Dependence of soft wheat sprouts development on fungicides and variety genotype

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Abstract. *The effectiveness of fungicides as inducers of biological variability in populations of common wheat was studied. It is shown that the disinfectants have an unequal effect on the development of seedlings of different wheat varieties. It was found that, under the influence of fungicides, the range of variability in morphological characteristics significantly increased in conditionally mutant populations as compared to the control. Revealed a different response of varieties to the effect of fungicides, due to the differences in their genotypes. The Serebristaya variety showed greater lability of statistical indicators in response to the action of fungicides than the Pavlogradka variety, which showed a higher level of physiological homeostasis. When creating the initial material for breeding, it is recommended to use varieties with a higher capacity for neoplasms to enhance the mutation process in experimental lines of varieties under the action of fungicides.*

Keywords: *wheat, fungicide, cultivar, mutant, population, variability, genotype.*

Introduction

According to the UN, by 2050, the world's population will reach 9 billion people, and the need for food will grow by 70%. At the same time, the potential of world agriculture is already under threat [10]. The main reason for the decrease in the productivity of crop production is the narrowing of the genetic base of agricultural crops [15]. The current loss of diversity poses a serious threat to the solution of the food problem for the entire world community. Therefore, at the present stage, the problems of conservation and rational use of plant genetic resources have become state, strategically important for each country [4, 15-17].

The problem of the genetic uniformity of cultivated varieties of cultivated plants is currently well known in the scientific community [2, 3, 17], its consequence is a colossal loss of grain yields due to the damage of crops by various phytopathogens [2-4, 12], and first of all - rust fungi, due to the similar reaction of varieties to pathogens [16]. One of the ways to overcome the

current situation is the creation and use of new varieties and hybrids of grain crops that can provide a sustainable increase in crop productivity [13]. The most important in solving this problem belongs to soft wheat, with the future productivity of which is associated with ensuring the global food security of mankind [18].

In order to expand the genetic base of wheat, both the traditional method of chemical mutagenesis [8] and the search for new biologically active chemical compounds capable of inducing genetic changes in wheat populations [5, 7, 16] are used. When using chemical compounds, it is necessary to take into account not only the specificity of their impact, but also the potential mutability of crops and varieties, the biological specificity of the target itself [9]. The world achievements of induced mutagenesis in relation to different crops clearly indicate the role of the genotype in the mutation process: crops are classified as highly and low stable. Low stable are rye, oats and durum wheat, and highly mutable - barley, rice and soft wheat [14]. The genotype of the variety significantly affects the sensitivity to the mutagen, the frequency and spectrum of visible mutations. When studying the role of the genotype in induced mutagenesis, it was found that the ability of an organism to variability depends on its genetic characteristics, the number and size of chromosomes, age, ploidy, and other factors [11].

In recent years, there has been an increasing interest in fungicides as inducers of changes in genotypes associated with the emergence of new traits and properties that increase the productivity and adaptability of the crop. Such studies are already being carried out quite widely [1-3, 5, 7], however, the contribution of a biological object to the induced variability of populations is not sufficiently highlighted in the scientific literature.

Purpose of the study

In the process of studying the effects of the influence of biologically active chemical compounds of a new generation of decomposable fungicides AltSil and Alkasar on the biological properties of plants, to study the effect of fungicides on the growth and development of plants in the early stages of ontogenesis; features of the manifestation of phenotypic variability of seedlings of spring wheat varieties Pavlogradka and Serebristaya, depending on their genotypic differences.

Material and methods

In 2017–2020 the seeds of wheat varieties Serebristaya and Pavlogradka were treated with AltSil and Alkasar fungicides: Each of the fungicides was used in two concentrations: at a dose recommended for grain production (n) and a double dose (2n) to enhance the formative process and assess the damaging effect on cellular and organismic wheat plant systems [1].

Germination of seeds was carried out in rolls, observing the methods and requirements of GOST for seed organizations [6]. In the discussed series of experiments, 10 variants of the experiment, 60 seeds in each roll, were laid. The test objects were seedlings of the Pavlogradka and Serebristaya spring soft wheat varieties, the seeds of which were not exposed to fungicides. The experiment was carried out according to the following scheme (tab. 1):

Table 1.

Experiment scheme

№	Experiment variant	Fungicide and active ingredient
1	Spring wheat variety Pavlogradka	control, without seed treatment
2	AltSil (Pavlogradka) - AlP(n)	AltSil: tebuconazole
3	AltSil (Pavlogradka) - AlP(2n)	AltSil: tebuconazole
4	Alkasar (Pavlogradka) - AkP(n)	Alkasar: difenoconazole+cyproconazole
5	Alkasar (Pavlogradka) - AkP(2n)	Alkasar: difenoconazole+cyproconazole
6	Spring wheat variety Serebristaya	control, without seed treatment
7	AltSil (Serebristaya) - AlS(n)	AltSil: tebuconazole
8	AltSil (Serebristaya) - AlS(2n)	AltSil: tebuconazole
9	Alkasar (Serebristaya) - AkS(n)	Alkasar: difenoconazole+cyproconazole
10	Alkasar (Serebristaya) - AkS(2n)	Alkasar: difenoconazole+cyproconazole

Results and discussion

In our experiment, disinfectants containing various active ingredients had an unequal effect on the morphometric parameters of Pavlogradka seedlings. AltSil at a concentration (n) caused accelerated plant growth, forming a longer coleoptile, and a double dose (2n) delayed the development of this trait, however, the shoots were thicker in thickness and with a more developed root system. In addition, the leaf blades of the shoots were wider and more intensely colored. The Pavlogradka cultivar forms more developed shoots ($\overline{x}$ = 128.4 mm), but with a narrower range of variability (Cv = 10.1%) than in mutant forms (Cv = 19.2-21.2%, tab. 2). The action of the fungicide Alkasar caused an increase in the range of variability in the length of the sprout at both concentrations (n and 2n) with a significant decrease in the level of development of the sprout Conditionally mutant populations of the Serebristaya cultivar fluctuated in a wider range, both in terms of mean values and range of variability. This cultivar probably has a greater potential for variability under the influence of both fungicides than Pavlogradka, which has a higher physiological homeostasis.

Table 2

Statistical characteristics of the original varieties and their mutant populations

Population / Sprout length		AltSil (n)	AltSil (2n)	Alkasar (n)	Alkasar (2n)	Control, no processing
Pavlogradka	$\bar{x} \pm S\bar{x}$	108.6±0.38	98.9±0.33	98.4±0.34	98.3±0.31	128.4±0.22
	Cv (%)	21.2	20.1	21.0	19.2	10.1
Serebristaya	$\bar{x} \pm S\bar{x}$	108.9±0.30	97.5±0.41	113.8±0.23	98.6±0.42	139.6±0.24
	Cv (%)	16.8	24.5	12.3	25.6	10.3

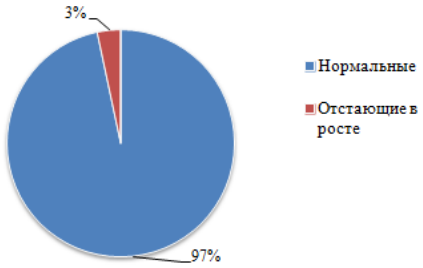
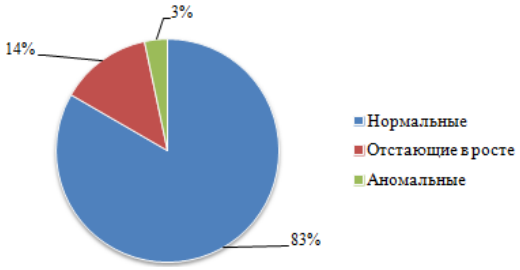


Fig. 1.Serebristaya, no treatment *Pavlogradka, no treatment*



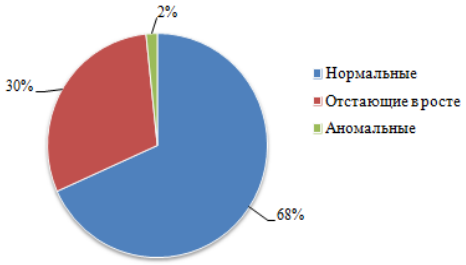
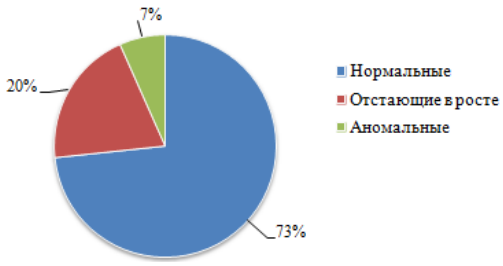


Fig. 2. Serebristaya, AltSil (n) *Pavlogradka, AltSil (n)*



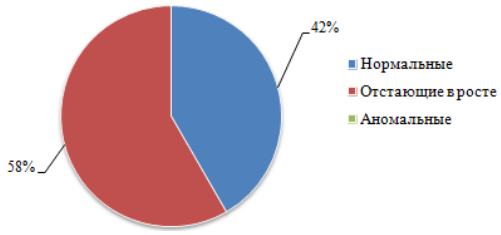
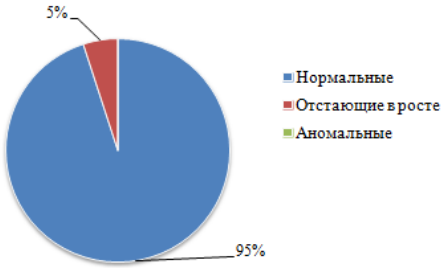


Fig. 3. Serebristaya, AltSil (2n) *Pavlogradka, AltSil (2n)*

In addition to the analysis of statistical parameters of populations, the ratio of the proportion of normally developed seedlings and the proportion of plants with deviations from the norm was assessed (fig. 1-6).

The seedlings of the variety Serebristaya, without treatment, did not have abnormal plants, the proportion of seedlings lagging behind in growth was 5%. (fig. 1). This is caused by a disease of three plants affected by mold because their kernels have not been treated with fungicides. The distribution diagrams of normal, stunted and abnormal plants show that in both treatment options (ALS –n and

ALS-2n), normal plants predominated (Fig. 2, 3). Lagging plants in the first variant accounted for 14%, abnormal - 3%. The doubled dose of the fungicide had a more pronounced inhibitory effect, therefore, the proportion of seedlings lagging behind in growth increased to 20%, abnormal - to 7%.



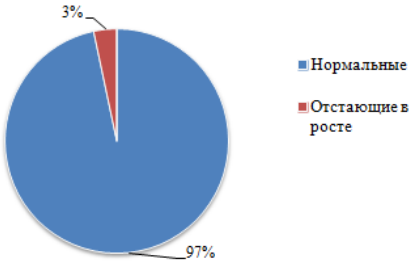
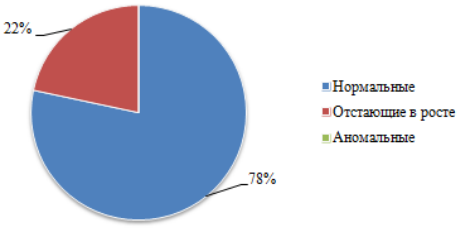


Fig. 4. Serebristaya, no treatment *Pavlogradka, no treatment*



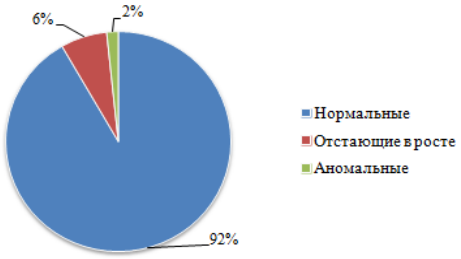
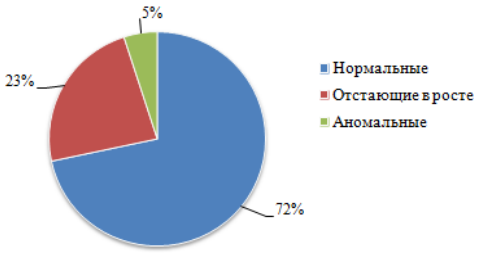


Fig. 5. Serebristaya, Alkasar (n) *Pavlogradka, Alkasar (n)*



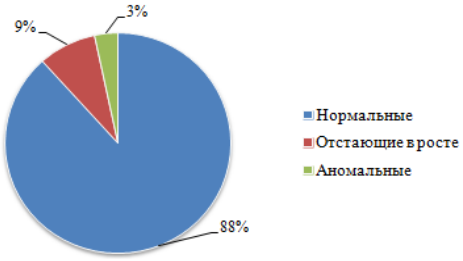


Fig. 6. Serebristaya, Alkasar (2n) *Pavlogradka, Alkasar (2n)*

The Pavlogradka cultivar without treatment formed more normal plants than the mutant forms (97%), and did not have abnormal seedlings, but the proportion of those lagging behind in growth was 3% (2 grains were affected by Fusarium). In the populations of Pavlogradka treated with a single dose of the fungicide AltSil (AlP –n), normal plants prevailed, the proportion of seedlings lagging behind in growth was 30%, abnormal plants - 2%. The doubled dose of the fungicide had a more pronounced inhibitory effect, therefore, the proportion of plants lagging behind in growth increased to 58%, without abnormal seedlings (fig. 3).

In both variants of the treatment of the Serebristaya cultivar with the fungicide Alkasar (AkS - n and AkS-2n), normal plants prevail, with a single dose (78%, and without abnormal seedlings), and with a double dose - 72% of normal seedlings (Fig. 4, 5). A double dose of Alkasar exerted an inhibitory effect to a greater extent, as a result of which the proportion of seedlings lagging behind in growth increased to 23%, and abnormal plants appeared, accounting for 5% of the total population (Fig. 6). The

effect of the fungicide Alkasar in a single dose shows that in the experimental populations, normal plants predominated 92%, lagging behind in growth with a single dose of the fungicide was 6%, taking into account abnormal plants (2%). The doubled dose of the fungicide had a more pronounced inhibitory effect, so the proportion of plants lagging behind in growth increased to 9%, and abnormal ones - up to 3%.

Conclusions:

1. The multidirectional effect of various disinfectants and their consumption rates on the morphometric parameters of seedlings was established: fungicides AltSil and Alkasar inhibited the development of seedlings of the Pavlogradka variety, reducing the average values of the trait by 15.4-23.5%.

2. The largest average value of the sprout length was observed in the control line of the Pavlogradka cultivar (128 mm), AlP (2n), AKP (n) and AkP (2n) were at the same level, - 98 mm, which showed an inhibitory effect on the development of seedlings, and the line AlP (n) - 108 mm (tab. 2) had a somewhat advanced development of shoots in comparison with them.

3. All mutant populations (CV within 20%) showed an average level of variability of the sprout length and a coefficient of variability close to it (CV within 20%), and only control - Pavlogradka had a low coefficient of variability (10%), from which we conclude that the fungicides we used increase the level of genetic diversity in populations of soft wheat treated with fungicides.

4. The lag in the development of seedlings of the Serebristaya variety was more significant (by 18.5-30.2%) than that of the plants of the Pavlogradka variety. The effect of the fungicides used on the level of population variability was revealed: the coefficients of variability of the shoots of mutant lines of the Pavlogradka cultivar in comparison with the control (Cv = 10.1%) increased to 21.2%, and the lines of the Serebristaya cultivar (Cv = 10.3%) increased to 25.6%. In general, the values of the coefficients of variability of the traits of the Serebristaya variety varied in a wider range than that of the Pavlogradka variety. The influence was exerted by both the type of fungicide and its dose, and varietal differences of plants (tab. 2).

5. AltSil in a single dose (AlP - n) showed weak stimulation of individual plants, AltSil in a double dose (AlP - 2n) and Alkasar - inhibition.

6. The mutant populations of the Serebristaya cultivar fluctuated in a wider range, both in terms of the mean values and the range of variability. This cultivar probably has a greater potential for variability under the influence of both fungicides than Pavlogradka, which has a higher physiological homeostasis.

7. When creating a source material for breeding, it is recommended to use varieties with a higher capacity for neoplasms to enhance the mutation process in experimental lines of varieties under the action of fungicides.

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