The effect of activated water parameters on glucose synthesis during photosynthesis

Alexander Grishin, *Andrey* Grishin, *Vladimir* Grishin, and *Inna* Knyazeva*

FSBSI "Federal Scientific Agroengineering Center VIM",109428, Russia

Abstract. The article presents the results of experimental studies to identify the nature of the relationship between the activated water parameters and the efficiency of glucose synthesis of vegetable crops using the example of set onion. It is noted that hydroponics is a method of growing plants in which nutrients can be artificially efficiently supplied to crops in mineral form as solutions. Solutions prepared on the basis of activated water are a new direction of hydroponic technology, which is insufficiently studied today. At the same time, to determine the degree of water activation, along with such indicators as pH and ORP, the activation degree in biology is usually expressed in terms of rH_2 index, which is a complex derivative of these two variables pH and ORP, that is, it most fully characterizes the properties of activated water. It is believed that the rH_2 scale varies from 0 to 42. Almost all plants feel comfortable at rH_2 25-35. For the experiment, onion bulbs were planted in the amount of 7 pieces for irrigation with a nutrient solution based on non-activated water (control samples) and 7 bulbs for irrigation with a nutrient solution based on activated water. Then, the concentration of glucose Cg was measured using a triple-repeat digital refractometer MA873 for each sample and the average value was calculated for the cases of non-activated and activated water. Throughout the experiment, the same conditions for growth were maintained in terms of temperature, illumination, humidity, gas composition and others affecting the development of the plant, except for the parameters of nutrient solutions. As a result, it was revealed that the nature of the change in Cg when fed with solutions based on activated water at a certain value of the parameter $rH_2 = 31$ has the greatest increase in Cg = 3.51%. At the same time, the measured Cg values at different values of the activation parameter rH_2 have a fairly close relationship, as evidenced by a fairly high correlation coefficient between them, equal to 0.73.

1 Introduction

A hydroponic system is a method of growing plants in which nutrients in the form of solutions can be artificially efficiently supplied to crops in their mineral form. This method has many advantages, including reducing pest problems, a constant supply of nutrients to the roots, and high productivity [1]. Solutions prepared on the basis of activated water are a new direction of hydroponic technology, which has not been sufficiently studied to date.

* Corresponding author: knyazewa.inna@yandex.ru

For example, the mechanism of the effect of activated water properties on photosynthetic processes in plant systems is explained, which determines the effectiveness of its use in crop production. Nevertheless, studies of the effect of activated water characteristics on the efficiency of production processes have not been conducted. A similar situation can be seen in the writings of other researchers. Activated water affects the growth rates of crops, namely height, characteristics of the root system (rice and wheat), nevertheless, in these works there is no information about the type of activated water used, its parameters and characteristics [2, 3]. Meanwhile, the issue of using activated water with the most optimal characteristics for the efficient flow of production processes remains open.

The purpose of these experimental studies is to identify the nature of the functional relationship between the parameters of activated water and the efficiency of glucose synthesis of vegetable crops using the example of set onion.

Activated water [4] is characterized by such parameters as: hydrogen index or pH acidity [5] and redox potential (ORP) [6].

As is known in crop production, the pH of the soil or hydroponic solution controls the availability of nutrients to the plant. Plants need nutrients in a water-soluble form so that they can be taken into the juice stream and transported to the part where they are required [6]. Changing the pH can modify the form of nutrients and, therefore, reduce or increase their availability, due to the fact that different nutrient solutions are in different pH ranges. In hydroponics, the ideal pH range is from 5.8 to 6.2, and for soil it is slightly higher, closer to 6.5. This range provides the plant with the maximum amount of most nutrients [7].

It is known that metabolism is associated with the system redox potential [8].

If there are various oxidizing agents in the water and reducing agents in the mixture, then the redox potential can be determined experimentally using a voltmeter with a high input resistance value or a pH meter in the potential measurement mode. Instead of a glass electrode, a platinum indicator electrode is taken, on which the potential of the E_{exp} is determined. After the measurement, it is necessary to switch to the potential value according to the standard hydrogen scale Eh (relative to the standard hydrogen electrode), using the ratio $Eh = (E_{exp} + 0.2)$ B [9].

Meanwhile, there is another parameter that is complex one [10] – a derivative of these two, that is, it most fully characterizes the activated water properties. The value of the redox potential in biology is usually expressed in terms of the rH_2 index.

Since the potential of a normal hydrogen electrode is conventionally considered to be zero, the Nernst equation is transformed as follows: at 20° and the conversion of natural logarithms to decimals is 0.029 n(F), and the negative pressure lg of molecular hydrogen, by analogy with pH, is denoted by rH_2, then $E_h = 0.029$ (lg $[H+]^2$ — lg $[H_2]$) or $rH_2 = (E_{exp} + 0.2)/0.029 + 2pH$.

It is believed that the rH_2 scale varies from 0 to 42.

Most plants develop optimally at rH_2 25-35.

2 Materials and Methods

The following parameters and patterns were chosen as the object of research: activated water in the form of the rH_2 index for different pH values and the nature of the dependence of the synthesized glucose concentration in the form of rH_2indices.

The shoots of set onion of the "Carmen" variety were used as the subject of research.

In the experiment, onion bulbs were used in the amount of 7 onion samples for irrigation with a nutrient solution based on non-activated water (control samples) and 7 onion samples for irrigation with a nutrient solution based on activated water. Before measuring the values of glucose concentrations, the bulb samples were fed for 7 days, the experiment began on 02/19/2024. Hereafter, glucose concentration in stroma was measured with the help of

refractometer MA873 with triple repetition of each sample, average value was calculated for non-activated and activated water.

Since the task of research is to study the nature of dependence, three values of rH_2 – 28, 29, and 31 - will be used as an argument. These values will be the parameters of the activated water used to prepare the irrigation solution. Control samples were watered with ordinary water and glucose concentrations were measured twice to obtain values of changes in synthesized glucose during its synthesis under unchanged conditions. That is, during the entire experiment, the same growth conditions were maintained in terms of temperature, illumination, humidity, gas composition and others affecting plant development, except for the parameters of nutrient solutions.

It was assumed that the initial data obtained for non-activated water were the starting point for further analysis and were not changed in experiments with activated water. When analyzing experimental data, the concentration of synthesized glucose Cg was calculated for solutions based on activated water with different rH_2 parameters, subtracting the values of Cg obtained for non-activated water. At the same time, it was considered that the increase in Cg during subtraction tripled in the last experiment, and doubled in the penultimate one. The average values were used for the analysis. Next, the dependences of the average glucose concentration on the values of the activated water parameters rH_2 were constructed and the nature of this dependence was determined.

3 Results and Discussion

The results of measurements and calculations were summarized in Table 1, which shows the results of the concentration of Cg glucose synthesis for feeding solutions based on ordinary non-activated water and for feeding solutions based on activated water. As well as the results of calculations of the change in Cg for feeding solutions with non-activated water and activated water for three rH_2 values. It can be seen from the table that the changes in Cg when fed with activated water significantly exceed the similar data of the control sample (CS).

Table 1. The results of measurements and calculations of the concentration of Cg glucose when fed with solutions based on activated water and non-activated water.

Sample No.		1	2	3	4	5	6	7	Av. val.
Non-activated water for feeding control samples CS	Synthesis of Cg, % 02/26/2024.	3.8	3.2	4.4	2.6	2.8	3.3	3.0	3.3
	Synthesis of Cg, % 03/05/2024.	3.9	3.5	4.6	2.9	3.1	3.6	3.7	3.6
	Changes in Cg, % CS	0.1	0.3	0.2	0.3	0.3	0.3	0.7	0.3
Activated water	$rH_2 = 28$	3.1	2.9	3.8	2.8	3.18	3.4	4.0	3.3
	Changes of Cg, %02/26/2024.	3.0	2.6	3.6	2.5	2.88	3.1	3.3	3.0
	$rH_2 = 31$	2.6	4.6	4.5	4.4	4.6	3.5	4.8	4.1
	Changes of Cg, % 03/05/2024.	2.4	4.0	4.1	3.8	4.0	2.9	3.4	3.5
	$rH_2 = 29$	3.1	3.46	4.0	3.6	3.6	3.9	3.5	3.6

	Changes of Cg, % 03/12/2024.	2.8	2.56	3.4	2.7	2.7	3.0	1.4	2.7

Figure 1 shows these results visually. The changes in the concentration of Cg glucose synthesis in the test samples in comparison with the control ones are shown here.

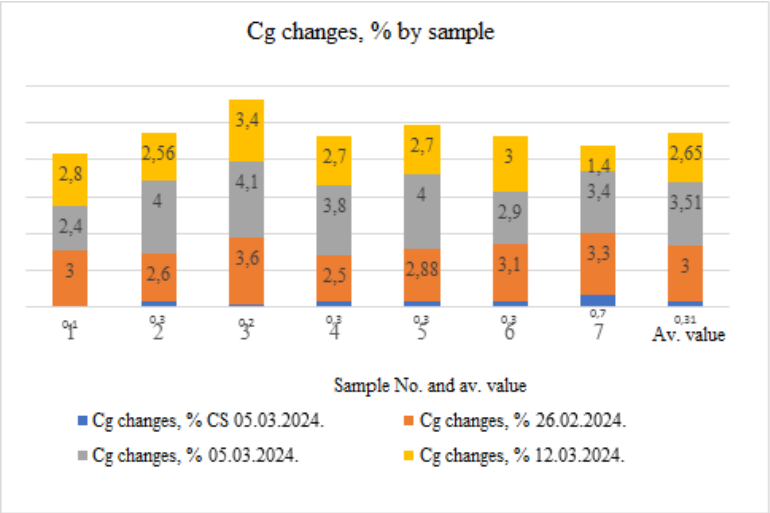

Fig. 1. Changes in Cg by samples, %.

To identify the nature of the changes in Cg, the studied values were summarized in Table 2, which shows the measured and calculated indicators of water activation and the average values of the Cg glucose concentration corresponding to these indicators, a diagram of the change in Cg was constructed using them when fed with solutions based on activated water, Figure 2.

Table 2. The change in the average Cg value depending on the parameters of activated water rH_2

Activated water parameter, rH_2	28	31	29
Change in the average value C_g, %	3	3.51	2.65
Correlation coefficient	0.73		

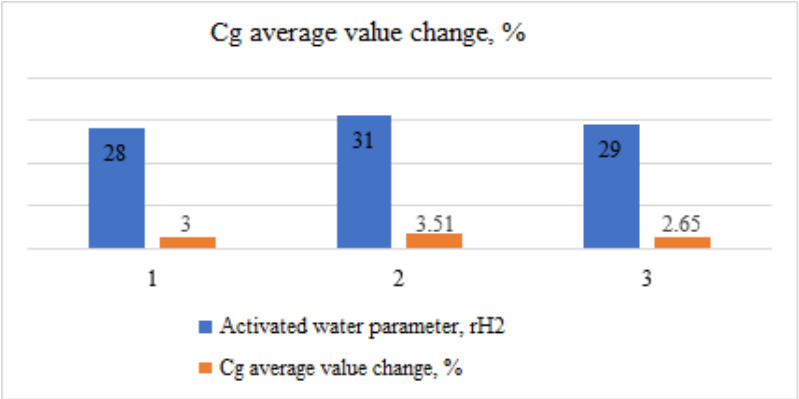

Fig. 2. Diagram of the change in Cg when fed with solutions based on activated water, depending on its parameters.

4 Conclusions

The nature of the change in Cg when fed with solutions based on activated water, depending on its parameters, is such that at a certain value of the rH_2 parameter = 31, the concentration of glucose synthesis has the greatest increase in Cg = 3.51%. At the same time, Cg and the activation parameter rH_2 have a fairly close relationship, as evidenced by a fairly high correlation coefficient equal to 0.73 between them.

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