Chunetova Zh.Zh., Shulembayeva K.K., Zhussupova A.I., Omarova B.

Department of Molecular Biology and Genetics,
Al-Farabi Kazakh National University, Almaty, 050038, Kazakhstan
*e-mail: Chanar-79-16-06@mail.ru

Mutagenic activity of cadmium chloride
on the genetic variability of soft wheat

Abstract: The action of the chemical compound – CdC1₂ on soft wheat varieties resulted in plant modifications on a number of qualitative and quantitative traits. Genetic analysis conducted on the basis of reciprocal crosses showed that the inheritance of altered traits in mutants is independent of the direction of crossing. Modification of habitus and phenotypes of mutant plants is accompanied by a violation of cell division in meiosis.

Key words: mutagenic activity, cadmium chloride, soft wheat varieties.

Introduction

Chemical mutagens are an effective means of formative processes in wheat breeding and receiving selection and significant deviations [1, 2]. Obtaining of mutants and using them for hybridization are required to study genetic nature of appearing changes which have great importance for the selection of effective and specific action of mutagens, and for extension and deepening of understanding the nature of the evolution of wheat. In this work we present some results of research on genetic analysis of the mutant wheat. New forms, such as dwarf mutants in wheat and barley, ultra-fast mutants in barley, resistant to fungal diseases, high-leasing and highly productive mutants might be obtained qualitatively by chemical mutagenesis [3]. These facts show that the mutants obtained by chemical mutagenesis can successfully serve as progenitors of new high-yielding varieties. However, to obtain mutants and study them – this is only the first stage of the selection work. More important is the using mutants in the hybridization to obtain positive transgressions. The hybridization makes possibility to better use mutations in wheat breeding [4-6].

Materials and methods

M₁-M₃ mutants obtained in the process of CdCl₂ on 4 varieties of soft wheat of local breed – Shagala, Kazakhstanskaya 3, Jenis and Lutescens 32 were used as research objects. The modified plants subsequently lay in the form of lines (A-1, A-2). During the experiment, we used the following methods: Cytogenetic, Hybridological, statistical and morphological.

Results and their discussion

Genetic analysis of mutant wheat. Chemical mutagenesis in plant breeding is used as an effective method in order to enhance the variability of the starting material. In the world literature there is sufficient information about the creation of commercial varieties derived from experimental mutagenesis. To apply selected mutants in selection process is necessary to examine their genetic nature. For this, in genetic research are using two methods: analyzes and reciprocal crosses.

Analyzing cross. In order to establish the nature of any mutational change by variables usually used carrying reciprocal crosses between the original form and receiving on the basis of its mutant subsequent analysis of the hybrids F₁. In our studies M₁ generation plants with modified number of quantitative and qualitative characteristics was preserved the properties displayed in M₁. To establish the homo and het-
heterozygous genotype of mutant plants was carried out analyzing cross with an initial variety.

Mutant forms with signs of anthocyanin coloration of the stem, pubescent leaf surface, lengthening with spike crossed with an initial variety of Kazakhstanskaya 3. In BC₁, splitting signs to change and corresponds to the normal ratio of 1:1, and in F₂ is 3:1 (χ² = 1.89). Similar results were obtained with the mutant varieties of Shagala on the grounds of anthocyanin coloration of stem and leaf axils. BC₁ and F₂ hybrids were observed splitting on the grounds of lengthening the stem and normal nodes in the ratio of 1:1 and 3:1, respectively, which indicates that the heterozygous nature of the mutant and monogenic inheritance of this trait.

In contrast, cleavage by productive tillering, length and density of the spike in BC₁ corresponded to 3:1, and an F₂ population of 15:1, 13:9 and 3:7, respectively. This shows that the traits of mutant lines are inherited by a polymer, and complementary mechanisms of epistatic interactions of non-allelic genes. This shows that plants reaction by chemical compounds depends on wheat genotype.

### Table 1 – Genetic analysis of F₂ and BC₁ hybrids by crossing mutants with Kazakhstanskaya 3 variety

| Signs of mutants shape                  | The ratio of altered (modified) and normal plants |
|----------------------------------------|--------------------------------------------------|
|                                        | BC₁   | F₂    |
|                                        | 1:1   | 3:1   |
|                                        | 0.06  | 0.40  |
|                                        | 1:1   | 3:1   |
|                                        | 0.04  | 0.89  |
|                                        | 1:1   | 3:1   |
|                                        | 0.20  | 1.89  |
|                                        | 1:1   | 3:1   |
|                                        | 0.20  | 1.87  |
|                                        | 1:1   | 3:1   |
|                                        | 0.90  | 1.38  |
|                                        | 1:1   | 3:1   |
|                                        | 0.20  | 1.14  |
|                                        | 3:1   | 15:1  |
|                                        | 0.42  | 0.003 |
|                                        | 2:1   | 13:3  |
|                                        | 0.38  | 0.26  |
|                                        | 1:1   | 3:1   |
|                                        | 0.06  | 1.38  |
|                                        | 1:1   | 3:1   |
|                                        | 0.06  | 9.7   |

Further studies displayed arising changes in M₁ by the elements of productivity of Kazakhstanskaya 3 and Shagala varieties appeared in subsequent M₂ – M₆ generations. It was proved to conduct reciprocal crossing, where the modified attributes are inherited independently from direction of the crossing. Pheno-
typic variation of plants was accompanied by a violation of the process of meiosis.

**Cytological analysis of M₂ mutant plants.** Chemical mutagens because of its ability to induce a higher frequency of mutations are used in many countries around the world to create a breeding material. Chromosomal aberrations and violation of cell division during meiosis is one of the major tests for mutagenicity. Most notable in this regard is a meiotic cell division, especially in subjects like wheat, having a large number of hardly identifiable chromosomes. Moreover, violations of meiotic division are more likely to be transmitted to the next generation.

In mutant plants of M₄ generation percentage of damaged cells in MI meiosis equals 35, and at anaphase AI and AII – 20, which indicates a significant reduction in percentage of cells with disorders compared to M₁ mutant plants (64% AI and 68% – AII). Violation of this phenomenon is cytomixis – transition of contents to neighboring cells, M₁ amounts 20-30% of all the studied cells, while the percentage of such cells in M₄ decreases to 7-9%. So, the percentage of abnormalities in mutant forms of Kazakhstanskaya 3 M₂ equals 55%, in contrast, violation in M₁ – 90-95%.

Violation of meiosis in mutant plants of Kazakhstanskaya 3 variety is shown on Fig. 1-4.

Same decrease in percentage of violations is observed in mutants of Jenis, Lutescens 32 and Shagala varieties. In AI and AII some minor violations as a lagging chromosome fragments on the pole, bridge, asynchronous division. Occasionally cells with no content are observed.
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Cytological analysis of mutant plants M3. To characterize meiosis in mutant lines of M3 and identification of monosomic and disomic plants in F₁ hybrids with the mutant P₁ 1080 cells were analyzed. Results of cytological analysis of M₁ mutant plants are shown on Figure 2. Proportion of cells with pyknosis in L1 line M₁ mutants of Kazakhstanskaya 3 variety equals 0.29; mutant of Jenis variety – 0.10; Lutescens 32 – 0.23; line L3 of Shagala variety – 0.21 in comparison with the impaired cell M₁, respectively. Proportion of cells with univalents reaches 0.19; 0.009 and 0.16, respectively.

So, in the older generation of mutants (M₁) of Kazakhstanskaya 3 and Shagala varieties, selected for practical selection, proportion of cells with impaired meiosis in M₁ is much reduced with mutants like M₁ and M₂. Violations in M₁ meiosis in plants from the above varieties have the same character as M₁ plants in meiosis. Typical violations in M₁ – M₃ progeny mutants include: pyknosis; formation of offset spindle in metaphase I; univalents, polyvalents and asynchronous cell division in AI. This study demonstrates mutagenic effects of studied chemical compounds.

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