

Summarizing the above it should be noted, that it was the first time when the graphical image was obtained by the lytic action of the virus on bacteria. This approach could be used not only for the artistic aims but as well for the practical use, for example, for the restriction of the action of microorganisms in out-of-the-way places.

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### ВЗАЄМОЗВ'ЯЗОК ФАГІВ ТА БАКТЕРІЙ ЯК ІНСТРУМЕНТ ОТРИМАННЯ ЗОБРАЖЕНЬ

Розглянуто отримання зображень шляхом літичної дії бактеріофага T4 на бактеріальний газон *Escherichia coli*. Обговорюються методичні аспекти підходу, зокрема, використання шаблонів різних типів, повне та часткове фарбування отриманого зображення різними барвенками. Запропоновано можливі перспективи використання, зокрема, обмеження дії мікроорганізмів у важкодоступних місцях.

Ключові слова: бактеріофаг, *Escherichia coli*, літична дія, літична зона.

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### ВЗАИМОСВЯЗЬ ФАГОВ И БАКТЕРИЙ КАК ИНСТРУМЕНТ ПОЛУЧЕНИЯ ИЗОБРАЖЕНИЙ

Рассмотрено получение изображений путем литического действия бактериофага T4 на бактериальный газон *Escherichia coli*. Обсуждаются методические аспекты подхода, в частности, использование шаблонов разных типов, полное и частичное окрашивание полученного изображения различными красителями. Предложены возможные перспективы использования, в частности, ограничение действия микроорганизмов в труднодоступных местах.

Ключевые слова: бактериофаг, *Escherichia coli*, литическое действие, литическая зона.

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### TEST SYSTEM BASED ON ROOT EXUDATES FOR HIGH-YIELDING COMMON BUCKWHEAT (*FAGOPYRUM ESCULENTUM* MOENCH.) FORM SCREENING

A new effective non-invasive method of screening of highly productive forms of buckwheat sowing (*Fagopyrum esculentum* Moench.) based on rapid testing of buckwheat seedling intensity exudation of organic acids root system in the laboratory is offered. Buckwheat seeds were germinated on agar gel layer which contains in its composition acid-base indicator followed by visual assessment of the indicator color changes around primary root and plants with the largest area of color change were selected. The effectiveness of the method was confirmed in the field conditions by phenotyping of plants and significant differences in determining the structure and yield performance of selected plants were found. Statistical analysis of indicators grain number and grain weight showed that these indicators in selected plants were over 6 times higher than in the control variant with the degree of reliability of 99%.

Keywords: screening, buckwheat, phenotyping, seedlings, root exudates.

**Introduction.** Buckwheat is a well known valuable agricultural cereal culture used traditionally in the food industry of Ukraine. However, due to the peculiarities of the secondary metabolism this culture can be widely used in the pharmaceutical and medical industries as a source of a significant amount of bioactive substances [1]. But buckwheat may not have the performance as cereal crops because of their biological characteristics. At the same time the potential of buckwheat are not always used sufficiently. Development of new methods of selection can greatly affect the disclosure of genetic potential of the crop and expand its use. Taking into account the substantial value of buckwheat in the food industry the search for effective and rapid methods for the selection of high-performance forms

of culture do not stop. Development of new methods requires complex analysis and improvement and modification of previous methods of selection.

Most known methods of selection of high-performance forms of buckwheat is selection at the stage of budding or flowering plants [2, 3, 4]. They are held on the last phenological phases of plant development and aimed at creating productive large inflorescences. A method of selecting plants for buckwheat complex features [5] is that plants are selected for buckwheat sign of breeding and structure characteristics at the crop ripening phase. Plants selected are propagated via meristem culture *in vitro*, encouraging re-blooming. Seeds from regenerative plants are got by directed re-pollination with known genotypes. The essence

of the method is that buckwheat plants selected visually at the phase of ripening. From the plants selected isolate axillaries buds that are sterilized in aseptic conditions laminar box, separate axillaries meristems, inoculate in the culture medium, induce morphogenesis of shoots and the formation of roots and get plants rooted *in vitro*. The resulting plants are planted in containers with unsterile soil in greenhouses and after acclimatization get plants that are genetically identical to the selected ones; after flowering plants pollinate with known genotypes to produce seeds that are subcultured for breeding in subsequent generations. The disadvantage of this method is the having of multiple stages and using tissue culture method, which in turn makes the method complicated in execution and rather expensive.

The above mentioned methods of selection forms highly focused on functional signs of aerial parts, which are fixed at the later phases of phenological development. But root system of plants that performs multiple functions is neglected thereat, although we know that it plays an important role in the life of plants and formation of productive capacity. The surface of the root system is in 50-150 times greater than the surface of the aerial part. In addition to the mechanical functions the roots serve important physiological processes: transport (providing transportation of substances in above ground organs), absorption of water and mineral elements from the soil) and the excretion of various chemical nature and the biological value substances to the environment. Their role in the formation of production capacity is investigated not enough. This is especially true for such unique culture as buckwheat characterized by specific peculiarities of the root system.

The prototype developed method of selection of high-performance forms are selection based on visual assessment of buckwheat seedling root system at the early stages of development [6]. According whose separate sprouted seeds planted in a test tube with nutrient medium and grown until reaching the length of the primary root of majority of seedlings over 10 cm. Specimens of the plants with a maximum length of root, taken into account the intensity of lateral roots are selected. The disadvantage of this method is the need to ensure each plant separate tubes with nutrient medium, which in turn makes the method quite cumbersome in performing. In addition, despite the fact that the selection is made in the early stages of plant roots to reach a certain length required for some time that something slow down the selection process.

The purpose of our work was to develop a new non-invasive method of screening for high-performance forms

buckwheat functional characteristics of the root system. The main criteria were: the search of express-marker for selection; reducing significantly the time of selection; the possibility of increasing the samples to handle an increasing number of plants for breeding practices.

**Material and methods.** Buckwheat seeds of Rubra variety within 3 hours were soaked in distilled water, then transferred to a Petri dish on wet filter paper and placed in a thermostat with a temperature of 27°C for germination. For visual control of root secretions acid-base indicator color with the transition in the pH range of 3 to 6.8 was used. Sprouted seeds planted at the bottom of a flat cell on a layer of 1% agar-agar gel thickness ~ 3 mm, containing 5 mg/100 ml of bromocresol green (variant 1) or bromocresol purple (Variant 2) so that the root was immersed in the thick gel and kept in an incubator at 27°C without light. After a visual assessment of root exudate intensity two versions with 10 plants in each were collected: low intensity root secretions – control; high intensity of root exudate – experiment. The selected plants were planted in the field and grown at conventional farming methods of cultivation of buckwheat [7]. Phenotyping of plants in the field was performed according to the recommendations of V.O.Yeshchenko [8]. Statistical analysis of data was performed by analysis of variance according to Fisher [9].

**Results and discussion.**

The root system of buckwheat has highly synthetic and excretory activity – root exudates buckwheat, namely organic acids, dissolve remote forms of mineral nutrients, resulting in a relatively small mass of roots characterized by a high intensity of nutrient absorption. So the average absorption of minerals by buckwheat is 38.8 mg/g of root, while millet – 22 mg/g, spring wheat – 14.5 mg/g barley – 7 mg/g and winter wheat – 4,9 mg/g [10]. It is clear that buckwheat plants that have a high level of root secretions can provide themselves more fully with mineral nutrients and consequently have more favorable conditions for the disclosure of its productive capacity.

Our preliminary research the quality of the root exudates showed extensive excretion of oxalic acid by buckwheat plant root system [11]. To visualize the intensity of root secretions model system was developed based on the ability of chemical dyes change color depending on the pH. In a culture *in vitro* on the medium with the addition of acid-base indicators sprouted buckwheat seeds begin to form the primary root, which provides oxalic acid in the root environment changing gel color (Fig. 1).

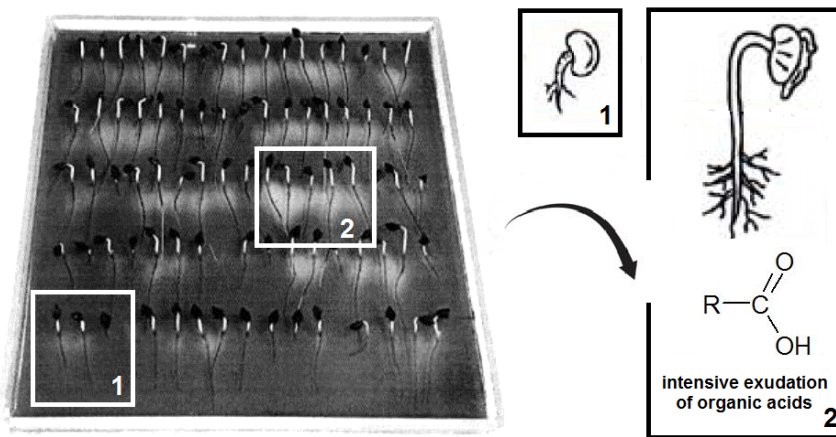
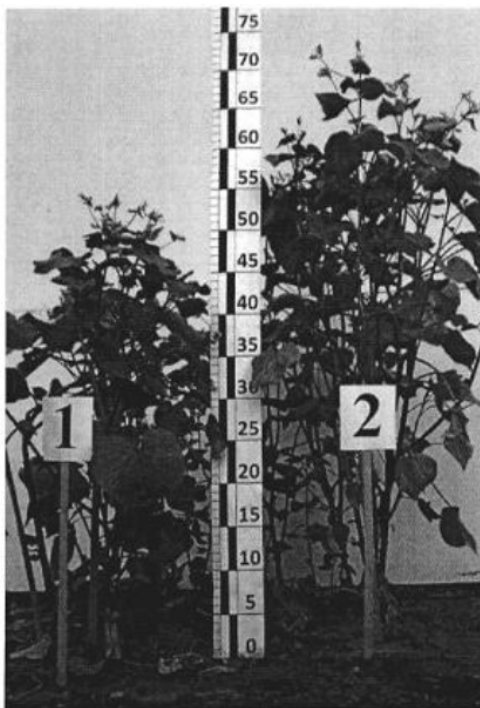


Fig. 1. Intensity of root exudates of buckwheat sowing plants (*Fagopyrum esculentum* Moench.):  
 1 – low intensity excretion root exudates; 2 – high intensity excretion root exudates

The intensity of color change was assessed excretion activity of organic acids not evaluating them biochemically (quantitative), that reduces significantly the selection term. In the first phase seedlings were divided into two groups according to the color change intensity for further field studies: with low intensity root secretions – the control group, and with high intensity-experiment.

In the second phase, during field research observations of the plants was observed that plants grown from seeds of buckwheat with a high level of root secretions outstripped significantly in the development of plants with low root secretion level (Fig. 2).



**Fig. 2. The phenotype of buckwheat sowing plants (*Fagopyrum esculentum* Moench.) with different secretion intensity of root exudates:**

1 – plants with low intensity root secretions; 2 – plants with high intensity root secretions

At the final stage of experiment plant phenotyping was performed in order to determine the peculiarities of crop formation structure. The potential productivity of buckwheat plants is largely determined by the number of vegetative and generative organs. We revealed a direct correlation

between the performance of plants and their grain number, determined by the number of inflorescences per plant and the number of grains in them [12]. In the experimental variant plants with height 125.7 cm were formed being higher by 27% than control (Table. 1).

**Table 1. Crop structure dependence of plants sowing buckwheat (*Fagopyrum esculentum* Moench.) from the intensity of root exudate excretion**

Group of investigated plants	Total plant height, cm	Number, pieces				Average weight of grain from plant, g
		Nodes	Branches	Inflorescences	Grains from plant	
<i>Variant 1 (bromocresol green)</i>						
Control	99,7	11,7	4,0	35,2	33,4	0,97
Experiment	122,6	14,0	4,5	51,2	222,8	6,91
Difference	22,9	2,3	0,5	16,0	189,4	5,94
<i>Variant 2 (bromocresol purple)</i>						
Control	97,1	11,8	4,1	33,6	37,8	1,10
Experiment	128,7	14,1	4,6	53,8	231,8	7,19
Difference	31,6	2,3	0,5	20,2	194,0	6,09
<i>The average</i>						
Control	98,4	11,8	4,1	34,4	35,6	1,04
Experiment	125,7	14,1	4,6	52,5	227,3	7,05
Difference	20,3	2,3	0,5	18,1	191,7	6,02
LSD <sub>01</sub>	20,7	1,8	1,0	15,8	104,2	3,21

Another important morphological feature is the number of nodes on the stem, which varies depending of genotype and growing conditions. Increase of the nodes in the zone of fruiting contributes to greater stem productivity and therefore plants in general. The node number in the branching area is a parameter that defines the precocity of

buckwheat and its growth opportunities [13]. Analyzing the number of nodes on the stem showed also a significant difference between the study options. Their number was 14.1 pc in experiment, while 11.8 pc in control.

Concerning plant branching one could see fairly significant differences between the variants. Counting the num-

ber of inflorescences and seeds showed the true advantage of these indicators in experiment version. Number of inflorescences and seeds in the control variant was 34.4 and 35.6 pc., while 52.5 and 227.3 pieces in experiment version. It is worth to note that some plants that never formed grain in the control variant were observed.

Plant productivity is complex trait resulting from the interaction of the aggregate morphological characteristics and properties that determine the peculiarities of plant growth and development. The value of each individual complex features from a total is different. The result of all components and features are grain number and weight of grain from the plant, which exceed in experiment by 6.8 times the control variant with the degree of reliability of 99%.

**Conclusions.** Thus, it was proved the efficacy of high-yielding common buckwheat early screening method of root exudates using acid-base indicators. Both proposed indicators proved effective. Our results yield structures in the field indicate that developed a new non-invasive screening method is highly effective and achieve the claimed technical result and can serve as a reliable tool for creating original material in breeding buckwheat sowing.

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### ТЕСТ-СИСТЕМА НА ОСНОВІ КОРЕНЕВИХ ЕКСУДАТІВ ДЛЯ СКРИНІНГУ ВИСОКОПРОДУКТИВНИХ ФОРМ ГРЕЧКИ ПОСІВНОЇ (*Fagopyrum esculentum* Moench.)

Запропоновано новий ефективний неінвазивний метод скринінгу (відбору) високопродуктивних форм гречки посівної (*Fagopyrum esculentum* Moench.), який базується на експрес-тестуванні проростків гречки в лабораторних умовах на інтенсивність ексудації органічних кислот кореневою системою. Насіння гречки пророщували на шарі агарового гелю, який містить в своєму складі кислотний індикатор з наступною візуальною оцінкою зміни забарвлення індикатора навколо первинного кореня, і відбирали рослини з найбільшою зоною зміни кольору індикатора. В польових умовах підтверджена ефективність методу шляхом фенотипування рослин та виявлені значні відмінності у формуванні структури врожаю та продуктивності відібраних рослин. Статистичний аналіз показників озерненості та ваги зерна показав, що у відібраних рослини ці показники у понад 6 разів перевищували контрольні варіанти, зі ступенем достовірності 99%.

Ключові слова: метод відбору, фенотипування, проростки, кореневі ексудати.

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### ТЕСТ-СИСТЕМА НА ОСНОВЕ КОРНЕВЫХ ЭКСУДАТОВ ДЛЯ СКРИНИНГА ВИСОКОПРОДУКТИВНЫХ ФОРМ ГРЕЧИХИ ПОСЕВНОЙ (*Fagopyrum esculentum* Moench.)

Предложен новый эффективный неинвазивный метод скрининга (отбора) высокопродуктивных форм гречихи посевной (*Fagopyrum esculentum* Moench.), который основан на экспрес-тестировании проростков гречихи в лабораторных условиях на интен-

сивность экссудации органических кислот корневой системой. Семена гречихи проращивали на слое агарового геля, который содержит в своем составе кислотно-основный индикатор с последующей визуальной оценкой изменения окраски индикатора вокруг первичного корня, и отбирали растения с наибольшей зоной изменения цвета индикатора. В полевых условиях подтверждена эффективность метода путем фенотипирования растений и выявлены значительные отличия в формировании структуры урожая и продуктивности отобранных растений. Статистический анализ показателей озерненности и массы зерна показал, что у отобранных растений эти показатели более чем в 6 раз превышали контрольные варианты, со степенью достоверности 99%.

Ключевые слова: метод отбора, фенотипирование, проростки, корневые экссудаты.

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## SPATIAL-TEMPORAL DYNAMICS OF LITTORAL ZOOPLANKTON COMMUNITY OF THE OLEKSANDRIVKA RESERVOIR

The analysis results of spatio-temporal dynamics of zooplankton communities from littoral of the Oleksandrivka reservoir are presented. The features of the seasonal changes in species composition, faunal and ecological spectrums, quantitative indicators (density and biomass) and the dominant species complexes of littoral zooplankton was revealed. The analysis of seasonal dynamics of qualitative and quantitative development of zooplankton in the littoral zone within the upper, middle and lower parts of the Oleksandrivka reservoir was conducted.

Keywords: Ecology, the Oleksandrivka reservoir, littoral, zooplankton community.

**Introduction.** At present, the anthropogenic factors have ecological importance for aquatic ecosystems [1-2]. Examples of human activities involve the restructuring of individual components of ecosystems (including groups of animals) [3], their structural and functional organization [4], and transforming rivers to reservoirs with different hydrological regime [5]. Many reservoirs were created over the past 50-60 years [6] and today they are the main type of water in Ukraine [7]. Special interests have littoral hydrobiocenosis that differ significantly from the pelagic and play an important role in the functioning of aquatic ecosystems [8]. They are characterized by high rates of biodiversity [9] and biological productivity [10] and the complex structural and functional organization [11]. This littoral zone occupies a large area of water, such as in the Kiev reservoir it is 38% [9]. Particular attention is drawn to the reservoir of the South-Ukrainian energy complex, which is an important part of the Oleksandrivka reservoir.

Zooplankton is an important component of aquatic ecosystems, which plays an important role in the circulation of matter and the energy transformation [2]. Most of the zooplankton belongs to the primary and secondary consumers [12]. Zooplankton is the foundational supply base for the young and planktonophagous fish at higher trophic levels [13].

Purpose – analysis of seasonal dynamics of structured littoral zooplankton communities in the Oleksandrivka reservoir.

**Materials and methods.** The object of our research were species of same groups of zooplankton: rotifers (class Eurotatoria), cladocerans (class Branchiopoda, order Cladocera), copepods (class Copepoda) and ostracods (class Ostracoda). Monogononh rotifers, copepods and cladocerans were determined to the species, bdelloid rotifers and ostracods – to subclass and class. The dynamics of the same seasonal changes was analyzed on the basis of data obtained from the Oleksandrivka reservoir during the different seasons (spring, summer and autumn) in 2009–2010.

The material sampled by filtering 50 liters of water through a conical plankton net [14] from four standardized sampling stations [15]: I – the left bank of the upper part, N 47°51.429' E 31°07.721'; II – the right bank of the middle part, N 47°42.802' E 31°11.267'; III – the left bank of the middle part, N 47°44.110' E 31°44.681'; IV – the right bank of the lower part, N 47°42.042' E 31°13.704'. Within each station, the samples were taken at various points (habitats): in the thickets of higher aquatic plants (overgrown) and clean areas of littoral macrophytes pond (not over-

grown). At the station of the upper part of the Oleksandrivka reservoir dominated the formations of the common reed (*Phragmites australis* (Cav.) Trin. Ex Steud.). At the station of the middle and lower parts of the reservoir dominated the formations the claspingleaf pondweed (*Potamogeton perfoliatus* L.). The projective cover of higher aquatic plants increases from the top of the reservoir to its middle reaches – from 30 to 50%.

For general qualitative analysis 34 samples were collected using the conical net. Further processing of samples and analysis were performed on the basis of generally accepted methods. The species composition of zooplankton was identified in the laboratory due to identification guide [14, 16-19].

**The results and their discussion.** In the spring within all research stations was marked only the sites free of vegetation, and diversity of zooplankton was presented with 29 species: rotifers – 13 species, cladocerans – 85, copepods – 8. During the daily studies in the summer in common reed sites and in the sites without water plants 73 species of littoral zooplankton were registered: rotifers – 33 species, cladocerans – 26, copepods crustaceans – 14. In autumn 54 species of zooplankton were found in sites without aquatic plants and with reeds: rotifers – 16 species, cladocerans – 26, copepods – 12.

If we consider the representation of the species, during different seasons the serious reconstruction occurred. Species diversity of the littoral zooplankton increased in summer in 2,5 times in comparison with spring, and decreased in 1,4 times in autumn. Seasonal changes in species diversity of littoral zooplankton can be explained by the same reasons [5]. In summer comparing with the spring, the projective coverage and the overgrowth level of the habitat significantly increased, creating more favorable conditions for the development of aquatic littoral. Thus, in the spring samples were registered cryophilic species of rotifers – *Brachionus angularis*, *Br. nilsoni*, *Notholca acuminata*, *N. squamula*, which were absent during the summer and autumn research. Instead, a number of thermophilic representatives were met in the summer: rotifers of the genus *Lecane*, *Leptadella* and *Trichocerca*, *Tripleuchlanis plicata* et al.

The similarity of the species composition lists in different seasons was characterized by the Jaccard index as the very low: between spring and summer –  $J = 30,4$ ; between spring and autumn –  $J = 27,2$ ; between summer and autumn –  $J = 39,3$ . Especially low was the similarity between