Control unit for the dosed feeding of the nutrient solution into the industrial aeroponic installation system

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Abstract. The development of the agricultural sector for the production of promising varieties of potatoes is limited to viral infections, as well as to the use of poor quality seed material. The most effective way of producing elite potatoes seeds is aeroponic system of potato seeds breeding. To improve the installations performance and reduce the cost, it is proposed to use the gate control unit for dispensing nutrient solution to the root system of potato plants. In the course of research, it is possible to adjust the designed control unit for filing a nutrient solution at certain intervals and automate industrial aeroponic installations operating at large areas.

Keywords: aeroponic installation, nozzles, electro-mechanical drive

1. Introduction

Potato is one of the main products and a source of vitamins. In conditions of Siberia, in connection with lesions of viral infection, potato cultivars resistant to biotic and abiotic factors of the environment are not cultivated. Relevant is the implementation of effective ways to produce elite seed material. One of the effective methods for the potatoes seed production is the aeroponic one.

Aeroponics is the method of growing plants without the use of aggregate medium. Providing plants with nutrients and water is carried out by spraying the nutrient solution to the roots of plants [1, 2, 3]. Plants are fixed by a support system, while the root system of plants is suspended in the air. However, for successful industrial cultivation of elite potato seeds, optimal cultivation conditions, mainly dosed and the periodic feeding of nutrient solution should be provided [4].

2. Problem Statement

The aim of the research was the development of the control unit technological system for dispensing nutrient solution in aeroponic industrial installations for the system automated operation with the option of pre-setting operating modes.

3. Theory

With the aim of obtaining seed potatoes methods of growing potato tubers in conditions of closed and open soil are used. There are currently a large number of methods of efficient obtaining the virus tested potato stem cuttings. The most common method of obtaining seed potatoes are hydroponic installations using various inert substrates [5, 6, 7]. However, there are serious hydroponic systems limitations due to the insufficient aeration of plant roots [8, 9]. By far, the most effective methods are aeroponic installations [10].

Aeroponics is a non-substrate method of potato plants cultivation including mini-tubers obtaining. Unlike the methods of hydroponic production, in aeroponic installations, nutrient solution is sprayed on the plants root system. The nutrient solution spray periods are interlaced with the periods of plant roots aeration [11, 12, 13].
The most significant element in design and technology solution for the aeroponic installation is nutrient solution supply control unit for providing regular intervals and prescribed dosages. When the period and the intensity of solution spraying are chosen incorrectly, oppression of plants growth processes and hydration of the root system can happen. To provide the effective work, there is a need to develop domestic installations for aeroponic systems automated control with a possibility of presetting the operation modes.

Aeroponic system is proposed in which the required pressure at nozzles for irrigation of the root system has no pumps. The required pressure is provided by the location of the tank with nutrient solution at a certain height at the plants irrigation blocks level (Figure 1).

For more efficient operation of installations, units for controlling the feeding of nutrient solution, which feed the dosed solution to the plants root system into the trays at the pre-set time intervals and can be manually controlled, should be implemented into the aeroponic systems.

4. Experimental results
A control unit for dosed periodic feeding of nutrient solution into the industrial aeroponic installations working under pressure was designed at the department of mechanical engineering technology, Omsk State Technical University. Figure 2 shows a control unit for aeroponic installations.
Figure 2. Control unit for dosed feeding of the nutrient solution into aeroponic installation at specific time intervals

Using the nutrient solution feeding control unit relay, it is possible to specify a certain time of solution feeding and a certain number of cycles, including pre-setting the hours, minutes and seconds of the aeroponic installation operation. The control unit can be configured for automatic and manual mode of operation depending on the purpose of the experiments when working with aeroponics. Using LEDs the operating mode of the control unit (START, STOP) is displayed. The most important advantage of this control unit (BU-1) is the possibility to automate the different time periods of obtaining mini potato tubers in large industrial scales of aeroponic units. Figure 3 shows a picture of the assembled control unit (BU-1).

Figure 3. Picture of a nutrient solution feeding control unit in aeroponic installations

As a result of experiments on the development of the industrial aeroponic installation control unit, a control unit for the dosed feeding of the solution with different operating modes and a periodic supply of nutrient medium to the root system of potato plants was developed.
5. Discussion
As a result of experiments to design the nutrient solution feeding, a control unit for the host unit for feeding the nutrient solution was developed. It was found that the control unit (BU-1) has the undoubted advantages of automation capabilities for obtaining elite virus-free potato planting material. When designing a control unit, control relays were installed, which allow to specify the work at specific time intervals (hours, minutes, seconds) and set the cycles, which allows to spray dosed nutrients providing breaks for plants aeration. The designed control unit (BU-1) can be used in industrial installations and cultivation of potato micro-tubers in large areas. Creating microclimate for plants, which includes feeding and aeration of the root system will have a positive impact on the growth of potato plants, as well as obtaining mini tubers.

6. Conclusion
The results of the research include the analysis of Russian and foreign publications concerning the efficiency of aeroponic and hydroponic systems for producing potatoes planting material. It was found that the most efficient method of obtaining virus-free potato material is the aeroponic one. However, plants planted in aeroponic conditions, need a regular feeding of nutrient solution by spraying at specific time intervals; besides, the root system needs periodic aeration. As a result, the control unit with relay control was developed for managing dosed nutrient solution feeding, including cycles, time and modes of automatic and manual operation depending on the purpose of the experiments.

References
[1] Filho S and Barros J 2018 Am J Potato Res 1-8 Available at: https://doi.org/10.1007/s12230-018-9644-2
[2] Kang J G, Kim S Y, Om Y H and Kim J K 1996 J Kor Soc Hortic SC 37 24-27
[3] Chang D C, Park C S, Kim S Y and Lee Y B 2012 Potato Res 55 69-81
[4] Terentyeva E O and Tkachenko V 2017 News SUMMARY 1 75-82 (Russian)
[5] Navarrete J 2004 Evaluacion de dos micropropagacion de metodos para la produccion de semilla de prebasica categoria dos variedades de papa bajo condiciones de invernadero. UCE, Quito (Ecuador): MSc. Thesi. 12 457-502 (Spanish)
[6] Navarrete J 2004 Trabajo de grado presentado como requisito parcial para optar titulo Ingeniero Agronomo. (Quito: Universidad Central del Ecuador, Facultad de Ciencias Agrícolas) pp 234-238 (Spanish)
[7] Chang D C 2000 Am J Potato Res 77 395-403
[8] Gislérod H R and Kempton R J 1983 Sci Hort 20 23-33
[9] Nikolaev A B and Z. Ni 2014 Int J Adv St. 2 15-21
[10] Kang J G, Kim S Y, Om Y H and Kim J K 1996 J Kor Soc Hortic Sc. 37 24-27
[11] Bobrow J E, Dubowsky S and Gibson J 1985 Int J Robotic Res. 4 (3) 3-17
[12] Broćić Z, Milinković M, Momčilović I, Poštinić D, Oljača J, Veljković B and Milošević D 2018 J Proc and En Agr 22 (1) 49-52
[13] Valkov V M and Vershinin V E 1977 Automated control systems of technological processes (Leningrad.: Mechanical engineering)