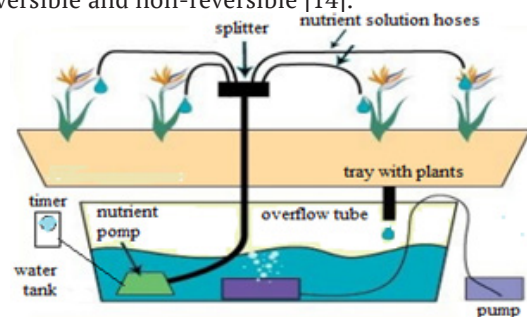


Figure 1. Scheme of the drip irrigation system.

In reverse drip irrigation methods, excess nutrient solution is returned to the storage tank and reused. In non-reversible systems, the timer for feeding the nutrient solution must be set so that there is no excess moisture. In non-reversible systems, the timer for feeding the nutrient solution must be set so that there is no excess moisture. The non-reversible drip irrigation method is less troublesome to maintain, since the nutrient solution is not reused, and therefore there is no need to monitor the pH level and the concentration of nutrients in the solution. However, the non-reversible option requires a very precise timer setting. Reversible methods do not require very precise timer settings, because the excess nutrient solution is returned to the storage tank for a repeat cycle and the risk of flooding of the roots is minimized. However, in this

case, one should not forget about constant monitoring of the PH level, as well as the composition of the nutrient solution [15,16].

Another method of irrigation system is aeroponics (air system). The aeroponic system is the most high-tech system of all existing ones. When using this hydroponic system, the roots of plants are in the air. The nutrient solution is sprayed directly onto the roots, enveloping them in a mist of nutrient suspension.

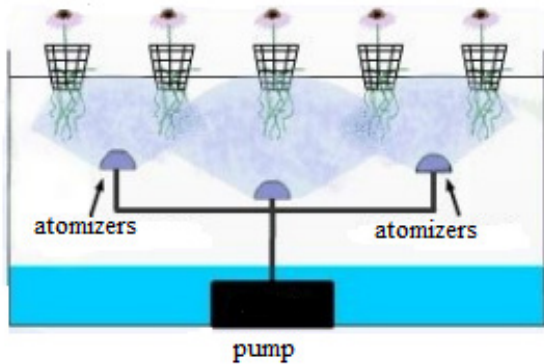


Figure 2. Scheme of aeroponic irrigation system.

This method of supplying the nutrient solution ensures maximum oxygen supply to the roots. No hydroponic system of a different operating principle can compete with an aeroponic system. Plants grown in aeroponics have an outstanding growth and maturation rate. Aeroponic systems require a very precise timer setting because the pump must supply a nutrient solution every few minutes for a few seconds and do so at a precise frequency. The nutrient solution in the aeroponic system is supplied by a medium or high-pressure pump and sprayed onto the roots through nozzles [17].

Research results. For the above methods of watering hydroponic green fodder in a hydroponic system, in our studies, an automatic nutrient solution supply system was implemented, timers (electronic time relays) and control of the lighting system and environmental control were used for watering, as well as turning the pumps on and off at the set time.

Choosing a platform for process automation:

Automation of the process is carried out using the Arduino UNO R3 microcontroller, which is a tool designed for designing electronic devices (Fig. 3).



Figure 3. Measurement of the root system by the sensor.

A hydroponic experimental plant for growing green mass was assembled and implemented at the Department of Automation and Process Control of the National Research University "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers". The system is based on the Arduino UNO R3 module.

Arduino boards were chosen by us based on the following

considerations: they are widely available, inexpensive and various programming materials are available on the Internet. The Arduino open source software is used to work with Arduino systems. The code can be written in the programming language of the same name, suitable for Arduino microcontrollers. To connect sensors and modules to the Arduino Uno R3, it is convenient to use Trauma shield, which makes it possible to connect to a computer using a USB cable.

WiFi monitor and TDS/EC/PH/Temp controller is a modern device that allows you to remotely monitor the parameters of the solution and automatically monitor pH and EC. Broadcasts data online and records the history of changes in indicators. It has two relay outputs for PH and EC control. It works through the Tuya Smart app.

Timers (electronic time relays) are used to transmit commands from one electrical circuit to others with certain pre-set time delays. Which were used in automation and control schemes in hydroponic systems [18].

The electronic time relay in our developments works according to a given algorithm:

- Turn on;
- Management;
- On shutdown.

In electronic time relays, analog and digital circuit solutions are used to obtain a time delay. As a rule, these are integrated (analog) circuits or digital logic devices (timers).

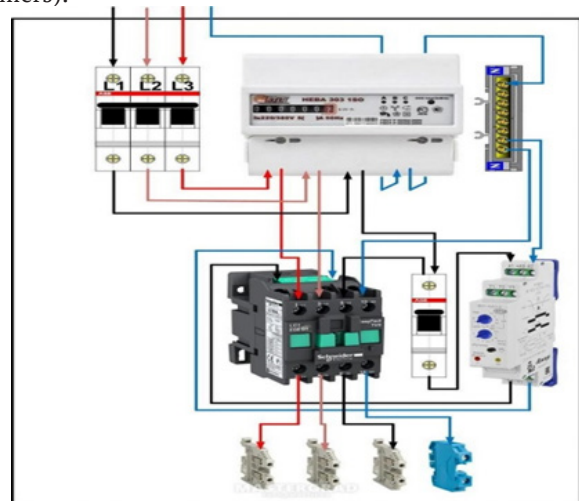


Figure 4. Timer (electronic time relay).

Figure 4 shows a timer (electronic time relays) and its connection diagram, which can be used to turn on the pump with a time delay. Also, when growing green fodder by the hydroponic method, where an automated system is used, in addition to timers (time relays), various automation tools are used, which are described in [19].

The principle of operation

The installation is based on a control unit based on Arduino UNO R3 module TDS/EC/PH/Temp, to which sensors and actuators are connected. The controller, thanks to the built-in Wi-fi module, connects to the Internet and sends it the necessary settings from the control panel and sends it the indicators of acidity, concentration, power consumption, the number of days since landing.

The second part of the system is topping-up modules. These are independent devices with their own controller, which, at the command from the control controller, are turned on to top up the liquid (acid, alkali, concentrate A, B, or pure water). Thus, the parameters of the nutrient solution are automatically adjusted. We use five topping

modules in our system, however, if you don't need any of these modules, you don't need to install it, and you don't need to edit the sketch.

The parameters of the nutrient solution are measured every half hour: pH at 0 minutes of every hour, and pm at 30 minutes of every hour. When starting the measurement manually via the Control panel, both parameters are measured simultaneously. If the parameters deviate from the specified range, automatic correction is activated using the topping modules [20].

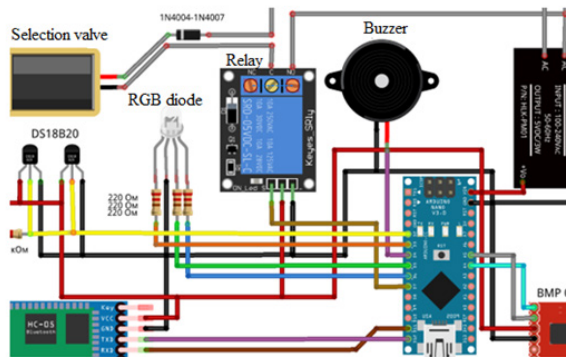


Figure 5. Generalized scheme of the control of the hydroponic system.

Findings. Based on the studies discussed above, it can be stated that in hydroponic systems when growing green fodder for livestock, the use of a timer (electronic time relay) to control humidity, temperature of the plant root system will allow a systematic approach to controlling the level of plant growth, as well as monitoring irrigation in general, and control of the lighting system, which makes it possible to automate the irrigation system and consider the control of the considered parameters in hydroponic systems [20].

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