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MODERN TRENDS IN AGRICULTURE SCIENCE: PROBLEMS AND SOLUTIONS

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ECOGENETIC VARIABILITY AT THE FIRST GENERATION AFTER MUTAGEN ACTION

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Changes in the structure and number of chromosomes can be caused by both external and internal factors. Chromosomal changes leading to mutations were first described in the genus Oenothera (Nazarenko, 2016). Subsequent studies of some plant species showed that these changes are a complex set of translocations. But even earlier, studies of other objects have shown that other types of changes (in particular, paracentric inversions) are quite often more likely causes of hereditary changes than much rarer translocations, although this type of change is more promising for cultivated plants. Already at the early stages of research, it became clear that chromosomal aberrations play an essential role in the evolution of living organisms (Shabani et al, 2022). The study of plant chromosomes in pachytene made it possible to establish that such types of rearrangements as deletions, duplications, inversions and translocations have a complex and complex character (Nazarenko and Izhboldin, 2017).

The key point for establishing the genetic potential of a mutagen in terms of hereditary variability, as well as an integrative indicator of genotoxicity, is cytogenetic studies of the factor (Pane et al, 2018). The main

interest in this regard are site-specific, highly active chemical compounds that have a chemical relation for the hereditary substance (DNA). A main trait of such factors in the impact is not only the predominant effect on certain genetic locus, but also a high induced variability with a less significant decrease in vital ontogenetic characteristics (the so-called mutagenic depression) (Oney-Birol and Balkan, 2019).

Analysis of the consequences of the action of a mutagen on the chromosomal level makes it possible to monitor the genetic activity of a substance, to show its capabilities in terms of induced variability, which will subsequently result in changes in the hereditary nature of economically and genetically valuable traits. At the same time, chemical supermutagens demonstrate an increased affinity for certain DNA regions, which further leads to an increase in the variability of some parts of the spectra of future changes (Spencer-Lopes et al, 2018). It is also necessary to monitor the changes that have occurred which directly influencing on the viability of the plant (Ram et al, 2019).

The use of chemical mutagenesis, taking into account the mechanism of action of a specific agent, allows in a short time to obtain new changes in form with permanent properties and features useful from a selection or genetic point of view, in particular, valuable changes in the biochemical structure in a short time. Such obtaining is significantly limited by the features of activities and chemical reactivity of a specific compound (Von Well et al, 2018). These factors show significant site-specificity, affinity to certain areas of hereditary material, which leads to the preferential induction of only certain types of traits. This can be both desirable (if these signs are useful) and negative (Wu et al, 2019).

Decisive in determining the effect of a chemical DNA-active substance is its effect on plant fertility, given the high potential of chemicals in particular in increasing the sterility of plants, formed by dominant mutations in this trait already in the first generation (Zaidi et al, 2019).

The use of chemical mutagens to treat wheat seeds leads mainly to depressing effects, although, unlike physical mutagens, especially those with a sublethal nature of action, sometimes certain chemical agents show a stimulating effect at low concentrations (Yang et al, 2019).

The general trend is the genetic improvement of winter wheat, one of the variants of which is induced biodiversity through the use of appropriate mutagenic factors (Abaza et al, 2020). Interdisciplinary research on the relations of agroecosystems through the knowledge of genetically determined processes, in particular the induction of biodiversity and its

preservation at an appropriate level to increase the potential capacity of agrocenoses of cultivated plants (Horshchar and Nazarenko, 2022b), allows to move to the regulation of productivity processes and the formation of quality at a fundamentally new level of regulation of genetic aspects of the interaction of organisms, as well as changes organism under the influence of ecogenetic factors: investigating the interaction of genetic processes and ecological relations (Bhat and Wani, 2017).

Wheat is the most widely grown and consumed food crop in the world with a current annual production level of over 620 million tons on a total production area of 217 million tons per hectare (Horshchar and Nazarenko, 2022a). In 2050, the world's population is estimated at 9.8 billion people and the demand for wheat reaches more than 900 million tons (Dorrani-Nejad et al, 2022). Central and West Asia and North Africa, a region with an average demand for wheat of about 191 kg / capita per year, accounts for more than 50% of wheat production in developing countries (Mamenko and Yakymchuk, 2019).

Establishing mechanisms for realizing the potential for yield and grain quality of new varieties of winter wheat (Hase et al, 2020), with the introduction of different ecological and geographical forms and in comparison, with local varieties in synthesis with specific conditions at the population and plant level are fundamental for implementation in economic practice stable-functioning agrocenoses of winter wheat in special conditions of the North Steppe region (Dwinanda et al, 2020).

The problem of realizing the genetic potential of modern agricultural crops has led to the need to take into account the features of the plant's existence in the interaction between the genotype and environmental factors, taking into account the context of the interaction, its complexity, and the features of the genetically determined adaptive reaction (El-Azab et al, 2018). Only in this way is it now possible to effectively increase the overall productivity, technological qualities of products obtained from agrocenoses, without significantly harming its relative stability, and sometimes even increasing it (Beiko and Nazarenko, 2022a).

Under this approach, the mutagen is considered simultaneously as a genetic and environmental factor, which leads to the expansion of the possibilities of using the norm of the organism's reaction, its adaptive abilities, the level of variability and regulation of the adaptive response at the genome level (Bezie et al, 2020).

The use of a variety of varietal resources of different origins for genetic improvement through mutational variability is a significant priority

in modern research for various branches of agricultural science (Beiko and Nazarenko, 2022b).

The use of low-damage mutagenic factors on the new source material allows not only to significantly accelerate the improvement process, but also to obtain a significant expansion of the variability of existing forms (Lykhovyd, 2021), which can be used quite successfully for a wide range of research in both ecogenetic and breeding directions as source material or directly as future varieties (Hassine et al, 2022).

Plants as an object of this type of research, in contrast to other model objects, make it possible to study the types and frequencies of chromosome rearrangements directly during the first mitotic division after treatment. It is believed that the main factors influencing the dependence of the reaction on the action of the mutagen are the difference in the genotype of the original form (Gharib et al, 2021), the size of the chromosomes, the activity of the repair systems, and the duration of the mitotic cycle. Also, the genetic activity in cereals literally changes several times depending on the presence of appropriate genetic resistance systems, of which only a few basic ones are known at the present time (Hussain et al, 2021).

The aim of the research was to establish the consequences for the action of an epigenetic substance at the plant cell level for comparison with conventional physical mutagens and chemical supermutagens, to establish the variability of individual parameters, the possibilities of modeling and predicting the process, and the suitability of classical methods in the study of epimutagens, to identify possible depressive effects when using mutagens of the nitrosoalkylureas group in the first generation of plants of soft winter wheat varieties based on indicators of germination, survival, fertility, and yield structure in order to determine the optimal processing protocol in view of obtaining the necessary amount of material for further research.

Seeds of common wheat of six varieties (1000 seeds in each treatment variant and in control) were soaked in an aqueous solution of epimutagen Triton-X-305 (hereinafter TX-305, Merck KGaA, Darmstadt, Germany) at concentrations of 0.01%, 0.05%, 0.1%, and 0.5%. The exposure of each of the options was 36 hours. Seeds 8 winter wheat varieties of Balaton, Borovytsia, Zeleny Gai, Zoloto Ukrainy, Kalancha, Niva Odeska, Polyanka, Pochayna were treated with a solution of the chemical mutagen NEU (nitrosoethylurea) in concentrations of 0.01 and 0.025%, NMU (nitrosomethylurea) in concentrations of 0.0125 and 0.025%. Germination, survival, and fertility of pollen grains were evaluated in the M1 generation, and the parameters of the yield structure were analyzed.

Cytological studies were carried out on mitoses of the primary roots of wheat during the first hour of the passage of late metaphase and ear-ly anaphase for all types in laboratory brains. After treatment with mutagens, they were germinated in Petri dishes on a filter paper soaked with dis-tilled water in a thermostat at a temperature of +25°C. Then the central core with a depth of 0.8-1.0 cm was fixed at the Clark fixer, which consists of 3 parts of 96% alcohol and 1 part of ocular acid, with a stretch of 24 years. Fixation material was taken in 70% alcohol at a temperature of +2 °C in the refrigerator. For the skin version, 25-30 roots were fixed. Cytological analyzes were performed on temporary pressure preparations prepared with acetocarmin. Like the roots, they choked badly; the tissues were macerated with 45% acetic acid. Preparations were prepared according to the standard method. Roots was taken in 70% alcohol in the refrigerator. For an additional method, it is possible to fix single pairs of fragments, dicentric chromosomes, micronuclei and mixed chromosomes.

Eight varieties selected by the leading institutions of Ukraine were used: Balaton, Borovytsia, Zeleny Gai, Zoloto Ukrainy, Kalancha, Niva Odeska, Polyanka, Pochayna. The seeds were treated with a solution of the chemical mutagen DAB (1,4-bisdiazoacetylbutane) in concentrations of 0.1, 0.2, and 0.3%. 1000 grains of winter wheat were used for each treatment.

Such parameters as germination, survival after the overwintering period, the level of fertility of individual varieties, elements of the yield structure, plant height, general and productive bushiness, length, number of ears, grain size from the main spike, weight of grain from the main spike and plant, weight of a thousand grains were studied.

The experiment has been conducted under the conditions of the experimental fields station of the Science-Education Center of the Dnipro State Agrarian Economic University during 2017–2021. Winter wheat seeds (1000 grains for each concentration and water) were acted with a EMS (ethylmethansulfonate) 0.025%, 0.05%, 0.1%

Experiment consists of 32 variants (in total) by 8 winter wheat varieties Balaton, Borovytsia, Zeleny Gai, Zoloto Ukrainy, Kalancha, Niva Odeska, Polyanka, Pochayna. The genotypes were identified according to characterize winter wheat varieties variability for North Steppe subzone (Dnipro region).

The experiment has been conducted under the conditions of the experimental fields station of the Science-Education Center of the Dnipro State Agrarian Economic University during 2017–2021. Seeds 8 winter wheat varieties of Balaton, Borovytsia, Zeleny Gai, Zoloto Ukrainy,

Kalancha, Niva Odeska, Polyanka, Pochayna were treated with a solution of the chemical mutagen sodium azide in concentrations 0,01%, 0,025%, 0,05%, 0,1%. Germination, survival, and fertility of pollen grains were evaluated in the M1 generation, and the parameters of the yield structure were analyzed.

First of all, various cytogenetic studies are used to test for such features, as they are faster than any field monitoring and more reliable, carried the definition of depression in other ways.

Previously, it was quite widely noted that exposure to mutagens leads to a significant and sharp decrease in pollen fertility, while this was gradual in nature up to a certain dose (concentration), followed by a sharp increase in sterility. In this situation, however, it is not observed for all genotypes; moreover, in most cases it is much milder. This once again indicates that the changes caused by this sub-stance are rather small, less traumatic. In addition, the second point is that they clearly depend on the genetically determined mechanism of the adaptive response, which, in turn, differs even at the level of individual groups of varieties.

Such indicators as the general rate of chromosomal aberrations and various rates of individual changes in the spectrum were of key importance for determining the nature of the impact on the chromosomal apparatus. Thus, such indicators as the presence of double fragments, bridges, the ratio of fragments and bridges (in terms of the nature of the mutagenic factor), and the presence of complex chromosomal rearrangements were of great importance for the identification of a mutagenic factor at the cell level. However, the presence of such a number of micronuclei and lagging chromosomes with such a small presence of cells with complex aberrations has never been ob-served under the action of any chemical substance. Usually, this was typical for the action of just high doses of gamma-rays or chemical supermutagens, however, in this case, the survival of the material in this experiment is significantly higher than under the action of semi-lethal and sublethal doses or concentrations of mutagens.

The variability of the material in terms of the overall frequency of chromosome rearrangements showed that an increase in con-centrations generally leads to a significant increase in the frequency of chromosome aberrations, however, in relation to differences between varieties, the Tyuki test showed the unreliability of the result obtained and it cannot be said that, despite a slightly higher frequency for the second group of cultivars Courtot, Lyrik, and Flamenko, they somehow significantly differ from the cultivars of the first group, less susceptible to the action of this epimutagen, Spivanka, Altigo, and Podolyanka. Thus, for this indicator, we are forced to reject the

hypothesis of significant differences in the effect on the chromosomal apparatus of the cell.

The ratio of fragments and bridges is usually in favor of fragments, that is, more than 1, which is generally normal for the action of a chemical agent, except for the Lyrik variant, TX-305 0.5%, while in general this ratio first increases as the concentration increases, then begins a gradual decrease, that is, the same trend is observed as in earlier studies, when at high (at the level of semi-lethal) concentrations, the action of chemicals became less selective in terms of the frequencies of types of chromosomal rearrangements. In the constructed model, the varieties Flamenko and Podolyanka are most clearly distinguished, the other varieties are partially mixed in the factor space and, thus, have a significantly lower resolution when studying this set of parameters. It should also be noted that for the first-time indicators in the study of damaging effects at the cell level in our studies turned out to be less effective than indicators of growth and development at the previous stage of research. As a rule, the opposite is true - cytological studies are much more accurate for monitoring undesirable effects. At the same time, it is also obvious that in this case the focus of action is more shifted to changes that do not affect the DNA of the cell.

It was established that the action of NEU was less harmful than the action of NMU. Quite often, for most samples, 0.025% HEU action corresponded to 0.0125% NMU concentration. With NEU, remote mortality was much less likely, while NMU was characterized by high mortality during overwintering. Mutagens have less influence on the fertility of the studied genotypes than they have on survival. It is more uniform with regard to individual genotypes, NMU increased the sterility of the obtained material more than NEU. Among the parameters of the structure based on the reproduction of mutagenic depression, the most reliable plant height and TGW stood out. The sign of the number of grains from an ear almost does not vary. Signs weight of grain from the main ear and weight of grain from the plant as a whole vary in accordance with the increase in concentrations as a whole, but sometimes their reaction differs within a separate genotype.

It was established that the action of NEU was less harmful than the action of NMU. Quite often, for the majority of samples, the 0.025% NEU action corresponded to the 0.0125% NMU concentration (half as much), and there was no statistical difference in plant death between them.

It should also be noted that under the influence of NEU, distant death was much less likely and for many varieties under the influence of a concentration of 0.01% the difference was not statistically significant, while

NMU was characterized by high mortality during overwintering with statistical significance for both variants. In general, the indicators of similarity and survival reliably demonstrated the depressive effects of both NEU and NMU with increasing concentration (and in accordance for all genotypes, which allows us to attribute these signs to those that reliably reproduce the fact of mutagenic action for the studied factors. Zeleny Gai. Zoloto Ukrainy, Niva Odeska and Polyanka were more susceptible to the action of nitrosoalkylureas, the Pochayna variety was the least by a significant margin.

As an indicator, pollen fertility, it significantly exceeds the previous version in terms of concentration variability. At the same time, the value of the genotype drops significantly. So, in general, for the HEU 0.01% option, fertility is at the level of 80-85%, for HEU 0.025%, the fertility rate was 75-80%, for NMU 0.0125% 75-80%, for NMU 0.025% 68-74 %. That is, on the one hand, it is enough to ensure effective pollination, on the other hand, the effect of 0.025% NEU and 0.0125% NMU concentrations did not differ significantly in all cases.

Among the above-mentioned signs, according to the reproduction of mutagenic depression, the plant height stood out as the most reliable (variable under the influence of a certain mutagen) - it always differed from the control effect of all concentrations, in some genotypes there is no difference between NEU 0.01% and NEU 0.025%, NEU 0.025% and NMU 0.0125%. In all cases, the effect of NMU 0.025% is clearly identified. A high influence of genotype, increasing concentration and of the nature of the mutagenic factor.

TGW as a trait in almost all cases clearly demonstrates a statistically significant decrease with an increase in the concentration of nitrosoalkylureas, except in some cases when moving from the concentration of NEU 0.025% to NMU 0.0125% in one case between the concentrations of NEU, where sometimes there are no significant differences in mutagenic depression. It always differs in the manifestation of depression from the control. A high influence of genotype was confirmed, increasing concentration and the nature of the mutagenic factor. Thus, these signs are a reliable indicator of mutagenic depression.

The trait of the amount of grain from the ear almost does not vary, and only the effect of the NMU concentration of 0.025% always leads to a significant decrease. In general, the sign is characterized by low variability.

The signs weight of grain from the main ear and weight of grain from the plant as a whole vary more or less similarly and respond similarly to mutagenic depression to increased concentrations in general, but sometimes

their reaction differs within a separate genotype. A high influence of genotype, increasing concentration and of the nature of the mutagenic factor.

Nitrosoalkylureas as supermutagens showed a significantly higher depression of indicators in the first generation than the previously studied 1,4-bisdiazoacetylbutane (DAB), but even higher concentrations than those used did not lead to a critical or even semi-lethal decrease in ontogenesis indicators in plants of the first generation, so the applied concentrations should consider acceptable for practical use. In terms of its damaging ability, NEU is significantly inferior to NMU. Similar to DAB, indicators of germination, survival (to a lesser extent than for DAB), fertility, plant height, and mass of one thousand grains turned out to be models for detecting mutagenic depression, but the genotype-mutagenic specificity significantly decreased, especially for the indicator of fertility reduction, the role of concentration, on the contrary, increased. That is, the selected concentrations are more contrasting in action.

The action of nitrosoalkylureas did not lead to a critical or even sem-lethal decrease in ontogenesis indicators in first-generation plants, so the applied concentrations should be considered acceptable for practical use. In terms of its damaging ability, nitrosoethylurea is significantly inferior to nitrosomethylurea. Indicators of germination, survival, fertility, plant height and weight of one thousand grains turned out to be model for detecting mutagenicity, but the genotype-mutagenic specificity decreased significantly.

It was established that such parameters as germination, survival, fertility level, plant height, weight of thousand grains have the necessary level of variability, which reliably reproduce the level of mutagenic depression with increasing DAB concentration, which was confirmed by discriminant analysis. In some cases, it is also possible to use such indicators as the weight of grain from the main spike and the weight of grain from the plant.

It was established that the genotype-mutagenic interaction is quite clearly manifested under the action of DAB, especially in terms of similarity and survival indicators and highly variable elements of the yield structure. The mutagen showed a low damaging effect. The genotypes Balaton and Zeleny Gai showed a lower level of variability.

It was determined that it is from the DAB concentration of 0.3% that mutagenic depression is manifested in any cases according to any indicators. It is planned to study the variability of the obtained material both at the cellular level according to chromosomal aberrations and the mutational

variability of plants in next generations.

The general rate of chromosomal aberrations is not subject to genotype influence in its variability, but only increases with increasing concentration of the chemical supermutagen. General rate of chromosomal aberrations varies from 9.8% (variety Kalancha) to 11.2% (variety Borovytsia) under the action of EMS 0.025%, at an EMS concentration of 0.05% from 13.6% (variety Niva Odeska) to 18.1% (variety Zeleny Gai), under the action of EMS 0.1% the range was from 19.9% (variety Kalancha) to 25.7% (variety Borovytsia). During the initial analysis, only two genotypes more or less stood out, however, the Tukey HSD test showed that only the variety Kalancha, the most vulnerable to the action of this mutagen. Moreover, in spite of the indicators of ontogenesis, the cytogenetic test depends much more on the characteristics of the particular variety genome than on phenological manifested adapt-ability. At the same time, the variability of the selected components for this type of analysis is significantly lower than in the case of ontogenesis parameters, which allows us to make conclusions about the predominantly external causation of depression at the level of the organism as a whole.

The general rate of chromosomal aberrations decreased statistically significantly in each variety with increasing mutagen concentration, with one exception of the variety Polyanka, when switching from an EMS 0.025% concentration to an EMS 0.05% variant, where no statistically significant difference. In all cases, already at the first concentration of the mutagen, a sharp increase in rearrangements from an extremely high level by an order of magnitude was observed. In general, the mutagen for these concentrations showed high cytogenetic activity. Unlike the previous parameters, this one is extremely sensitive to the action of a mutagen, but the genotype-mutagenic interaction is significantly lower, practically absent, and, as a result, the response of varieties is uniform.

Regarding spectrum of chromosomal abnormalities, such types of rearrangements as fragments (single and double), bridges (chromatids and chromosomes), micronucleus, lagging chromosomes, number of cells on the proper stages of mitosis with two or more aberrations were identified and calculated. Each rebuilding was taken into account as a separate case; the frequency was calculated like relation number of this aberrations type to the total number of abnormalities for this variant in percent.

As in the case of the general rate of chromosome aberrations, the frequency of fragments and double fragments is not subject to the action of

variety characteristics in its variability, but only increases with increasing concentration of the chemical agent. The Tukey HSD test showed that when this type of aberration was induced, there were no statistically significant differences in terms of varieties in any case, in terms of concentrations there were differences in all cases.

In general, under the action of EMS 0.025% concentration, the part in the spectra by fragments and double fragments varies from 51.8% (variety Borovytsia) to 62.0% (variety Zeleny Gai), for EMS 0.05% from 53.9% (variety Pochayna) to 62.0% (variety Zeleny Gai) and for concentration EMS 0.1% from 44.7% (variety Pochayna) to level 52.6% (variety Niva Odeska). Although the number of fragments and double fragments increases with each increase in concentration, when moving from the second to the extreme concentration, the proportion of fragments in the spectrum drops to the point that it may be less than the total presence of other types of chromosomal aberrations. Significantly, according to the genotype factor, they distinguished themselves in the behavior of the varieties Pochayna.

For aberrations of the bridge type (single and double), the genotype factor also did not have a determining value, but an increase in concentration significantly changed the rate of this type of aberrations. The Tukey HSD test showed that in terms of concentrations, there were differences in all cases except for the variants Polyanka EMS 0.025% and Polyanka EMS 0.05%. However, it is also interesting what proportion was bridged by genotypes and concentrations. So, the specific part of the bridges varied in the case EMS 0.025% from 25.3% (variety Zoloto Ukrainy) to 36.6% (variety Borovytsia), for EMS 0.05% from 21.7% (variety Kalancha) to 30.4% (variety Borovytsia), at case of EMS 0.1% from 28.9% (variety Kalancha) to 37.0% (variety Balaton) in this case, the specific weight of the induction of bridges first decreases, and then, when moving from the second concentration to the third one, increases again. The variety Polyanka with lower variability for this trait was distinguished.

The ratio of fragments and bridges is characteristic of chemical supermutagens; a clear predominance of fragments and double fragments over bridges, in all cases under the action of chemical mutagen, significantly more than 1. Again, a similar trend, the ratio increases to maximum values at EMS 0.05% and again falls under the action of EMS 0.1%, so the specificity in the effect of EMS drops with increasing concentration after some peak value.

As for other types of aberrations (lagging chromosomes and micronuclei), the genotype factor again had no significance, an increase in

concentration significantly increased the frequency of these types of aberrations. The Tukey HSD test showed that with increasing concentrations, the differences were in all cases for all varieties. As for the total number of rearrangements, the part of micronucleus and lagging chromosomes was in the case EMS 0.025% from 7.9% (variety Niva Odeska) to 14.3% (variety Pochayna), for EMS 0.05% from 11.2% (variety Zeleny Gai) to 23.1% (variety Kalancha), at case of EMS 0.1% from 14.2% (variety Balaton) to 23.4% (variety Kalancha). Thus, in general, as the concentration increases, a part of such rearrangements increases, but the process can hardly be considered linear. The variety Kalancha stood out with a significantly higher degree of this parameter induction in the relative value.

For the frequency of cells with the presence of two or more aberrations, complex changes, a generally linear increase in this value with increasing concentrations is characteristic, which is normal. At the same time, the influence of the genotype on this process is insignificant, increase in concentration significantly raised the frequency of complex changes The Tukey HSD test showed that with increasing concentrations, the differences were in all cases for all varieties. The part of cells with two or more aberrations in the case EMS 0.025% from 10.5% (variety Pochayna) to 18.4% (сорт Kalancha), for EMS 0.05% from 13.4% (variety Zeleny Gai) to 22.4% (variety Kalancha), in case of EMS 0.1% from 13.9% (variety Kalancha) to 27.4% (variety Borovytsia). Again, with increasing concentration, part of these rearrangements increases, but for all varieties (except varieties Kalancha, Balaton). To stand out varieties Kalancha and Balaton according to the dynamics of the change in the ratio.

The use of chemical mutagens is specific in terms of increased activity in some DNA regions related to a to a chemical structure of this mutagen, while activity is reduced for other regions (locuses). Thus, in theory, on the cytogenetic level, there should be some higher level in interaction with the genotypes of some varieties than it is shown by experiment. The only on possible conclusion is that this group of genotypes is genetically rather homogeneous, which contradicts the data obtained during the investigation on the phenotype level (parameters of mutagenic depression). The only one suggestion remains, according to which the already noted variability is associated not with the genetic systems that are responsible for the adaptive tolerance to environment, but with those that are responsible for the creation of the adaptive potential.

This mutagen, which is typical for chemical mutagens, induces

preferably fragments (i.e., the ratio of fragments to bridges in all cases is more than one). However, with an increase in the concentration of the mutagen, this ratio for second concentration increases, then decreases, which also indicates the transition of concentrations to the high range, since a decrease in the identifying ability of markers of cytogenetic activity is just characteristic of all ecogenetic factors at high doses and concentrations. Thus, at this case the investigated factor in this reason is no different from others.

It was also previously noted that the number of complex aberrations (i.e., cells with two or more chromosomal rearrangements) significantly increases from concentration to concentration, with the complete absence of such aberrations in the control. The varieties are characterized by a normal level of spontaneous aberrations, slightly higher due to the lower modern plant genome stability, which is repeatedly noted for modern cultivated plants in spite of wild relatives and landraces. It is also typical for this mutagen that at high concentrations it is possible that the number of fragments is specifically lower than the number of rearrangements of the bridge type with the presence of lagging chromosomes and micronucleus in total, which in general is not always found for other supermutagens or is not so uniform in depending on the object of action genotype.

A total of 40 variants were sown, when analyzing the obtained material according to the factors genotype of the subject of action (variety) and increased concentration of the mutagen (sodium azide), we find that the first factor acted with a much higher level for germination and survival, but the factor of increasing concentration was also significant for germination and survival, and the interaction of genotype and mutagen was quite significant, although varieties, with some exceptions (Pochaina and Kalancha varieties were more hardy), showed a fairly similar reaction. In all cases, for all varieties, germination and survival decreased with statistical significance, that is, the fact of mutagenic depression was reliable. A sodium azide concentration of 0.1% was semi-lethal for all but two genotypes.

As for depression, Pochaina and Kalancha varieties differed significantly in their similarity, survival was always significantly different from similarity, i.e. the remote death of plants as a result of the mutagen action was always significant, but here the varieties Balaton, Borovytsia, Zelenyi Gai, Zoloto Ukrainy, Niva Odeska, Polyanka were more vulnerable. The concentration of sodium azide 0.05% differed significantly in the nature of the effect on the difference between germination and survival. As for the peculiarities of ontogenesis, the main phases under the influence of

moderate concentrations of sodium azide were delayed in comparison with the control by 3-4 days (depending on the concentration of the mutagen), which was statistically significant for the second and third concentrations, and by 4-5 days for the semi-lethal concentration. This agent causes a significant decrease in plant viability.

In all cases, for all varieties, fertility was statistically significantly reduced under the influence of all concentrations. The parameter is a completely reliable indicator of mutagenic depression, although not as strong as that of germination and survival and was not limiting for obtaining sufficient plant material.

The analysis was carried out according to 9 characteristics, but the total and productive bushiness, length, number of ears of the main spike are not given, since the variability was observed significantly only under the influence of the fourth and, not always, the third concentration. Only mid- and high-variable traits are given: plant height, grain size of the main ear, weight of grain from the main ear and plant, weight of a thousand grains (TGW). The analysis based on the above signs showed that the height of the plant was statistically significantly different from the control and from each other. In all cases, the action of sodium azide is clearly identified. The difference between varieties is much lower and is explained by the characteristics of the original form.

The characteristic number of grains from the main spike is the least variable, but still the difference for genotypes and different concentrations is statistically significant. Thus, in varieties (except Borovytsa and Pochayna) actually only two gradations were observed under the action of the mutagen, quite often there was no difference between the control and the first concentration, the second, third and fourth concentrations. The sign was low variable.

The characteristics grain weight from the main spike and grain weight from the plant as a whole change similarly and respond to changes in mutagen concentrations, but sometimes their response differs within a separate genotype. Thus, the lower variability in the weight of grain from the plant for the varieties Balaton and Borovytsia, between the control and sodium azide 0.01% for these genotypes, the difference is unreliable. The difference for genotypes and different concentrations is statistically significant .

TGW as a feature in all cases clearly demonstrates a statistically significant decrease in the parameter with an increase in the concentration of sodium azide and reacts to the level of plant height as a feature that reproduces depressive effects. The difference for genotypes and different

concentrations is statistically significant.

The conducted research confirmed the classification of parameters based on factor analysis. As can be seen, the parameters of germination, survival, plant height, weight of grain from the main ear and TGW stood out. It is also reliable to use the weight of the grain from the plant, although their response to the concentration of sodium azide 0.01% is not always statistically reliable.

Sodium azide as a mutagen showed a rather high damaging capacity for a chemical supermutagen by the manifestation of depression according to monitoring indicators. Reliable parameters for establishing the fact of mutagenic depression, depending on the concentration and genotype, are germination and survival, growth, pollen sterility, plant height, grain weight from the main ear, weight of a thousand grains. Partially in this plan, you can also use the indicator of the weight of the grain from the plant, but it is not always reliable about low concentrations in some genotypes. Genotype-mutagenic interaction in terms of the manifestation of depression is determined in two effects - increased death after the overwintering period in some varieties and lower variability in the index of grain weight from the plant. Factors genotype and mutagen concentration under the action of this supermutagen are always statistically significant for model indicators. In the future, it is planned to investigate the variability at the cellular level according to chromosomal aberrations and to proceed to the identification of mutations in the second-third generation under the action of sodium azide in the same concentrations.

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