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Types of changes in M_1 generation of selected cotton plant varieties after presowing treatment with gamma radiation and their economically valuable features

Abstract. The article presents the results on the types of changes in the M_1 generation of Ganja-160, Ganja-182 and Ganja-183 cotton varieties treated with gamma rays in different doses before sowing, and their economically valuable features. It was found that in addition to sterile, late-ripening, small-boll forms of plants, as well as large-boll, compact bush, fast-growing, high-fiber forms of economic value are found in plants altered by gamma radiation. The results showed that an increase in the gamma radiation dose leads to increasing in the percentage of variability, while parameters such as productivity, fiber yield and fiber length decrease compared to the control plant. Due to the special importance of productive, high fiber output, long-fiber, forms with high raw-cotton in one boll as a starting material, they were selected for use in next-generation plants. Thus, on the basis of them, it is possible to select economically valuable forms in future generations.

Keywords: indigenous cotton cultivars, pre-sowing gamma irradiation of seeds, M_1 generation, number of bolls, sterile, fiber output, fiber length.

Introduction

The creation of new intensive varieties and their introduction into production is one of the decisive factors in the dynamic development of cotton. It is clear that each newly created intensive type must be more productive, have high fiber quality and be resistant to diseases and pests. It is no secret that not every new certificated variety can meet the needs of a developing industry after a while. For this reason, the selection of varieties with high potential and meeting modern requirements has always been in the focus of breeders and geneticists. It is believed that in this direction, a rich starting material must be obtained to create sustainable varieties that meet long-term demand. [1]. Experimental mutagenesis is one of the main sources of raw material as a method that differs in this area [2].

Numerous studies have shown that experimental mutagenesis is one of the most reliable methods for the maintenance of valuable economic indicators in plants for the next few generations, as well as for the creation of new varieties. The effect of mutagens on seeds, pollen, hybrid forms also allows the creation of primary forms with a richer genotype [3]. It is believed that the effect of mutagens on plant seeds creates large-scale hereditary variability associated with chromosomal changes [4].

To these dates, it was possible to obtain new varieties of such crops as wheat, barley, soybeans, peas, corn and other agricultural crops that been grown by the method of experimental mutagenesis [5]. It has been shown that the genetic effects of various physical and chemical mutagens depend on their concentration, dose and duration of action [6]. It was also found that the stimulating effect of mutagens significantly affects the moisture level of the seed, the retention period of the mutagen, the genetic characteristics of the starting material, and so on [7].

Based on the effect of chemical mutagens on plant seeds, it has been possible to obtain different plant forms of different levels [8, 9]. It is noted that some of the constant forms obtained by this method due to the complex of economic valuable features can be used as a variety that differs from the parent forms. Some forms can be used as a donor in the creation of new varieties in the selection stages as a starting material according to their individual characteristics [10, 11].

Inexpensive, clear of ecological features with a stimulating effect, high neutralization of planting material, no lethal finals to planting material, minimizing seed damage during processing, no induced mutation, reducing energy consumption, etc. such features are the main reason for the growing importance of technology based on the use of radioactive radiation for seed processing [12].

Based on the above, as a physical mutagen, we used the technology of radioactive radiation, or more precisely, the treatment of seeds with gamma rays before sowing.

Materials and methods

As a research material, certificated cotton varieties such as Ganja-160, Ganja-182 and Ganja-183, the seeds of which were obtained without self-pollination for 2 years, were used. Cottonseeds were irradiated at doses of 5, 10, 50, 100, 200, 300 and 400 Gy at the RUXUND (Russia) facility using the Co^{60} isotope of source of gamma radiation.

Non-irradiated seeds of these varieties were used as control options. Seeds of all three irradiated and non-irradiated cotton varieties were sown in open field conditions on the experimental basis of the Ganja Regional Agrarian Science and Innovation Center. Sowing was carried out in the 2nd decade of April in 4 repetitions according to the scheme 90 cm x 10 cm. Considering that experimental mutagenesis did not allow dilution, a limited number of seeds (2 units) were sown in each nest. It is known that dilution in the field violates the percentage of mutation yield, and can also destroy plants that have changed in a positive direction, which is important for breeding process. In total, 100 seeds were used for each variant.

A few days after sowing, field germination of seeds was registered. Less (25%) and mass (75%) germinating formation were reported by variants and doses. In M_1, the periods corresponding to the flowering and ripening phases of development were recorded and the rate of opening of the bolls was determined.

During the study, the effect of gamma radiation at different doses on the growth and development of cotton plants was studied by measuring 25 plants in each variant during the phases of mass budding, flowering and maturation. At the end of the vegetation, the viability of plants was also studied.

Systematic phenological observations were made on plants during the entire vegetation period in the M_1 generation. At the end of the vegetation, altered plants were recorded in each variant, which differed from the original varieties in terms of phenotypic characteristics. Also, sterile, fertile, etc. formed in plants forms have been identified.

The collection of raw cotton began with the collection of samples. For this purpose, raw cotton of 20 bolls was collected from I and II places of II-V bar branches of all plants on each repetition. After the raw cotton of the samples was collected, the modified and unchanged plants were collected as an individual sample. To determine the frequency of mutations, the number of mutations occurring in 100 families in M_2 of a 100-count sample in M_1 was studied.

Biometric analysis of all indicators obtained in the study was calculated according to B.A.Dospekhov [13].

Results and discussion

The first thing that attracts attention from the results of our study is the discovery that the treatment of seeds with different doses of gamma rays before sowing causes a number of genotypic changes in the quantitative characteristics of plants. More precisely, the shape of the bush, branching, slicing of bolls, color of leaves, etc. such as polygenic features varied and differed from control. The results of the types and amount of variability in plants under the influence of gamma radiation are given in Table 1.

It is clear from the results that gamma radiation was able to cause different types of variability in plants at all doses. Examples of these variations are the fact that the shape of the arm is compact or scattered, the trunk is short compared to the control, and has a branched shape with numerous side branches, and so on can be shown.

In some cases, the effects of gamma radiation resulted in the fascia of the sympodial branches, forming plants with clusters of fruit branches. In the short sympodial branch of such plants sometimes dozens of small cones are formed. Such a change occurs only under the influence of physical mutagens, which is explained by disorders in the process of meiosis. During embryogenesis, these cells develop poorly and form short sympodial branches. It should be noted that the formation of such cluster-like sympodial branches is considered a rare hereditary variability.

Table 1 – Results on the types and amount of changes observed in the M_1 generation of cotton varieties with seeds treated with gamma rays (2021)

Name of variety	The dose of radiation, Gy	The number changed plants, units	Type and number of variability in plants											
			Form of the bush					Form of the boll			Maturity		Sterile	Semi-sterile
			Compact	Scattered	Strong plants with scattered stems	Branch fascia	Carlic	Plants with a bunch of bolls	Large	Small	Late-ripenning	Early-ripening		
Ganja-160	C	-												
	5	2	1									1		
	10	5	2			1				1		1		
	50	6	3											
	100	8	3			1				1		3		
	200	22	2	2	5	7			1			5		
	300	28		4	5	4	2	3	4		3		3	1
	400	25		3	1			4	5		5		4	3
Ganja-182	C	-												
	5	1	1											
	10	3	1									2		
	50	6	2							1		3		
	100	10	4		2					1		3		
	200	28	1	3	7	5	3		5		4		1	
	300	23		4	6				3		3		5	2
	400	17		1	1	3	3		2		3		3	1
Ganja-183	C	-												
	5	3	2									1		
	10	4	1							1		2		
	50	12	2			1		1		3		5		
	100	21		3		3	2	4	4		3		1	1
	200	29	1	2	5	2	2		6		5		4	2
	300	21		3	4	3		3	4				1	
	400	14		1	1		1	2	2		2		3	2

The effects of gamma radiation have also been felt in plants. Thus, very tall or small (deaf) plants were formed from irradiated seeds. Dwarf forms were observed only in Ganja-182 cotton variety and in case of irradiation of seeds of this variety in doses of 200 and 300 Gy.

Some plants have large or very small bolls. Bushes in such plants are very scattered, and they are characterized mainly by late maturity.

The plants with most small bolls were with compact bushes. In plants, even pairs of bolls have been found which is one of the rare types of variability. Plants marked with this form have been found when seeds are treated with high doses of gamma rays.

In the M_1 generation of the plants we studied, sterile, low-fetal, and high-yield forms were also found in various experimental variants. The number of such plants observed was relatively small, mainly when the seeds were treated with high doses of gamma rays.

In addition to sterile, late-ripening, small bolls, bunch-like fruit-branched forms of no experimental significance in the variations caused by gamma radiation, economically valuable (large bolls, compact bushes, and fast-growing) forms were also found.

Table 2 contains information on the number of changed plants in the M_1 generation of cotton varieties.

It is noteworthy from the table that the increase in radiation dose in all cotton varieties also leads to an increase in variability. In other words, an increase in the gamma radiation dose also leads to an increase in the number of altered plants.

Another interesting fact is that in doses of 300 grams and above, all cotton varieties have a greater number of deformed plants. For example, for Ganja-160, Ganja-182 and Ganja-183 cotton varieties, the total number of deformed plants at a radiation dose of 300 Gy is the respectively (28.0 ± 4.49), (22.1 ± 4.07) and (35.0 ± 6.16) percent, respectively. At a radiation dose of 400 Gy, the total number was (41.7 ± 6.36), (32.7 ± 6.50), and (70.0 ± 10.25) percent respectively.

Table 2 – Information on the variability of gamma radiation caused by cotton varieties in the first generation (M_1) plants

Variants	The doses of radiation, Gy	The total number of plants in M_1, units	Ganja-160: The number changed plants		The total number plants in M_1, units	Ganja-182: The number changed plants		The total number plants in M_1, units	Ganja-183: The number changed plants	
			Units	In % ($x\ s_x$)		Units	In % ($x\ s_x$)		Units	In % ($x\ s_x$)
1	C	316	-	-	356	-	-	336	-	-
2	5	296	2	0.67 ± 0.47	352	1	0.40 ± 0.34	308	3	0.97 ± 0.56
3	10	292	5	1.71 ± 0.76	336	3	0.89 ± 0.51	316	4	1.26 ± 0.63
4	50	292	6	2.05 ± 0.83	292	6	2.05 ± 0.83	276	12	4.35 ± 1.23
5	100	268	8	2.98 ± 1.04	288	10	3.47 ± 1.08	240	21	8.75 ± 1.82
6	200	220	22	10.0 ± 2.02	272	28	10.3 ± 1.84	224	29	12.9 ± 2.24
7	300	100	28	28.0 ± 4.49	104	23	22.1 ± 4.07	60	21	35.0 ± 6.16
8	400	60	25	41.7 ± 6.36	52	17	32.7 ± 6.50	20	14	70.0 ± 10.25

Periodic phenological observations showed that in all variants of cotton varieties, the stages of growth and development at the beginning of the vegetation were normal, and no variability was recorded. Sharp differences were observed in the later stages. In addition, although normal bolls were formed during the reproductive development of the observed plants, most of the bolls were not opened at the end of the vegetation period, and the mature bolls were located in the lower part of the sympodial branches.

As is known, gamma radiation is allowed to cause modification changes in the productivity elements of various agricultural crops. It is clear that in a cotton plant there is a direct positive correlation between the amount of product and the number of bolls per plant and the mass of one boll. However, there are many factors that affect the amount of gross product. These factors include early maturity, resistance to disease and pests, etc. such symptoms can be attributed. Irrigation, fertilization, etc. carried out in this direction. The impact of such a set of agro-technical measures on the increase, as well as reduction of production is quite large. In our research, we have tried to reduce the impact of environmental factors on plants with the help of special measures.

Parameters such as the productivity of bush, the mass of raw cotton in a boll, fiber output, fiber length and strength are important indicators of the quantity and quality of cotton. With this in mind, we have tried to clarify the effect of gamma radiation on the quantitative and qualitative indicators of the cotton varieties we studied. The results obtained are reflected in Table 3.

It is known that the mass of raw cotton of a boll is one of the main elements of productivity of a variety. In addition to varietal characteristics, the mass index of raw cotton in a boll is a variable parameter depending on agro-technical measures, abiotic and mutagenic factors.

Table 3 – Influence of gamma ray treatment of seeds on economic values of cotton varieties in M_1 generation

Name of variety	The dose of radiation, Gy	The yield of bush, g	Fiber output, %	The mass of raw cotton in a boll, g	Fiber length, mm
Ganja-160	C	154	34.2	6.3	34.6
	5	136	36.7	6.1	34.9
	10	139	36.4	7.9	33.8
	50	112	36.2	6.4	34.5
	100	85	35.9	6.0	33.6
	200	84	36.5	6.1	33.3
	300	62	35.5	5.8	33.6
	400	82	36.5	5.8	32.3
Ganja-182	C	131	34.5	6.8	34.1
	5	100	34.8	6.6	34.1
	10	114	34.6	5.2	33.5
	50	153	37.2	7.0	33.7
	100	126	35.4	6.2	33.2
	200	82	34.0	5.5	33.9
	300	79	34.9	5.6	33.4
	400	68	34.0	5.2	34.1
Ganja-183	C	140	36.6	6.5	34.2
	5	102	37.9	6.3	33.2
	10	138	37.2	6.9	32.6
	50	110	35.7	6.6	33.4
	100	140	34.9	6.1	32.4
	200	112	34.6	5.6	31.7
	300	76	33.7	5.4	33.0
	400	96	33.5	5.3	31.9

It is clear from the analysis of the results presented in the table that pre-sowing treatment of seeds with gamma rays can cause quantitative and qualitative changes in the M_1-generation of cotton. It was found that an increase in the gamma radiation dose in Ganja-160 cotton variety leads to a decrease in the amount of product per bush. For example, if in the M_1 generation of this variety, the amount of product per bush in the 10 Gy radiation dose variant was 139 g, in the 300 Gy dose it was 62 g, and in the 400 Gy dose it was 82 g. Therefore, an increase in the dose of gamma radiation leads to a decrease in the yield of the product in one dose at all doses.

Similar results were obtained for the mass of raw cotton in a boll. While the weight of cotton in one boll of the control variant of Ganja-160 cotton variety was 6.3 g, in doses of 300 and 400 Gy it was 5.8 g in both variants. It is noteworthy that the weight of cotton (7.9 g) in one boll of the bush at a dose of 10 Gy is more than the mass in one boll of the control variant (6.3 g).

In Ganja-182 cotton variety, if the seeds were irradiated at a dose of 50 Gy, the weight of the product per bush was 153 g, which is about 22 g more than the weight of the control variant. In this cotton variety at high (300 and 400 Gy) doses of gamma radiation, as in the Ganja-160 cotton variety, the weight of the product in one branch was less than the weight of the control variant (131 g). Thus, the weight of the product in one bush at these doses was 79 and 68 g, respectively, which is 52 and 63 g less than the weight of raw cotton in one bush of the control variant, respectively.

Approximately similar results were obtained for Ganja-183 cotton variety. In this case, an increase in the radiation dose at high doses leads to a decrease in the weight of both the cotton on one arm and the weight of the cotton on one other arm compared to the control. For comparison, the weight of cotton in one arm of the control sample of this variety was 140 g, while in doses of 300 and 400 Gy, respectively, 76 and 96 g. For the weight of cotton in a cotton ball, these figures were 6.5, 5.4 and 5.3 g, respectively.

As it is known, sort samples of cotton are evaluated mainly by fiber yield and fiber quality. For this reason, today in all cotton-growing regions of the world, cotton is grown directly on the basis of fiber. Thus, different cotton varieties are distinguished by their unique fiber yield and fiber quality. It should also be noted that fiber yield indicators in the same variety can vary to varying degrees depending on many factors. In other words, the effect of agro ecological factors can change fiber yield. In this regard, the study of the effects of mutagenic factors is of particular importance. Based on the fact that radioactive radiation has a dose-dependent, stimulating effect, as well as being a mutagenic factor, we have tried to clarify our conclusions on the fiber yield and fiber quality of the cotton varieties we studied.

It should be noted that the length of cotton fiber is one of the most important economic characteristics of this plant, and the quality of the fiber is mainly determined by this feature. In the textile industry, fiber is valued as a raw material for various types of textiles. Like the yield of cotton fiber, the length of the fiber can change under the influence of various agro ecological factors. Changes in water and nutrient regimes, disruption of the agro-technological process and various mutagenic factors can affect the length of the fiber. The length of the fiber can vary depending on both the variety and the location of the cocoons in the plant [14].

From the results presented in Table 3, it is clear that pre-sowing treatment of seeds with gamma rays does not significantly affect the fiber yield and fiber length in the M_1-generation of cotton, except for small deviations.

It is more obvious that there is no significant difference between the experimental variants of Ganja-160 cotton variety, the seeds of which are treated with gamma rays. Thus, the fiber yield is 36.7% in the 5 Gy dose variant, 36.4% in the 10 Gy variant, 36.5% in the 50 Gy variant, 35.5% in the 300 Gy variant, and 400 Gy variant. and 36.5%. In the control variant, this figure was 34.2%.

No significant differences were observed in the fiber length of this variety. There was only a small increase in the dose of 5 Gy, and a small decrease in larger doses. To be more precise, in this variant, the fiber length was 34.9 mm at a dose of 5 Gy, 33.8 mm at a dose of 10 Gy, and 32.3 mm at a dose of 400 Gy.

In Ganja-182 cotton variety, the fiber yield was approximately the same at all doses, with the exception of the 50 Gy variant. In the 50 Gy dose variant, the fiber yield was slightly higher. The length of the fiber, on the other hand, has hardly changed, except for small deviations within the error of the experiment.

Thus, treatment of seeds with gamma rays (with the exception of 50 Gy) did not create significant differences in the fiber yield of Ganja-182 cotton variety, and radiation at a dose of 50 Gy gave a positive result compared to control.

In the M_1 generation of Ganja-183 cotton variety, the effect of gamma radiation on the seeds did not cause significant differences in terms of fiber yield. At low doses for this variety, an increase in fiber yield was observed from 36.6% in the control to 37.9% (5 Gy) and 37.2% (10 Gy). High radiation doses resulted in a regular decrease in fiber output to 33.5%.

In Ganja-183 cotton variety, pre-sowing treatment of seeds with gamma rays caused a slight reduction in fiber length compared to controls. Thus, the length of the fiber in the control variant was 34.2 mm, 31.7 mm in 200 Gy, 33.0 mm in 300 Gy and 31.9 mm in 400 Gy.

In the M_1 generation of Ganja-183 cotton variety, it was not possible to find any regularity in the effect of gamma radiation on the fiber length depending on the radiation dose. In this case, too, the small deviations were mainly due to the error of practice.

Based on the results of our research, it can be considered that by sowing the seeds with gamma rays before sowing, it is possible to change the mass of raw cotton in a boll, which is one of the main elements of cotton, and select individuals with high fiber yield.

Thus, by exposing the seeds to gamma radiation, it is possible to obtain unusable, sterile, semi-sterile, fine-grained, late-ripening forms, as well as productive, high-fiber, long-fiber and high-density forms of cotton in one boll. These forms are of special importance as a starting material, on the basis of which it is possible to select economically valuable forms in future generations.

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