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

Abstract: The action of the chemical compound – $CdC1_2$ 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

M_1-M_3 mutants obtained in the process of $CdCl_2$ 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.

Cytological studies were carried out using a microscope LOMO Mikmed-1. Genetic analysis of qualitative and quantitative traits of wheat F_1 and F_2 hybrids were conducted. Statistical analysis was limited to estimation of the arithmetic mean and in order to determine the reliability of the difference between the arithmetic means of quantitative traits using the Student's t test, genetic – finding a significant $\chi 2$ value [7, 8]. Accounting of chromosomal abnormalities in MI, AI and AII of meiosis was performed on temporary acetocarmine preparations under the microscope MBI-3. The representativeness of research result provided an adequate sample size – 60-100 plants.

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 F_1. In our studies M_2 generation plants with modified number of quantitative and qualitative characteristics was preserved the properties displayed in M_1. To establish the homo and het-

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erozygous 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 BC_1 splitting signs to change and corresponds to the normal ratio of 1:1, and in F_2 is 3: 1 ($\chi 2 = 1.89$). Similar results were obtained with the mutant varieties of Shagala on the grounds of anthocyanin coloration of stem and leaf axils. BC_1 and F_2 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 BC_1 corresponded to 3:1, and an F_2 population of 15:1, 13:9 and 3:7, respectively. This shows that the treats 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 F_2 and BC_1 hybrids by crossing mutants with Kazakhstanskaya 3 variety

Signs of mutants shape	The ratio of altered (modified) and normal plants					
	BC_1			F_2		
	Line 1					
The length of the spike	27:25	1:1	0.06	188:57	3:1	0.40
Beardless spike	32:29	1:1	0.04	168:48	3:1	0.89
Anthocyanins stem	10:13	1:1	0.20	126:32	3:1	1.89
Pubescence sheet	8:10	1:1	0.20	112:28	3:1	1.87
	Line 3					
Cranked stem	22:20	1:1	0.90	118:31	3:1	1.38
Tillering of plants	45:13	3:1	0.20	120:5	15:1	1.14
The length of the spike	45:18	3:1	0.42	223:51	13:3	0.003
Anthocyanin color of sheet leaves	19:23	1:1	0.38	97:29	3:1	0.26
The thickness of the spike	33:31	1:1	0.06	85:54	9:7	1.38

Further studies displayed arising changes in M_1 by the elements of productivity of Kazakhstanskaya 3 and Shagala varieties appeared in subsequent M_2 – M_6 generations. It was proved to conduct reciprocal crossing, where the modified attributes are inherited independently from direction of the crossing. Phenotypic variation of plants was accompanied by a violation of the process of meiosis.

Cytological analysis of M_2 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 M_2 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 M_1 mutant plants (64% AI and 68% – AII). Violation of this phenomenon is cytomixis – transition of contents to neighboring cells, M_1 amounts 20-30% of all the studied cells, while the percentage of such cells in M_2 decreases to 7-9%. So, the percentage of abnormalities in mutant forms of Kazakhstanskaya 3 M_2 equals 55%, in contrast, violation in M_1 – 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.

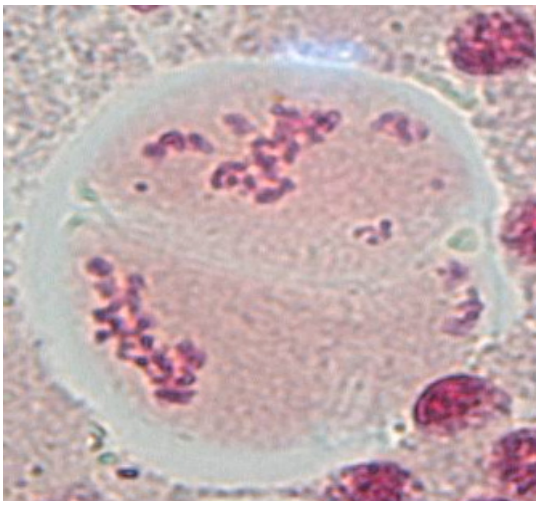

Figure 1 – Disorientation of equator chromosomes

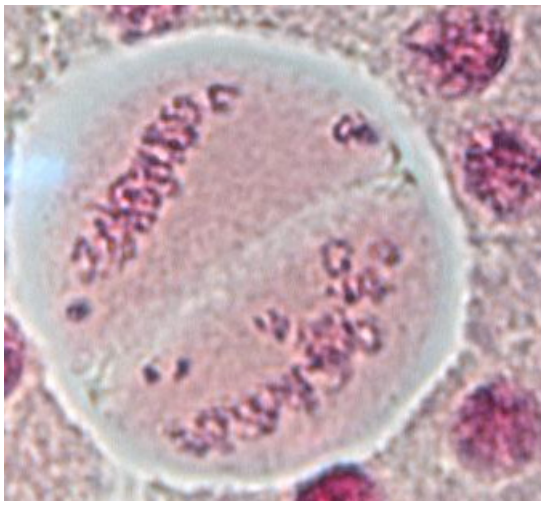

Figure 2 – Fragmentation of equator chromosomes

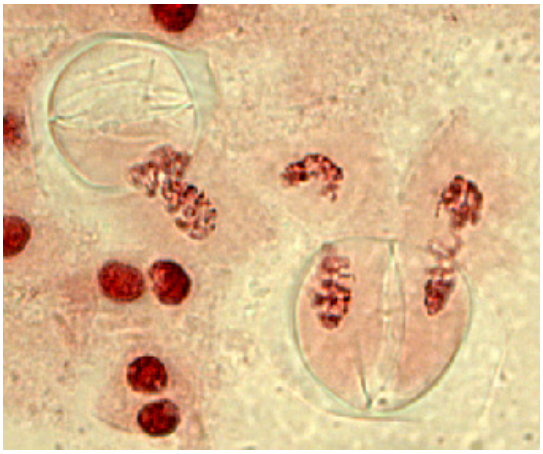

Figure 3 – Cytomixis – transition of cell contents into the neighboring

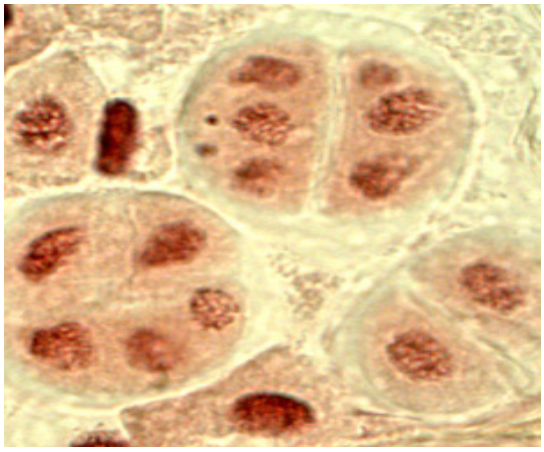

Figure 4 – Pentad and hexad formation

Cytological analysis of mutant plants M3. To characterize meiosis in mutant lines of M3 and identification of monosomic and disomic plants in F_1 hybrids with the mutant P_1 1080 cells were analyzed. Results of cytological analysis of M_3 mutant plants are shown on Figure 2. Proportion of cells with pyknosis in L1 line M_3 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 M_1, respectively. Proportion of cells with univalents reaches 0.19; 0.009 and 0.16, respectively.

So, in the older generation of mutants (M_3) of Kazakhstanskaya 3 and Shagala varieties, selected for practical selection, proportion of cells with impaired meiosis in M_1 is much reduced with mutants like M_1 and M_2. Violations in M_2 meiosis in plants from the above varieties have the same character as M_1 plants in meiosis. Typical violations in M_1 – M_3 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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