APPLICATION OF THE ACCELERATOR MASS SPECTROMETRY METHOD TO STUDY THE MECHANISMS OF RADIATION MUTAGENESIS OF RICE CROPS: THE CURRENT STATE OF THE ISSUE

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Breeding rice crops resistant to drought and new diseases is a vital strategic task of modern rice growing due to the increasing shortage of water resources and the natural evolution of pathogens and viruses. The use of ionizing radiation for induced mutagenesis in plants allows creating crop varieties with desired properties. Ionizing radiation makes it possible to obtain a high percentage of chromosomal disorders with a high probability, which compares favourably with chemical mutagens, which usually lead to changes in individual genes. However, at the moment the mechanism of radiation mutagenesis is not fully understood, which does not allow to use this method to the full extent for breeding new crops with desired properties. The purpose of this study is to formulate a scientific research problem of investigating the effects of neutron radiation on the rice crop's mutagenesis and developing a new drought-resistant rice variety using the obtained knowledge.

According to study [1], rice has a relatively simple genome, which makes it a convenient model object for biotechnological research using ionizing effects.

Neutron radiation is actively used as a mutagenic ionizing effect for several crops. In particular, the authors [2], using the example of cotton seeds, empirically established a proportional dependence in the degree of biological potential disclosure with the absorbed dose when irradiated with neutrons for 24, 48, 72 and 96 hours (neutron flux was $8{,}64\times10^8$ n·s, $17{,}28\times10^8$ n·s, $25{,}92\times10^8$ n·s and $34{,}68\times10^8$ n·s, respectively). Increasing the exposure time up to 120 and 144 hours, on the contrary, led to a decrease of the germination energy in comparison with the control seeds. It means that under the influence of neutron irradiation the indicators of germination energy and seed viability increase, but with a further increase of seed irradiation time, these indicators decrease.

It has been shown that one of the possible mechanisms of the neutron irradiation effects on the change in the energy of seed germination is the formation of stable isotopes ${}_7N^{15}$ and ${}_6C^{14}$ as a result of nuclear reactions [3, 4].

According to research [5], accelerator mass spectrometry is one of the most efficient and versatile methods for elemental composition determination and can be used to determine the isotopic composition of studied objects. The method allows determining isotopes which content is less than 10^{-12} in the examined sample. Conventionally, such installation is divided into three parts: a low-energy mass spectrometer, an ion accelerator, and a high-energy mass spectrometer and can potentially be implemented on the basis of the EG-5 electrostatic accelerator at JINR (Dubna, Russia).

In addition to the isotopes $_7N^{15}$ and $_6C^{14}$, accelerator mass spectrometry makes it possible to analyze the content of cosmogenic nuclides in the Earth's crust, such as ^{14}C, ^{10}Be, ^{26}Al, ^{36}Cl, ^{129}I, which are formed in the atmosphere [6] as a result of cosmic rays exposure. That opens up prospects for studying the fundamental mechanisms of living organisms adaptation to the environmental changes.

Thus, the analysis of the available literary sources indicates the possibility of solving the problem of breeding a drought-resistant rice variety by using the neutron generator options and the developing accelerator mass spectrometry option based on the EG-5 electrostatic accelerator (JINR, Dubna, RF).

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[1] V.E. Viana, C. Pegoraro, C. Busanello and A. Costa de Oliveira (2019). Mutagenesis in Rice: The Basis for Breeding a New Super Plant. Front. Plant Sci. 10:1326. doi: 10.3389/fpls.2019.01326

[2] T.A. Khodzhaev (2014). Influence of neutron radiation on seeds of cotton. Mir sovremennoj nauki. 3 (25), 57-62.

[3] K.N. Mukhin (1974). Experimental nuclear physics. Atomizdat. 584

[4] T. A. Khodzhaev (2015). IR spectroscopic study of the mechanism of the effect of pre-sowing irradiation of cotton seeds with thermal neutrons in the process of germination and productivity in the field conditions. Izvestiya VUZov Kyrgyzstana. 9, 3-6.

[5] A.R. Striganov (1955). Isotopic effect in atomic spectra. Uspekhi Fizicheskikh Nauk. V.55, 3, 365-414.

[6] A. V. Blinov (1999). Accelerator mass-spectrometry of cosmogenic nuclides. Soros educational journal. 8, 71-75.