Alternating impulses of pressure for new technologies in food production

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Abstract

Introduction. The aim of this research was to study the effect of alternating impulses of pressure on changes in the physicochemical properties of liquid nutrient solutions and media for hydroponic systems used in food production.

Materials and methods. Liquid nutrient solutions such as double distilled water, irrigation water for drip irrigation systems, and solutions with fertilizes were used for processing. Spring barley “Myronivskyi 22” and vigorous triticale “Soncedar kharkivskyi” were used for testing growing crops. Rotary-pulsed apparatus of the cylindrical type with clearances 120×10^{-6} m was used. The method of testing growing crops and method of optical microscopy were used.

Results and discussion. For growing of spring barley “Myronivskyi 22” such parameters were selected: processing time - 30 s, processing frequency 5, angular velocity - 315 s^{-1}, impulses of pressure – 390 kPa. For growing of vigorous triticale “Soncedar kharkivskyi” selected parameters were: processing time - 15 s, processing frequency 1, angular velocity - 300 s^{-1}, impulses of pressure – 370 kPa.

The analysis of experimental data showed the effectiveness of using of alternating impulses of pressure for treatment of liquid nutrient solutions and media for hydroponic system. The productivity of the growing agricultural crop of spring barley “Myronivskyi 22” increased by 32.8% and the productivity agricultural crop of vigorous triticale “Soncedar kharkivskyi” increased by 33.3%. Growth rate for spring barley increase by 20.5%, and for vigorous triticale increased by 22.7%.

A study of growing crops using irrigation water showed that as a result of using alternating pressure impulses for processing liquid nutrient solutions and media for a hydroponic system, the yield of the grown agricultural crop of spring barley "Mironovsky 22" increased by 33.3%, and the yield of the agricultural crop of vigorous triticale "Soncedar Kharkivskyi" increased by 33.5%. The growth rate of spring barley increased by 22.2% and of vigorous triticale by 24.4%.

The highest yield was obtained using a nutrient solution containing fertilizers. The highest growth rate of experimental crops was observed using irrigation water for drip irrigation systems.

Conclusions. Analysis of experimental data showed the effectiveness of using alternating pressure impulses for processing liquid nutrient solutions for hydroponic systems to increase the productivity of cultivated agricultural crops and the yield of green biomass.

Introduction

The characteristics of food products depend on many factors. One of them is the quality characteristics of raw materials, since they are the basis of finished food products. Raw materials include: ingredients, technological additives, and packaging materials. Fruits, vegetables, corn, herbs, grains, berries are important components of food raw materials.

The first stage of food production begins with growing crops. This is why many food industries rely almost entirely on agriculture. As soil degradation continues and fresh water supplies become scarce, developing farming approaches that use both land and water more efficiently and productively to grow food is essential. This is why research into methods to increase land productivity and the use of alternative farming methods is particularly important (Chadwick et al., 2023).

Agriculture occupies 38% of the Earth's surface and is the largest amount of land dedicated to a sole purpose (Foley et al., 2011). Regrettably, farming is also believed to be the main cause of climate change, biodiversity loss, and degradation of land and clean water. As a consequence, it is important to consider other methods and processes of plant cultivation to continue the environment and support global population growth. Food security has become a major challenge for the future owing to the scarcity of land, rising global population, urbanization, and polluted soil and water resources (Erekath et al., 2024). Alternative agricultural technologies, methods and equipment as innovative food production technologies provide increased productivity with limited resources and an improved carbon footprint. Artificial control of light, temperature, gases and humidity allows for indoor plant growth. Powerful of innovative technologies gives the possibilities to reduce the energy and recourses consumption of foodstuff production. There are intensively developing novel food processing technologies that are environmentally-friendly and energy-saving ones (Ivanov et al., 2021).

Improved root water and nutrient acquisition can increase fertilizer use efficiency and is important for securing food production. Root nutrient acquisition includes proliferation, transporter function, exudation, symbioses, and the delivery of dissolved nutrients from the bulk soil to the root surface via mass flow and diffusion (Chapman et al., 2012). Plant roots respond to the soil environment both spatially and temporally by avoiding stressful soil environments and proliferating in more favorable environments (Jin et al., 2017).

The use of greenhouses, vertical farms, aquaponics, hydroponics, and other plant growing methods have thus been studied and implemented over the years (Asiabanpour et al., 2018). Growing plants in greenhouses allows them to be protected from harsh weather conditions such as hail, snow, extreme cold or extreme heat; and at the same time, it becomes possible to grow off-season varieties. Soilless production systems have emerged as sustainable options for food production. Among other agricultural systems, the opportunities that soilless systems offer are becoming increasingly evident.

Vertical farming systems, particularly around heavily populated areas, can meet everyday consumer needs for fresh, nutritious products and, at the same time, also contribute to resilient food systems (Kumar et al., 2023). Vertical farms are a novel type of farming in a controlled-environment with a total replacement of solar radiation with artificial lighting that provides the necessary nanometers of the spectrum for the growth and development of plants (Avgoustaki and Xydis, 2020).

One such non-soil based system is aquaponics, an agricultural production system that brings together aquaculture and hydroponics (Abusin et al., 2020). Hydroponics is a soilless farming method that can contribute to meeting the global food demand, improving food sustainability as well as ensuring food availability in a novel high efficiency yet low maintenance way (Goh et al., 2023). In hydroponic systems, the potential of hydrogen is constantly changing as the plant grows. Therefore pH control is a requirement in hydroponic solutions, because the plant growth depends on this. The pH range from 5.5 to 7.5 is most favorable for the availability of nutrients from most water nutrient solutions.

The physical and chemical properties and parameters of associated liquid aqueous systems, solutions and media, such as: oxidation-reduction potential, pH value, and dissolved oxygen may be changed by the physical methods such as hydrodynamic treatment. The method of alternating impulses of pressure is one of the methods of controlled energy impact with many hydrodynamic effects, such as power of pressure of shift, cavitations, the effect of explosive boiling, collective effects in assembly of vials, crossness of an interphase surface in gas-liquid bubbly medium, action of hydrodynamic oscillations, alternating impulses of pressure, effects which associated with acceleration of movement of a continuous phase. The most important effects of the alternating impulses of pressure are allied with increase of velocity of association of a continuous phase of medium. Three-dimensional and period concentration of energy gives the possibility to receive the big capacity of pulsation power accomplishment, to release internal energy of substance, to create active energetic processes which take place at microlevel and also at nanolevel (Shurchkova and Dubovkina, 2015).

The aim of this study was to investigate the effect of alternating impulses of pressure throughout the processing of food products on the change in the physicochemical properties of liquid nutrient solutions and media for hydroponic systems.

Materials and methods

Materials

The objects of the study were various types and kinds of methods and modes of processing liquid nutrient solutions and media for use in the food industry and for hydroponic systems as the first stage of food production.

The subject of the study was the change in the physicochemical parameters and properties of liquid nutrient solutions and media for hydroponic systems.

Liquid nutrient solutions and media for hydroponic systems were used:

- double distilled water;
- irrigation water for drip irrigation systems that meet the requirements to the acidity of irrigation water according to agronomic and environmental criteria, type I;
- solutions with fertilizes on the $1\times10^{-3}m^3$ ($(Ca(NO_3)_2$ – 1×10^{-3} kg, KH_2PO_4 – 0.25×10^{-3} kg, $MgSO_4$ – 0.25×10^{-3} kg, KCl – 0.125×10^{-3} kg, $FeCl_3$ – 0.0125×10^{-3} kg).

For testing growing crops were used:

- spring barley “Myronivskyi 22”,
- vigorous triticale “Soncedar kharkivskyi”.

Experimental installation

The experimental investigation was carrying out on the investigational unit on Figure 1.

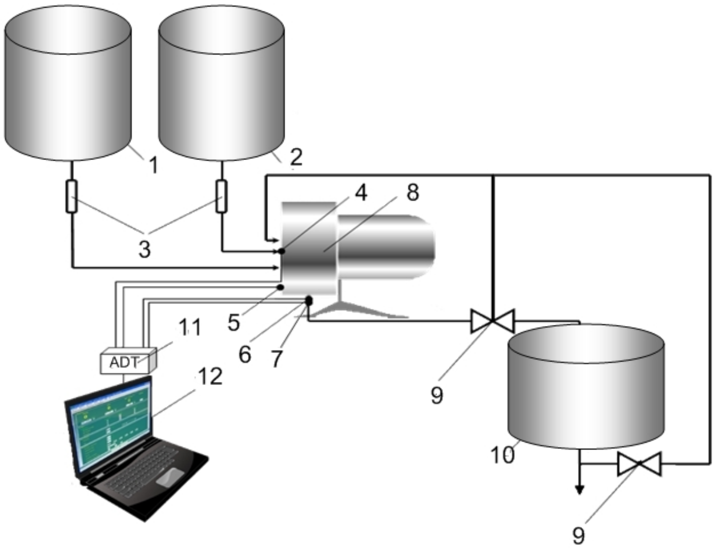


Figure 1. The scheme of experimental unit:
1 – tank for liquid; 2 – tank for nutrients; 3 – flow meter;
4 – temperature sensing device; 5 – pressure sensing device;
6 – temperature sensing device; 7 – pressure sensing device;
8 – rotary-pulsed apparatus; 9 – valve;
10 – tank of treatment liquid nutrient solution; 11 – analogue-digital transmitter;
12 – personal computer

The main part of this unit is rotary-pulsed apparatus. That's why the object of this scientific investigation study was rotary-pulsed apparatus in which liquid solutions and liquid nutrient solutions and media were processed by alternating impulses of pressure and were powered by hydrodynamic effects such as the speeds of shift of a stream, pressures of shift of a stream.

The work of the experimental unit is carried out as follows. At first liquids: associated liquid aqueous systems, water solutions, media are inflowing at the tank for liquid 1. After that through the flowmeter 3 associated liquid aqueous systems and solutions follows into the chamber of rotary-pulsed apparatus 8 for the processing by alternating impulses of pressure. From the tank for nutrients 2 liquid nutrients or fertilizers are inflowing through the flowmeter 3 and follows into the chamber of rotary-pulsed apparatus 8. In the chamber of rotary-pulsed apparatus 8 instant mixing occurs by the alternating impulses of pressure.

There are two ways of the processing. The first way is in continuous uninterrupted mode at once and the second way is in recirculation mode after instant mixing by alternating impulses of pressure in the chamber of rotary-pulsed apparatus 8 with specific variable duration period of processing.

After treatment liquid nutrient solutions and media for hydroponic systems follows into tank of treatment liquid 10 through the valve 9.

During the experimental investigation a number of parameters are controlled: temperature by the temperature sensing device 4 and 6, pressure by pressure sensing device

5 and 7. Other parameters are controlled by analogue-digital transmitter 11 and results transmitted on personal computer 12. The construction of rotary-pulsed apparatus was the cylindrical type with the working chamber. The subsequently positions in working volume between coaxial cylinders of the «rotor-stator-rotor» system were selected (Fig. 2) (Dubovkina, 2017).

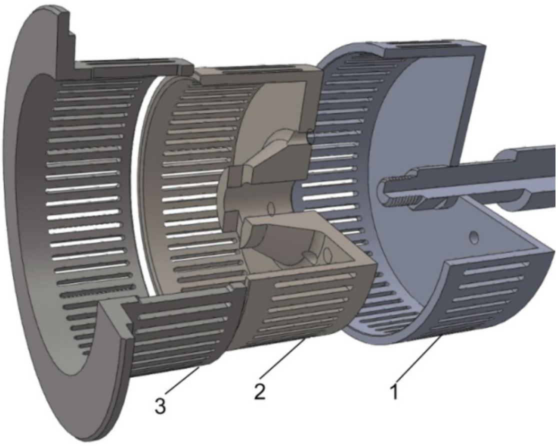


Figure 2. The scheme of working chamber
1 – external rotor; 2 – stator; 3 – internal rotor

Important technical parameter such as speed of shift of a stream was recognized for treatment of liquid solutions with the appliance of the alternating impulses of pressure (Dubovkina et al., 2019).

By the consequences of the computation was established that the principal values of speeds of shift of a stream emerge in RPA with coaxial clearances between first rotors, stator and second rotor 120×10^{-6} m.

Table 1

Local values of pressure in the sector of input of water and water systems and the output of the water systems from the clearances

Surfaces of working volume	Low pressure value, 10^3 Pa	High pressure value, 10^3 Pa	Changing of pressure ΔP, 10^3 Pa
at the external surface of the internal rotor	-60	+370	390
at the external stator surface	-160	+110	270
at the inner stator surface	-130	+50	180
at the inner surface of the external rotor	-110	+90	200

For circulation out of processes of treatment water nutrient solutions provided in to processing in uninterrupted mode during special time and exceptional hydrodynamic conditions which can realize during the alternating impulses of pressure.

The duration of treatment varied from 5 s to 600 s. This time was found by the mathematical calculating and volume parametric imitation modeling and was applied in nature experimental investigations.

Throughout the treatment in uninterrupted mode was used instantaneous depressurization in a working volume. The recovering of the parameters to the atmosphere pressure was spent by two ways. The first way was recovering to primary pressure during 30 s. The second way was recovering to primary pressure instantly.

Methods

Investigation of the liquid nutrient solutions and media for hydroponic systems during testing growing crops

To grow green fodder from testing agricultural crop in the hydroponic workshop, the optimum temperature for growing this agricultural crop is created 21-23 °C. To create conditions of sufficient lighting, fluorescent lamps (LD-40, LB-20, DRLF-400 or similar) are used at the rate of 800–1000 lux per 1 m^2, the use of side and top lighting is assumed. Crops are grown on waterproofing material (polyethylene films), directly on racks or tiered structures. Sprouted grain of the agricultural crop of barley variety testing agricultural crop is spread at the rate of 3.0–4.0 kg per 1 m^2. The grain is covered with agro fiber.

After 8 hours, the agro fiber is removed, the top and side lighting are turned on, and watering is started with the nutrient solution obtained under the conditions of alternating impulses of pressure. Feeding of the nutrient solution is carried out by aerosol irrigation of the surface for 30–50 s with an interval of 6–10 min.

Consistent fulfillment of the necessary technological requirements ensures intensive growth of green masses. On the 5th day control measurements were carried out. On the 5th-8th day green mass is collected using the method of folding in the form of a mat, which is twisted into a roll and transported for preparation of feed for animals.

Investigation of the biological composition of liquid nutrient solutions and media for hydroponic systems

The biological composition of liquid nutrient solutions and media for hydroponic systems was investigated by the method of optical microscopy.

Microscopy of liquid nutrient solutions for hydroponic systems carried out before testing growing crops and on 5th day after growing.

The analysis of the all received examples was carried out with the application of research wide field upright microscope system Carl Zeiss Axio Imager Vario II at 640 magnification, and the most visible areas were photographed.

All liquid samples were analyzed in motorization mode in direct illumination, which passes all the way through the examples of liquid water solutions of the hydroponic systems.

Statistical analysis

For the reception related data, liquid samples of liquid nutrient solutions and media for the application in food industry, for hydroponic systems were analysed with the following statistical procedure (Ozomwna, 2007). The data represents the mean of a minimum three replicates ± standard deviation. Graphical presentation of experimental data was performed using standard statistical processing programs – Microsoft Excel 2010.

Results and discussion

Investigation of the liquid nutrient solutions and media for hydroponic systems during testing growing crops

During the first stage of investigation of testing growing crops for green hydroponic fodder, mineral nutrition of the root system was not used. The theoretical justification of this approach is based on the fact that for a period of 5–12 days, the endosperm of the seed is a physiologically active nutrient tissue for the germination and development of seedlings to the stage of pasture maturity ($16–20×10^{-2}$ m). The seeds of grain and leguminous crops have a sufficient supply of nutrients that are in the endosperm, and they are mobilized and used both during the heterotrophic period of germination and at the beginning of autotrophic nutrition of seedlings during photosynthesis. All reserve substances from the endosperm are used by the growing embryo (dark stage), and later by the seedling during photosynthesis (light stage) (Acevedo et al., 2002).

The effectiveness of the method for processing a nutrient solution and medium for hydroponic systems by alternating impulses of pressure depends on the parameters that are used. Based on experimental studies, and numerical modeling and calculation parameters were selected: duration – 15–30 s, frequency of treatment 1–5, angular velocity – 300–315 s^{-1}, impulses of pressure 370–390 kPa. This parameters can be achieved in working chamber of the RPA.

The first example of the liquid nutrient solution was double distilled water. For growing of spring barley "Myronivskyi 22" was selected distilled water with pH 6.5. This value of pH is optimal for growing spring barley. For growing of vigorous triticale "Soncedar kharkivskyi" double distilled water with pH 5.5 was selected. The control examples were used without treatment. The results of testing growing crops are showed in Table 2.

Table 2

Influence of alternating impulses of pressure on the yield of green biomass on double distilled water

Parameters	Control example without processing		Processing by alternating impulses of pressure	
	B	T	B	T
Plant height, 10^{-2} m	15.9±0.01	16.1±0.01	18.7±0.02	18.8±0.01
Productivity kg/m^2	13.4±0.02	13.5±0.02	17.8±0.02	18.0±0.02
Average mass of one mat, kg	26.6±0.02	40.1±0.02	35.6±0.04	54.0±0.005
Growth rate, c.u.	4.4	4.5	5.3	5.4

Note: B is agricultural crop of spring barley "Myronivskyi 22", T is agricultural crop of vigorous triticale "Soncedar kharkivskyi". c.u. is a coefficient of growth of feed biomass to dry seeds - control term (duration of the heterotrophic period of germination) 5 days.

For growing of spring barley "Myronivskyi 22" were selected: processing time - 30 s, processing frequency 5, angular velocity - 315 s^{-1}, impulses of pressure – 390 kPa. For growing of vigorous triticale "Soncedar kharkivskyi" were selected: processing time - 15 s, processing frequency 1, angular velocity - 300 s-1, impulses of pressure – 370 kPa.

The analysis of experimental data showed the effectiveness of using of alternating impulses of pressure for treatment liquid nutrient solutions and media in hydroponic system on the productivity of the growing agricultural crop of spring barley “Myronivskyi 22” increased by 32.8% and the productivity agricultural crop of vigorous triticale “Soncedar kharkivskyi” increased by 33.3%. Growth rate for spring barley increased by 20.5% and for vigorous triticale increased by 22.7%.

The second example of the liquid nutrient solution was irrigation water for drip irrigation systems that meet the requirements to the acidity of irrigation water according to agronomic and environmental criteria.

For growing of spring barley “Myronivskyi 22” irrigation water with pH 6.7 was used. For growing of vigorous triticale “Soncedar kharkivskyi” double irrigation water with pH 5.8 was selected. The results of testing growing crops are shown in Table 3.

Table 3

Influence of alternating impulses of pressure on the yield of green biomass on irrigation water for drip irrigation systems

Parameters	**Control example without processing**		**Processing by alternating impulses of pressure**	
	B	**T**	**B**	**T**
Plant height, 10^{-2} m	16.1±0.02	16.5±0.01	18.9±0.02	19.1±0.01
Productivity kg/m^2	13.5±0.02	13.7±0.02	18.0±0.03	18.3±0.02
Average mass of one mat, kg	27.0±0.01	41.1±0.01	36.0±0.02	54.9±0.02
Growth rate, c.u.	4.5	4.5	5.5	5.6

The analysis of experimental data showed that the result of applying of alternating impulses of pressure for treatment liquid nutrient solutions and media in hydroponic system on the productivity of the growing agricultural crop of spring barley “Myronivskyi 22” increased by 33.3% and the productivity agricultural crop of vigorous triticale “Soncedar kharkivskyi” increased by 33.5%. Growth rate for spring barley increased by 22.2% and for vigorous triticale increased by 24.4%.

During the second stage of investigation of testing growing crops for green hydroponic fodder, liquid nutrient solutions with fertilizers were used.

Table 4

Influence of alternating impulses of pressure on the yield of green biomass on liquid nutrient solutions with fertilizers

Parameters	**Control example without processing**		**Processing by alternating impulses of pressure**	
	B	**T**	**B**	**T**
Plant height, 10^{-2} m	16.1±0.02	16.5±0.01	18.9±0.02	19.1±0.01
Productivity kg/m^2	13.5±0.02	13.6±0.02	18.1±0.02	18.2±0.02
Average mass of one mat, kg	27.0±0.02	41.0±0.02	36.5±0.04	54.9±0.005
Growth rate, c.u.	4.5	4.6	5.5	5.6

The analysis of experimental data showed that the result of applying of alternating impulses of pressure for treatment liquid nutrient solutions and media for hydroponic system on the productivity of the growing agricultural crop of spring barley "Myronivskyi 22" increased by 34% and the productivity agricultural crop of vigorous triticale "Soncedar kharkivskyi" increased by 33.8%. Growth rate for spring barley increased by 21.7% and for vigorous triticale increased by 22.2%. Experimental statistics showed that the highest productivity was achieved with the nutrient solution which includes fertilizers.

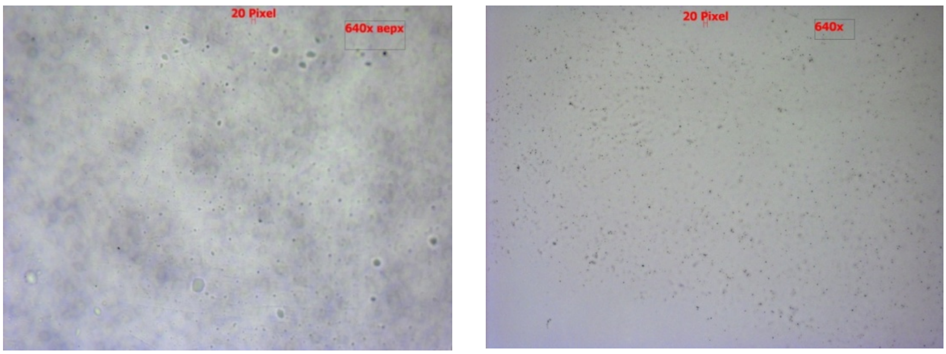
The highest growth rate for testing growing crops was achieved with irrigation water for drip irrigation systems that meet the requirements to the acidity of irrigation water according to agronomic and environmental criteria.

Treatment of liquid nutrient solution of hydroponics with application of alternating impulses of pressure causes structural transformations in the nutrient liquid at the micro- and nanolevel, as a result of which its physical and chemical parameters change, as well as the mass transfer and hydromechanical processes between macro- and micronutrients and water are intensified, their assimilation and assimilation by agricultural crops improves, as a result of which growth is accelerated.

Biological characteristics of liquid nutrient solutions and media for hydroponic systems

The hydroponic in technological schemes of the growing crops of plant variety is incredibly multicomponent complex biological system which includes alive organisms. The microscopic evaluation of nutrient solutions of the hydroponic from greenhouses were carried out.

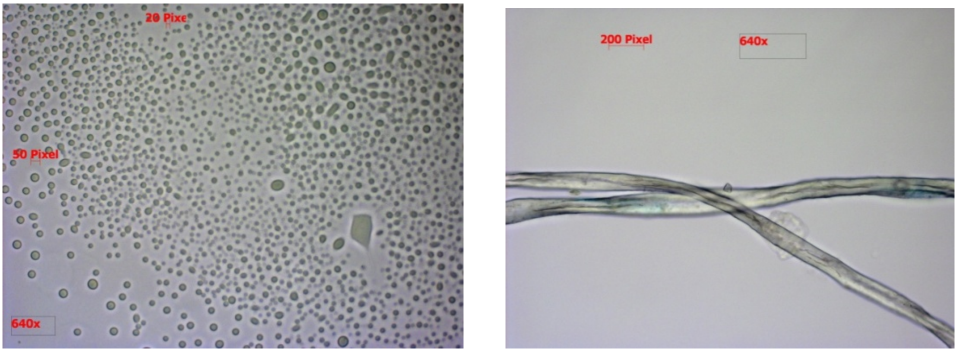
During the investigation it was established different organisms in a single drop of the hydroponic solution magnified at 640 times and in recirculation systems after testing growing crops. From the given micrographs it is visible that the example of the double distilled water does not contain different microorganisms (Figure 3).



a **b**

Figure 3. Micrograph of the nutrient solution of the hydroponic solution before testing growing (× 640 times magnification):
a – spring barley "Myronivskyi 22"; b – vigorous triticale "Soncedar kharkivskyi"

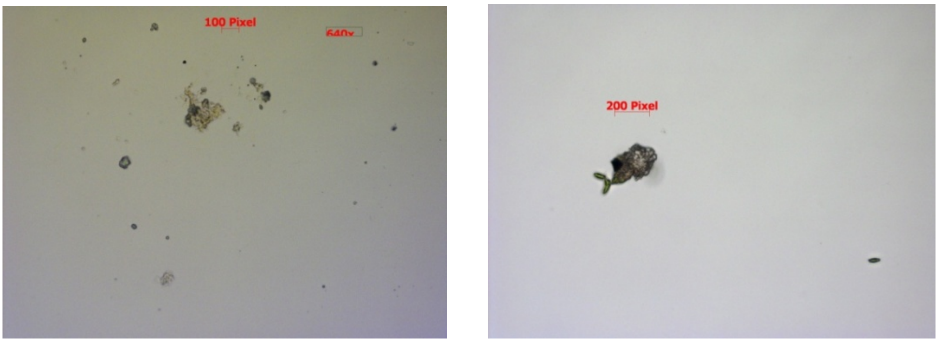
Through analysis from the given micrographs it is visible on Figure 4 that in the sample of hydroponic solution after testing growing crops, algae and cyanobacteria were identified. It was found that after growing spring barley cyanobacteria predominated (Figure 4a), and after growing vigorous triticale algae predominated (Figure 4b).



a **b**

Figure 4. Micrograph of the nutrient solution after testing growing (× 640 times magnification):
a – spring barley "Myronivskyi 22"; b – vigorous triticale "Soncedar kharkivskyi"

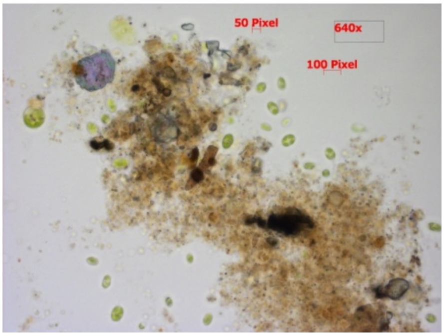
On the specified micrographs it is visible that the example of the irrigation water for drip irrigation systems contained a small amount of single-celled microorganisms (Figure 5). This is due to the fact that irrigation water contains some dissolved impurities which are nutrients for microorganisms.

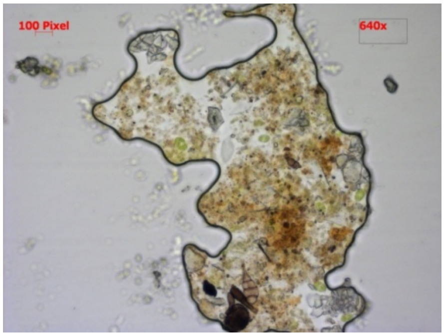


a **b**

Figure 5. Micrograph of the nutrient solution from irrigation water for drip irrigation systems before testing growing (× 640 times magnification):
a – spring barley "Myronivskyi 22"; b – vigorous triticale "Soncedar kharkivskyi"

During the investigations at microscope such water habitants were discovered: chlorella, it is a single-celled fresh water algae; small amoebas; fast-moving protists; *Chlamydomonas reinhardtii*, diatoms; *Euglena gracilis*, single-celled flagellate eukaryotes, and many other (Figure 6). It was found that after growing spring barley, *Chlorella vulgaris* and *Chlamydomonas reinhardtii* predominated and after growing vigorous triticale *Amoeba proteus* predominated.



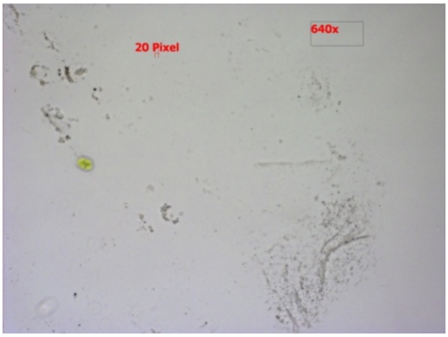


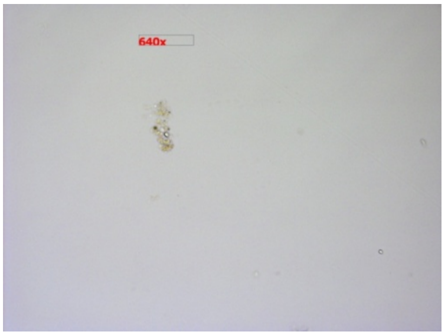
a **b**

Figure 6. Micrograph of the nutrient solution from irrigation water for drip irrigation systems after testing growing (× 640 times magnification):
a – spring barley "Myronivskyi 22"; b – vigorous triticale "Soncedar kharkivskyi"

On the specified micrographs it is visible that the example of the nutrient solution with fertilizers contained a small amount of single-celled microorganisms (Fig. 7).

But it should be noted that compared to the previous sample of the nutrient solution for testing growing crops the number of microorganisms was greater. This is suitable to the fact that nutrient solution with fertilizers contains dissolved impurities which are nutrients for microorganisms.



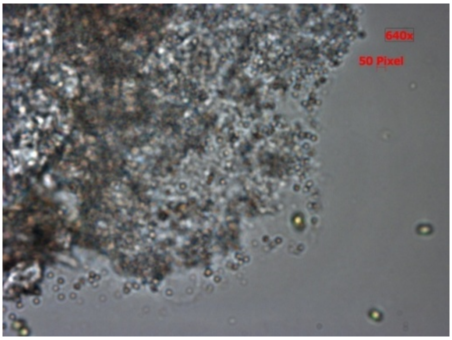


a b

Figure 7. Micrograph of the nutrient solution from the nutrient solution with fertilizers before testing growing (× 640 times magnification):
a – spring barley "Myronivskyi 22"; b – vigorous triticale "Soncedar kharkivskyi"

Chlorella vulgaris, Chlorella sorokiniana, Chlamydomonas reinhardtii, Dunaliella salina and cyanobacteria such as *Synechococcus* spp.*, Anabaena* spp.*, Nostoc* spp.*, Calothrix* spp.*, Scytonema* spp.*,* and *Cylindrospermum* spp. were identified in the nutrient solution after testing growing crops (Fig. 8).

This can be explained by the presence of dissolved nutrients and additional water treatment by alternating impulses of pressure.



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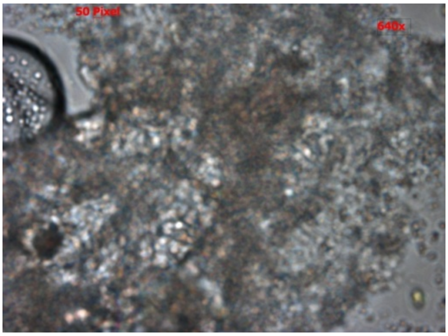

b

Figure 8. Micrograph of the nutrient solution the nutrient solution with fertilizers after testing growing (× 640 times magnification):
a – spring barley "Myronivskyi 22"; b – vigorous triticale "Soncedar kharkivskyi"

It is common knowledge that hydroponic includes microscopic organisms: various bacteria, protists, algae and cyanobacteria. They are important members of aquatic communities. Algae can give useful information about the productivity and health of recirculation hydroponic systems. For example, some forms of algae are indicative of low nutrient surroundings while others indicate high nutrient levels and some species favor acidic surroundings while others more basic.

Studies conducted at laboratory and greenhouse scales have demonstrated the significant effects of applying live cell suspensions, dry biomass, cell extracts, or hydrolysates of microalgae on the growth of economically important cereals, such as wheat, corn, rice, and sorghum, as well as certain spice crops and vegetables (Alvarez et al., 2021).

Cyanobacteria and eukaryotic microalgae are not homogeneous monophyletic groups but rather belong to diverse bacterial or eukaryotic evolutionary lines and phylogenetically distinct groups (Chabili et al., 2024).

Many of the bloom-forming algae are cyanobacteria such as blue-green algae, some of which can potentially produce toxins that may have harmful effects on aquatic and hydroponic growing crops. Microalgae and cyanobacteria along with fungi and bacteria constitute the uppermost layers of soil collectively called biological soil crust, which plays a critical role in enhancing soil fertility and crop productivity (Abinandan et al., 2019).

The microscopic organisms can change physical and chemical properties of the liquid nutrient solutions and media for hydroponic systems as a result of their life activities. Microalgae and cyanobacteria have the potential to act as environmental friendly biostimulants/biofertilizers that improve crop quality and yield (Gonçalves, 2021). The integrating microalgae cultivation with modern agriculture technologies such as hydroponics (Parmar et al., 2023) is very promising.

It has been shown that hydroponics is a very promising environment for research, as it makes it possible to analyze the conditions for growing agricultural crops, and control the duration and intensification of plant cultivation. This is the beginning of research work, and much research will be carried out in the future, but the results obtained help to understand the main mechanisms of the organization of biological systems.

Conclusions

At the present time one of original and innovative method and equipment that was used for advance of processing by samples of liquid nutrient solutions and media for the application in food industry, for hydroponic systems as the first stage of the foodstuff production is the method of alternating impulses of pressure.

New experimental and theoretical studies and modeling have shown that the method of alternating impulses of pressure may possibly be suitable for processing in food industry and foodstuff production, where hydrodynamic effects are found to be an substitute to traditional methods and modes in technological lines, equipment and processes of liquid nutrient solutions and media for the application in food industry, for hydroponic systems as the first stage of the foodstuff production.

Experimental studies of the testing growing crops demonstrated increasing the the productivity of the growing crops yield of green biomass by 32.8–34%. Growth rate for testing growing crops increased by 20.5–24.4%.

The analysis of experimental microscopy data showed the biological composition of liquid nutrient solutions and media for hydroponic systems before and after testing growing crops. It is important for growing crops in recirculation hydroponic systems with reuse of nutrient solution.

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