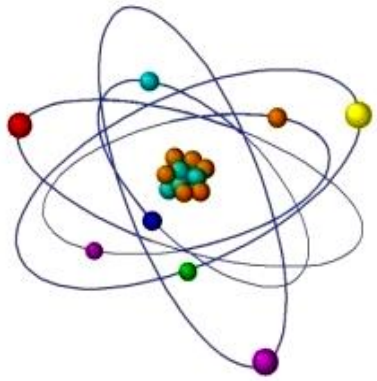
RADIOBIOLOGICAL HYPOTHESIS OF THE EVOLUTION OF GEORGIAN WHEAT



[1]Gogebashvili M.E*, [1]Ivanishvili N.I, [2]Chokheli M.I., [1]Shubitidze M.N, [2]Chxutiashvili G.A, [2]Samadashvili C.Z.

[1]I.Beritashvili Center of Experimental Biomedicine, Laboratory of Radiation Safety Problems, Georgia.
[2]Scientist-Research Center of Agriculture, Georgia

*Corresponding author: gogebashvili@gmail.com

ABSTRACT: *The efficiency of research on the origin and evolution of crop species is largely determined by the development of multidisciplinary theoretical and methodological approaches. Modern molecular genetics and archaeological techniques have revealed new aspects of the theory of centers of the origin of crop species. Based on this, the issue of the evolution of Georgian wheat landraces is one of the most important scientific tasks for understanding the processes of unique gene centers formation outside the known boundaries of the spreading cultural zones. In thisaspect, the search for factors of the possible effect on the evolution of specific species can significantly advance us in understanding the formation of isolated groups of the genus Triticum L. Despite many years of study on this issue, the absence of a definitive, generally accepted pattern of the origin of all species of wheat makes it difficult to ascertain the exact phylogeny of both ancestors and the genus as a whole. In our studies, we considered the possibility that radiation factor may be involved in the evolution of Georgian landraces. It is shown that in the case of the radiation effect, conditions are created for evolutionary changes towardthe polyploidization of species.The use of endemic species: Triticum monococcum L- 2n = 14, Triticum timopheevii (Zhuk) Zhuk.-2n=28, Triticum macha Dekapr. & Menabde - 2n=42, Triticum zhukovskyi Menabde & Ericzjan- 2n=42, Triticum dicoccum Schrank ex Schübler - 2n = 28, Triticum aestivum 2n = 42. Revealed clear dependence of radioresistance on the level of their ploidy. Having examined the places where endemic wheat species were found and matched them tothe background radiation of this zone, the conclusion is made about the possibility of the impact of the radiation factor on the evolutionary process of Georgian wheat landraces.*

Key words: wheat, radiation, ploidy, evolution.

INTRODUCTION

Georgia's wheat, as well as grape vines, have great historical and cultural significance, in addition to their agricultural purpose. This is the reason for the great interest in scientific research on the origin and distribution of wheat. Based on the use of molecular-genetic, biochemical, botanical, cytological, immunological, geographical, archeological and other methods, as a result of many years of research on various types of wheat, a hypothesis was formed about the possible course of evolution of the genus Triticum [1,2,3,4]. As early as the end of the 18th century, the first hypotheses appeared that indicated the existence of parallelism in the localization of wild and cultivated plants [5]. The abundance of hypotheses led to the revelation of mutually contradictory results. Vavilov made a significant contribution to the formation of views on the centers of origin of cultivated plants [6,7,8,9,10]. He was the first one to show that cultivated plants developed not

only limited distribution boundaries but also a specific area. Despite its small area, Georgia is the only country in the world where 15 types of wheat are recorded. Out of 15 types of wheat, 5 of them are endemic to Georgia. The mountainous regions of Racha-Lechkhumi are considered to be the place of origin of endemic Georgian wheat. [11,12.] Based on expedition materials and theoretical conclusions, Vavilov unequivocally showed that the centers of origin of cultural plants are located in the zones of optimal climatic conditions of the earth, and what is especially noteworthy, these "centers" are mainly located in mountain ecosystems. There is an abundance of evidence in favor of the assumption that the first foci of cultivation of such plants were mountain ecosystems and from there spread to the surrounding bar areas [13]. According to the natural parameters, the mentioned zones differ in temperature, soil moisture, relief diversity, which created favorable conditions for the geographical isolation of species. At the same time, if we take into account the differences of evolutionarily established forms, we can assume that genetically diverse centers should be characterized by some additional natural conditions, under the influence of which it would be possible to cause intense mutational processes. In mountainous regions - high radiation background can be considered as such condition.

As is known, the natural radiation background is determined by the mountain deposits, soil and water, as well as space radiation. An important component of the radiation background is the natural radioactivity of mountain rocks and soil, which is mainly represented by radioactive potassium, uranium, thorium and their decay products. No less noteworthy is the fact that, unlike the modern radiation background, radiation exposure reached a significant level in the past geological eras. [14] The evolution of Georgian wheat provides an opportunity to obtain a rather wide range of genetic material [15], the results of research conducted in this direction can be used as a model for explaining the evolutionary processes of the relatively closed zones of mountainous regions. Based on the above-mentioned factors, the aim of our research was to study the possible influence of ionizing radiation on the course of evolutionary processes of endemic Georgian wheat, as well as on the formation of phylogenetic processes in specific mountainous regions of Georgia.

MATERIAL AND METHODS

Wheat plants with different genomic indicators were used as the object of research: *Triticum monococcum.L, Triticum timopheevii (Zhuk) Zhuk, Triticum dicoccum Schrank ex Schübler, Triticum macha Dekapr. & Menabde, Triticum zhukovskyi Menabde & Ericzjan, and Triticum aestivum*. The modeling factor of radiation exposure was gamma radiation, which allows for determining the level of radioresistance of genotypes of researched plants. Pre-sowing irradiation of wheat seeds was carried out on a gamma-device (irradiation source ^{137}Cs, dose rate – 1,1 Gy/min).

RESULTS AND DISCUSSION

As can be seen from fig.1, the selected varieties of wheat differ from each other in the level of radioresistance. Because of this, it was not difficult to separate three groups according to radioresistance: I-2n=14- is characterized by low radioresistance; II-2n=28- group with medium radioresistance; III-2n=42- the most radiostable group.

Such a clear dependence between ploidy and the level of radioresistance is a theoretical basis for the conclusion that in the presence of radiation factor in the environment, the directed formation

of mechanisms of adaptive effects is taking place. In particular, the process of polyploidization of many plant organisms during radiation exposure creates a prerequisite for the formation of a genotype with high radioresistance. This phenomenon is confirmed by studies of polyploidization processes of Georgian wheat varieties [16]. It is clear that the realization of these forms of natural selection requires long-term, chronic exposure to the selection factor. By comparing the Vavilovian picture of the centers of origin of cultivated plants and the zones of uranium deposits, it can be confirmed that many centers of intense speciation exactly correspond to the zone of uranium deposits, which is characterized by an anomalously high natural radiation background on the Earth's surface [17].

All of this confirms the correspondence of the location of almost all the centers of intensive speciation of cultural plants investigated by Vavilov [18] and many micro-centers of the origin of narrow-endemic species of related crops identified by Zhukovsky [19] with uranium accumulation zones, which are characterized by high natural radioactivity of the environment, which is completely understandable from the point of view of modern radiobiology; That is, it is possible that the main mutagenic factor is a highly radioactive environment, which has the ability to affect the entire complex of plants at the same time. Presumably, the latter circumstance can explain the parallelism in the variation of the inheritance of related organisms. Those natural circumstances (optimal climatic zones, differences in the microclimate of mountainous regions, temperature, soil, amount of precipitation, conditions of geographical isolation), which, according to Vavilov, determined the localization of the centers of form formation, probably also influenced the origin of species.

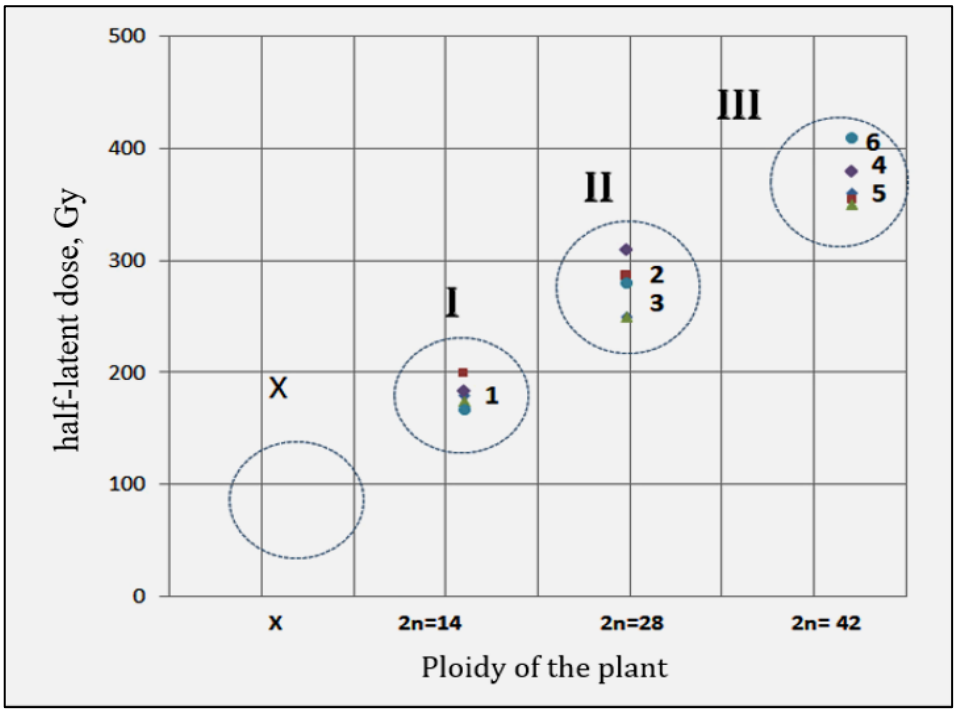


Fig. 1. Ranked groups of radioresistance of test plants

1-*Triticum monococcum.L,* 2-*Triticum timopheevii (Zhuk) Zhuk.,*
3-*Triticum dicoccum Schrank ex Schübler,* 4-*Triticum macha Dekapr. & Menabde.,*
5-*Triticum zhukovskyi Menabde & Ericzjan.,* 6-*Triticum aestivum L.*
Conditional groups of I-III radioresistance, X-hypothetical zone of radioresistance.

Of particular importance are studies showing that intense radiation exposure appears to be the most powerful and major factor in induced mutagenesis. During the long geological effects, the impact of the mentioned factor ensured intensive speciation processes and active natural selection.Therefore, the study of the radiological state of endemic areas can significantly strengthen the position in the assessment of the role of ionizing radiation in the evolution of local wheat species.

For the reliability of the model of the effect of radiation on the formation of endemics, we carried out an analysis of the zones in which the main endemic kinds of wheat were found for a certain period of time. This zone was mainly represented by the Racha-Lechkhumi region [20,21].Geographically, this zone is located on the northern borderline: Tsageri-Orbeli-Lailashi-Patara Oni; Eastern border: Khvanchkara-Dgnorisa; South and West: Tamakoni-Gordi-Mkewana (fig. 2).As can be seen from the presented picture, this area is characterized by a highdegree of isolation of landscapes, as well as a high rate of radioactivity. The study of the radionuclide content of the mentioned zone showed the presence of radioactive elements of uranium, thorium, and potassium in the soil [22]. Taking into account the physical characteristics of these natural radionuclides (for example, the half-life of uranium - 4.4 billion years), we can assume the radioactivity of this zone for many geological periods.

Fig. 2. The landscape zone of Racha-Lechkhumi, where several types of Georgian endemic wheats have been recorded.

CONCLUSIONS

Thus, as a result of the analysis of the radiobiological parameters of the detection zone of Georgian wheat species (Racha-Lchkhumi), a conclusion can be made with great probability about the participation of radiation in the formation of genotypes within the given zone. Radiation is such an influencial factor that has the ability to cause polyploidization processes in wheat species, which, in turn, leads to an increase in their radioresistance. It is on the basis of this last statement that we tried to formulate the radiation-local hypothesis of the evolution of Georgian

wheat varieties, in favor of which Vavilov's phrase - "the zones of the maximum variety of cultural plants, are also the centers of their origin" [8].The paleobotanical data obtained in recent years about the development of agriculture in specific areas are noteworthy, which indicates the polycentric origin of this field [23].Naturally, the radiation-local hypothesis offered by us does not provide a concrete answer to the question of the evolution of Georgian wheat. However, the radiobiological approach indicates a lack of defined evolutionary links (Fig, 1) both at the level of the organism and the origin of specific genes. It is known that in the ecological zones of isolated landscapes, there is a high probability of the disappearance of certain forms of organisms, which is why the study of intermediate genetic links (due to their existence) creates great difficulties, and molecular-genetic studies are carried out only on the basis of existing genetic lines. In our opinion, further study of the detailed issues related to thepeculiarities of the evolutionary processes of isolated mountain ecosystems requires multidisciplinary approaches.

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