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EFFECT OF IONIZING RADIATION AND THE ORIGIN OF HYBRID POTATO SEEDS ON THEIR GERMINATION

Anatoliy PODHAIETSKYI, Natalia KRAVCHENKO, Vladislav KOVALENKO

Sumy National Agrarian University, 160 Herasym Kondratiev St., 40021, Sumy, Ukraine, Tel.:+38-054-262-78-16

Corresponding author email: podgaje@ukr.net

Abstract

The specificity of the mutual influence of radiation exposure and interspecific hybridization methods through their simultaneous use on the germination of hybrid seeds, the growth and development of formed plants has been experimentally proved. The difference in the germination rate of hybrid seeds in the control is influenced by the origin of hybrids, in particular maternal forms, that has resulted in a 1.8-time difference between combinations. Half of the populations have shown a positive reaction of the use of radiation exposure to germination energy, regardless of its dose that should be considered as the process stimulation. However, in some combinations, the value of some variants is lower than in the control that indicates a specific interaction of the two factors: interspecific progeny origin and radiation dose. In the five combinations of six, the maximum effect of seed germination energy is found in the variant with the radiation dose of 200 Gy, compared to the control, that is in the range of 3.0-8.0 absolute percent. The similar, though not always the same data, have been obtained on the laboratory seed germination. The average value of the indicator, compared with germination energy, is 1.7-2.2 times greater. The disturbance of the growth and development of young plants isby and large observed as the formation of two stems from the initial point of growth or after the formation of rosette-like tops, as well as the formation of only cotyledon leaves without the point of growth.

***Key words**: potato, backcrosses, growth and development deviation, interspecific hybrids, laboratory seed germination, radiation exposure, seed germination energy.*

INTRODUCTION

Recently, the scope of radiation exposure application has significantly expanded. It is used to reduce the spread of infection, pests (Iman et al., 2008) during the storage of agricultural produce - the inhibition of life processes during this period (Avdiukhina et al., 2016), in particular potatoes (Rezaee et al., 2011). The method of pre-sowing seed irradiation is especially widely used (Marcu et al., 2013; Toni et al., 2013). For the purpose of its practical use, mobile gamma-ray sources (or units) have been designed, and the research area is called radiological and biological technologies (RBT).

However, traditionally, radiation exposure has been and is most commonly used in breeding that has enabled, in a short span of time, to obtain the most diverse genetic material, to achieve genetic variability, which is absent in nature, and therefore unavailable to breeders. The high efficiency of this method is confirmed by a large (more than 3,000) number of varieties of different crops created subject to its application (Mohanjain, 2012).

Moreover, the successful application of the above method has largely depended on the biological characteristics of crops. Significant results have been obtained in the breeding of sunflower (Encheva et al., 2014), barley (Kozachenko, 2010), tomatoes (Sikder et al., 2013) etc.

Despite the fact that radiation mutagenesis has been used in potatoes for a relatively long period of time (Asseieva, Blagovidova, 1935), so far its involvement in breeding practice has resulted in only seven varieties (Zia et al., 2018). At the same time, the source breeding material, which is the most diverse and valuable in many respects, has been created as well.

With the use of radiation mutagenesis in potato breeding, the breeders have managed to relatively easily change the color of tubers, the depth of “eyes” (Singh, 1970), increase resistance to extreme temperatures, reduce the content of glycoalkaloids, and boost crop yields (Zia et al., 2018).

New approaches to the intensification of using the radiation exposure method are associated with its being combined with other methods. Significant advances in this regard have been made in barley breeding (Kozachenko, 2010). In potatoes, it has been suggested that radiation exposure should be combined with *in vitro* plant growth (Souleymane et al., 2016). Under such conditions, the breeders have managed to significantly increase the variability of the studied material, accelerate the identification of mutagens and obtain plants free from infection (Ulukapi, Nasircilar, 2015). This has resulted in the obtaining of positive outcomes in the creation of salt-resistant samples (Yaycili, Alicamanoglu, 2012; El-Hetawy et al., 2018). Due to soma clonal variability it has been managed to increase the height of plants, the number of nodes, the average number of tubers in the potato variety Desiree. However, the reaction to the experiment variants in the potato variety Diamond is somewhat different (Afrasiab H., Iqbal, 2010). The radiation exposure of shoots without leaves, with leaves and microtubers with doses of 5-30 Gyhas enabled to reveal that it is the microtubers that have turned out to be the most resistant to the induction of *in vitro* mutations (Souleymane Bado et al., 2018). The study of radiation exposure of test-tube plants has enabled, in variants with the doses of 5 and 10 Gy, to obtain a positive effect on their growth and development, to boost crop yields (Sherin A. Mahfouze et al., 2012).

From a breeding and genetic perspective, potato is a complex culture. For successful creation of competitive varieties, it is necessary to expand its gene pool. Our studies (Podhaietskyi, 2012) and the research of other scientists (Gruneberg et al., 2009) have shown that this is possible for varieties only through the involvement of wild and cultivated species in breeding practices. On the contrary, the narrowing of the genetic basis of the source breeding material, as in China, has led to its low genetic diversity (Sharma et al., 2014), ultimately resulting in a decrease in the yield of commercial varietiesobserved relatively long ago (Gopal, Oyama, 2005). One of the most effective methods of introgression of valuable and effective genes into new varieties is the use of interspecific hybridization. For example, in Ukraine 10 varieties have been bred with the use of our source breeding material with wild Mexican species *S. demissum* Lindl., *S. bulbocastanum* Dun. (Podhaietskyi et al., 2017).

Due to the fact that until recently no studies have been conducted with the combination of two methods: interspecific hybridization and radiation exposure, in particular γ-rays, we have sought the goal to reveal their mutual influence at the stage of the germination of hybrid seeds from the backcrossing of secondary interspecific hybrids.

MATERIALS AND METHODS

The uniqueness of the material involved in the study is due to its origin. The hybrid seeds of the six complex combinations by genealogy have been used for irradiation. The six-species (five combinations) and three-species hybrids have been used as secondary interspecific hybrids (the offspring from the crossing of hybrids with wild, cultural species, varieties). The specificity of this material is the involvement of a wild Mexican species *S. bulbocastanum* Dun., which is characterized by a high and very high manifestation of numerous characters missing in commercial varieties, and phylogenetically distant from cultivated varieties, in crossing (Semeniuk et al., 2006).

The backcrossing of secondary interspecific hybrids has been conducted to cultivate a source pre-breeding material (hybrids, which are ineffective to be used directly in the breeding process without elaboration). The study has involved the backcrosses (“B”) (Bukasov and Kameraz, 1972) varied in their origin: in the combination of 91.318-6 x Svitanok kyivskyi it is a two-time backcross involving self-pollination of a primary inter-specific hybrid (B^2I_2), in the population of 89.24s34 x Kalynivska - B^1 from the crossing of two multi-species hybrids, in the com-bination of Shchedryk x Strumoka maternal form is a B^2 six-species hybrid, the population 81.397s50 x Barabara - B^1, and in 89.141s193 x Verdi - B^3. Only in one combination of 90.673/48 x Kalynivskaa B^2 three-species hybrid was used as a maternal form.

The six-species hybrids were of the following origin*://{[(S. acaule x S. bulbocastanum) x S.*

phureja] x S. demissum} x S. andigenum/ x S. tuberosum, a three-species hybrids - *(S. demissum x S. bulbocastanum) x S. tuberosum*.

The dry hybrid seeds, characterized by a complex genetic nature, were treated with gamma rays, the source of which was ^{60}Co at the Theratron Elit-80 therapy unit. Considering that microtubers from *in vitro* plants are more resistant to radiation exposure than seed pieces (Souleymane Bado et al., 2016), and botanical seed compared with microtubers, and taking into account the methodology of research conducted on other crops, the following doses of treatment of seeds have been selected: 100, 150 and 200 Gr. Untreated seed has been used as the control. The process of seed germination was reduced to placing each variant in a separate Petri dish, the lower and upper parts of which were covered with the moistened filter paper (Methodology, 2002). The experience was laid on April 12, 2014. Sprouted seeds were placed for further growth in the seed-boxes with a mixture of 1 part of loam, 1 part of sand and 1 part of humus. The germination energy was determined by the proportion of seeds sprouted in the first four days, and the laboratory germination – by the proportion of sprouted seeds within 15 days from their placement in Petri dishes (Zhatova, 2009). There were some deviations in the process of germination and cultivation of plants in seed-boxes.

RESULTS AND DISCUSSIONS

The effect of radiation doses on the germination energy, laboratory seed germination depending on the inheritance of interspecific hybrids, their backcrosses has been determined. We believe that due to the broad genetic basis of the test material it has been managed to identify a specific reaction of seeds involved in the study of samples, depending on their origin, to the radiation exposure. The hybrid seeds in the combination of 81.397s50 x Barbara were characterized by the minimal manifestation of germination energy in the control - 2.4% (Table 1). The opposite was true for the population of 91.318-6 x Svitanok kyivskyi with the level of the indicator manifestation which was 2.9 times higher. The obtained data have enabled to assert the influence of crossing components on the seed germination energy. The combinations of 89.24s34 x Kalynivska and 90.673/48 x Kalynivska differed only in a maternal form, but the difference between them by the manifestation of the indicator in the control was 1.8 times. In other words, the manifesttation of character among hybrid seeds was to a large extent dependent on the maternal crossing component - backcrosses of interspecific hybrids.

In general, a positive effect of radiation exposure on the seed germination energy was revealed, although with some differences in the relationship between the heredity of hybrid seeds and radiation doses. The maximum positive effect of radiation on the seed germination energy was revealed in the population of 91.318-6 x Svitanok kyivskyi. The difference in the proportion of seeds that came up during four days in the control and the average value of other variants was 2.9%, or 41.4% of the smaller value of the indicator. The similar data were obtained in the combinations of 90.673/48 x Kalynivska and 89.24s34 x Kalynivska, respectively, 2.6 and 2.2%. The opposite meaning was found, in particular, in the combination of Shchedryk x Strumok, in which the above mentioned difference was only 0.2%. That is, with the use of irradiated seeds, the indicator value was influenced by both radiation doses and the heredity of maternal forms.

The specificity of mutual influence of radiation doses and the heredity of hybrid seeds on the seed germination energy were revealed during our studies. The highest value of the indicator was in the combination of 90.673/48 x Kalynivska in the variant with the radiation dose of 200 Gy - 14.4%. In this respect, the population of 91.348-6 x Svitanok kyivskyi trailed only it in the variant with the radiation dose of 150 Gy - 13.3% that, we believed, was due to the stimulation of the seed germination process by radiation exposure. The opposite concerned the combination of Shchedryk x Strumok, where the seed germination energy in the two variants (radiation doses of 100 and 150 Gy) was lower than in the control. The last dose turned out to be unfavorable for seed treatment in the combinations of 81.397s50 x Barbara and 89.141s193 x Verdi. We believe that the latter indicates the offspring reaction to radiation, which is different from the reaction in the abovementioned combinations.

Table 1. Effect of radiation exposureon laboratory seed germination and germination energy

Population No.	Crossing combination	Radiation dose, Gy	Number of seeds in the Petri dish, pcs	Germination energy, %	Laboratory germination, %
1	91.318-6 x Svitanok kyivskyi	control	300	7.0	18.7
	The same	100	300	9.0	16.3
	″ –	150	300	13.3	29.7
	″ –	200	300	10.3	19.7
	Total/average	-	1200	9.9	21.3
2	89.24c34 x Kalynivska	control	340	3.5	6.8
	The same	100	340	4.1	7.4
	″ –	150	340	6.8	11.5
	″ –	200	340	8.5	14.1
	Total/average	-	1360	5.7	9.9
3	Shchedryk x Strumok	control	405	5.4	12.4
	The same	100	405	4.2	12.4
	″ –	150	405	4.2	8.2
	″ –	200	405	8.4	13,8
	Total/average	-	1620	5.6	11.4
4	81.397c50 x Barbara	control	550	2.4	4.6
	The same	100	550	3.3	6.6
	″ –	150	550	2.2	4.4
	″ –	200	550	6.0	12.6
	Total/average	-	2200	3.5	7.0
5	89.141c193 x Verdi	control	620	5.3	10.8
	The same	100	620	7.9	17.6
	″ –	150	620	4.8	9.7
	″ –	200	620	9.4	21.9
	Total/average	-	2480	6.9	15.0
6	90.673/48 x Kalynivska	control	640	6.4	10.0
	The same	100	640	7.7	15.5
	″ –	150	640	7.7	15.9
	″ –	200	640	14.4	27.5
	Total/average	-	2560	9.0	17.2

A special big difference of the variant with the highest seed germination energy (200 G) and control was found in the population of 90.673/48 x Kalynivska - 8.0% (Figure 1), which was 2.3 times of the smaller indicator value. In the other combination with the participation of the mentioned maternal form, the difference with the best variant was 5.0%, or 2.4 times. At the same time, the difference in the control of both populations turned out to be significant - 2.9%.

In the three combinations of Shchedryk x Strumok, 81.397s50 x Barbara and 89.141s193x Kalynivska the difference in the control was substantial in some variants with the radiation dose of 150 Gy.

With the exception of the combination of 91.318-6 x Svitanok kyivskyi a maximum difference in the control was observed when using the radiation dose of 200 Gy.

Somewhat different from the above was concerned the laboratory germination of seeds (Table 1). An increase in the duration of accounting for the germination of seeds up to 15 days from their sowing to germination had a positive effect on the number of germinated seeds. The population of 91.318-6 x Svitanok kyivskyi was characterized by the maximum value of the indicator in the control - 18.7%. The similar laboratory germination of seeds occurred in the combinations of Shchedryk x Strumok, 89.141s193 x Verdi and 90.673/48 x Kalynivska that was in the range of 10.0% to 12.4%.

The opposite was true for two populations not mentioned. Compared with the maximum value of the indicator the control value in the latter was 2.8-4.1 times lower. That is most populations differed significantly by difference in the manifestation of character.

The highest laboratory germination of seeds was observed in the combination of 91.318-6 x Svitanok kyivskyi with the radiation dose of 150 Gy - 29.7%. It was only 2.2% less in the population of 90.673/48 x Kalynivska although in another variant - 200 Gy. However it should be noted that the greatest difference in the control over the manifestation of the indicator (equal to 17.5%) was found in the last population.

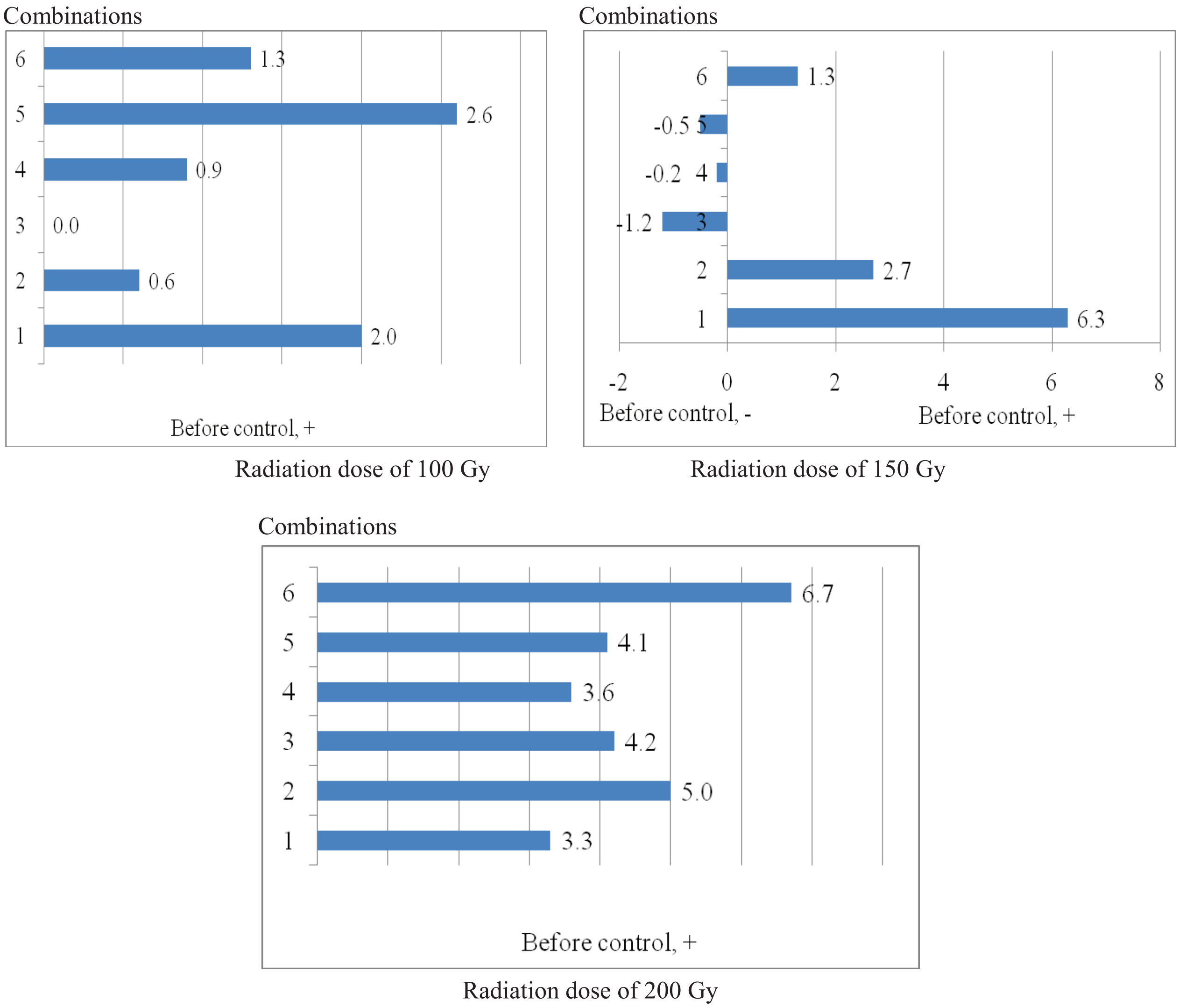

Figure 1. Difference in the control of seed germination energy depending on the radiation doses
Note: *the combination numbers shown are the same as in Table 1

The laboratory germination of seeds in certain variants of radiation doses was lower than in the control. However it concerned only the combination of 91.318-6 x Svitanok kyivskyi in the variant with the dose of 100 Gy and the populations of Shchedryk x Strumok, 81.397s50 x Barbara and 89.141s193 x Verdi after using the dose of 150 Gy (Figure 2). At the same time except for the combination of Shchedryk x Strumok the average value of laboratory seed germination in the variants with different radiation doses was higher than in the control. A positive effect of any radiation doses on the laboratory germination of seeds was found in the two combinations although the difference between the variants in such combinations was significant. For example, such difference was 12% (doses of 100 and 200 Gy) in the population of 90.673/48 x Kalynivska but it was only 6.7% in another combination involving the similar maternal form. That is a different reaction to the west was revealed in the above mentioned populations with the general positive effect of the radiation exposure of seeds on the indicator manifestation. In both populations the minimum positive effect on the laboratory germination of seeds was observed in the variant with the dose of 100 Gy.

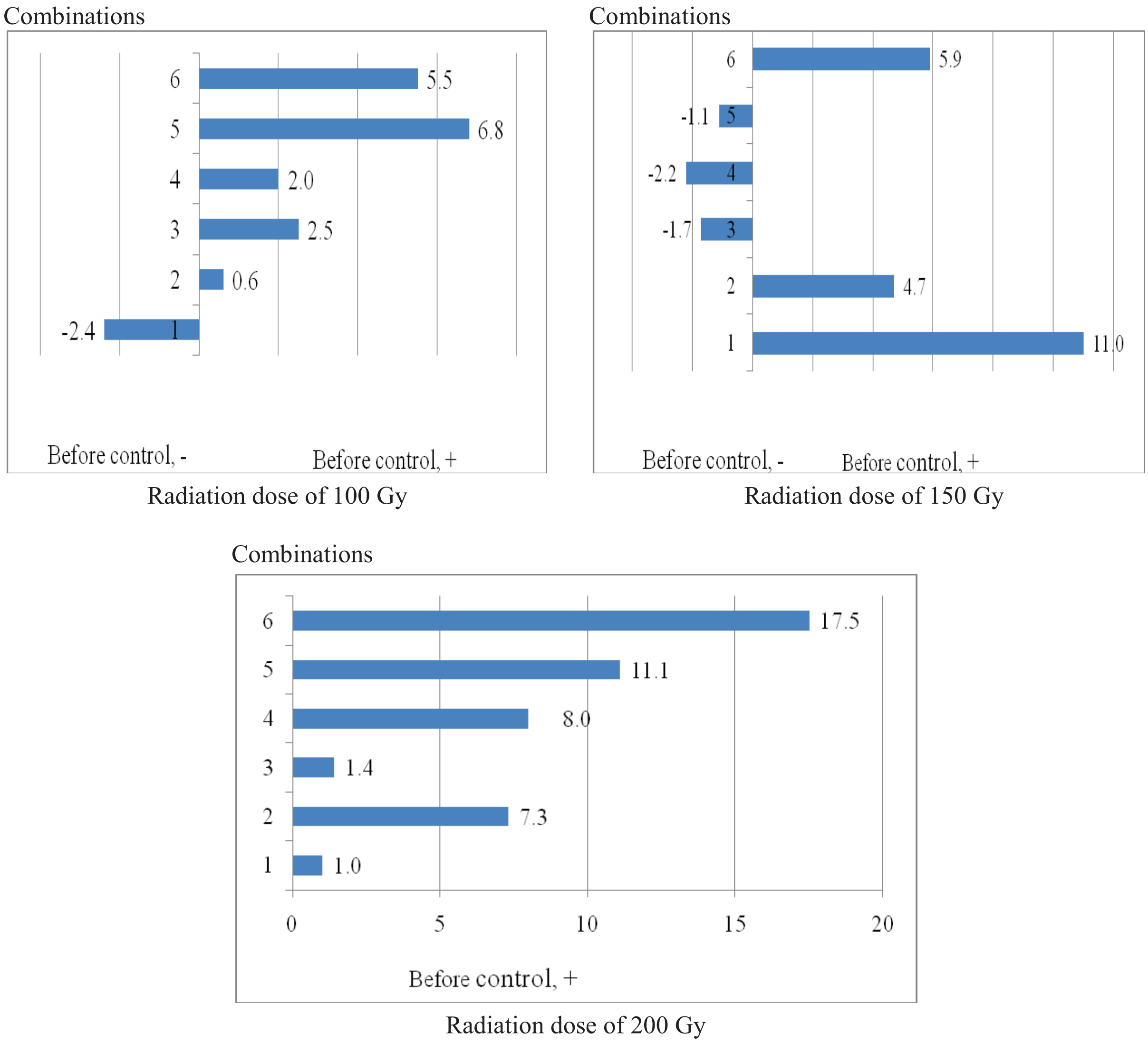

Figure 2. Difference with the control of seed germination energy depending on the radiation doses
Note: *the combination numbers shown are the same as in Table 1

The data shown in Table 2 indicate the specificity of the reaction of population genotypes on radiation doses. The lower seed germination energy compared to the control was revealed only in the combinations of Shchedryk x Strumok with the radiation doses of 100 and 150 Gy and 89.141s193 x Verdi (150 Gy). With the exception of the population of 91.318-6 x Svitanok kyivskyi. The greatest effect was obtained in the variant with theradiation dose of 200 Gy. The connection between the genetic nature of the population offspring and the seed germination energy was established during the study. The data obtained indicate that both in the control and in the experiment variants. the combination of 81.397s50 x Barbara was characterized by the minimum indicator value. At the same time the effect of radiation exposure on the seed germination energy was revealed in this combination. The minimum effect was obtained using the dose of 150 Gy when the difference with the control was only 0.1%. At the same time the irradiation of seeds with the dose of 200 Gy made it possible to significantly (compared to the control by 2.9 times) increase the indicator value.

The opposite was true for the population of 91.318-6 x Svitanok kyivskyi. The maximum energy of germination of its seeds is observed in the control. The same applied to the use of doses of 100 and 150 Gy. In the first case the difference with the control was 2.0% and in the latter - 6.3. However, the application of the dose of 200 Gy resulted in obtaining other data. The combination of 90.673/48 x Kalynivska was characterized by the maximum energy of seed germination - 14.4% that was explained by the specificity of the reaction of population offspring to radiation.

The results of calculating the correlation coefficient between the seed germination energy and their laboratory germination indicate their dense and positive dependence. Its value was +0.95.

We believe that the above is largely due to the proportional manifestation of indicators in the combination of 81.397s50 x Barbara depending on radiation doses. In comparison with other populations it was characterized by the lowest seed germination energy and had the similar laboratory germination. At the same time the difference in the control was somewhat different. It was higher after using the radiation doses of 100 and 200 Gy and less (by 0.2%) with the dose of 150 Gy.

Only the use of radiation dose of 150 Gy resulted in the maximum field germination of seeds in the combination of 91.318-6 x Svitanok kyivskyi. In comparison with other populations the highest value of the indicator was in the control. However the maximum effect of using the radiation dose of 150 Gy was observed in the seeds of the combination of 89.141s193 x Verdi and the doses of 200 Gy - in the population of 90.673/48 x Kalynivska.

The hybrid seeds especially those obtained from the involvement of wild and cultivated species in creating the source material are often characterized by morphological, anatomical characters. This may relate to the size and placement of embryo in the seeds. ivy. seed failure to germinate in the first year etc. All this affects the viability of plants growing from seeds.

Table 2. Difference between the combinations of crossing by the effect of radiation exposure on laboratory seed germination and germination energy

Ser. No.	Crossing combination	Radiation dose, Gy	Number of seeds in the Petri dish, pcs	Germination energy, %	Laboratory germination, %
1	91.318-6 x Svitanok kyivskyi	control	300	7.0	18.7
2	89.24c34 x Kalynivska	the same	340	3.5	6.8
3	Shchedryk x Strumok	– " –	405	5.4	12.4
4	81.397c50 x Barbara	– " –	550	2.1	4.6
5	89.141c193 x Verdi	– " –	620	5.3	10.8
6	90.673/48 x Kalynivska	– " –	640	6.4	10.0
7	Total/average	-	2855	5.0	10.0
8	91.318-6 x Svitanok kyivskyi	100	300	9.0	16.3
9	89.24c34 x Kalynivska	the same	340	4.1	7.4
10	Shchedryk x Strumok	– " –	405	4.2	12.4
11	81.397c50 x Barbara	– " –	550	3.3	6.6
12	89.141c193 x Verdi	– " –	620	7.9	17.6
13	90.673/48 x Kalynivska	– " –	640	7.7	15.5
14	Total/average	-	2855	6.1	12.9
15	91.318-6 x Svitanok kyivskyi	150	300	13.3	29.7
16	89.24c34 x Kalynivska	the same	340	6.8	11.5
17	Shchedryk x Strumok	– " –	405	4.2	8.2
18	81.397c50 x Barbara	– " –	550	2.2	4.4
19	89.141c193 x Verdi	– " –	620	4.8	9.7
20	90.673/48 x Kalynivska	– " –	640	7.7	15.9
21	Total/average	-	2855	6.0	12.2
22	91.318-6 x Svitanok kyivskyi	200	300	10.3	19.7
23	89.24c34 x Kalynivska	the same	340	8.5	14.1
24	Shchedryk x Strumok	– " –	405	8.4	13.8
25	81.397c50 x Barbara	– " –	550	6.0	12.6
26	89.141c193 x Verdi	– " –	620	9.4	21.9
27	90.673/48 x Kalynivska	– " –	640	14.4	27.5
28	Total/average		2855	9.7	19.1

The data of Table 3 show the deviations in the formation of plants both in the control and after the irradiation of seeds. It is established that their manifestation was largely influenced by the hereditary properties of seeds. For example no chloroticity of cotyledons in the control was detected in the combinations of 81.397c50 x Barbara and 90.673/48 x Kalynivska. In addition the manifestation of character in others was also significantly different. At the same time the effect of radiation dose on chloroticity of cotyledons was identified. The frequency of the material with this characteristic in the variant with the dose of 200 Gy on average was 1.8 times higher than in the control. The combination of 91.318-6 x Svitanok kyivskyi in which the proportion of seeds with chloroticity of cotyledons reached 11.9% was particularly distinguished in this respect.

Table 3. Frequency of deviations in the growth and development of seed lingson the initial stages

Ser. No.	Total number of plants, pcs	Proportion of plants with deviations, %								
		1**	2	3	4	5	6	7	8	9
1*	56	8.9	0.0	23.2	28.7	7.1	3.4	1.8	26.9	0.0
2	23	4.4	0.0	43.5	21.7	30.4	0.0	0.0	0.0	0.0
3	50	2.0	4.0	34.0	22.0	20.0	0.0	10.0	8.0	0.0
4	25	0.0	0.0	44.0	32.0	13.0	0.0	4.0	4.0	4.0
5	67	1.5	3.0	43.3	17.9	6.0	0.0	13.4	13.4	1.5
6	64	0.0	1.6	53.0	26.5	6.3	1.6	3.2	7.8	0.0
7	285	2.8	1.8	40.0	24.2	11.2	1.1	6.3	11.9	0.7
8	49	6.1	0.0	22.5	42.9	22.5	0.0	0.0	6.1	0.0
9	25	0.0	4.0	48.0	28.0	4.0	0.0	8.0	8.0	0.0
10	50	0.0	6.0	34.0	10.0	38.0	0.0	12.0	0.0	0.0
11	36	0.0	2.8	22.2	38.9	19.4	0.0	0.0	16.7	0.0
12	109	5.5	3.7	45.0	24.7	10.1	0.0	3.7	4.6	2.7
13	99	0.0	7.1	66.6	16.2	1.0	0.0	0.0	9.1	0.0
14	368	2.5	4.4	44.2	24.5	13.5	0.0	3.3	6.8	0.8
15	89	5.6	1.1	30.3	33.8	5.6	5.6	1.1	16.9	0.0
16	39	0.0	7.7	51.3	28.2	0.0	5.1	2.6	5.1	0.0
17	33	9.1	0.0	51.5	18.2	12.1	6.1	0.0	3.0	0.0
18	24	0.0	8.3	45.8	25.0	4.2	0.0	0.0	16.7	0.0
19	60	0.0	5.0	51.6	16.7	6.7	0.0	5.0	8.3	6.7
20	102	1.0	6.9	36.2	22.5	17.7	1.0	6.9	7.8	0.0
21	347	2.6	4.6	41.3	24.7	9.2	2.9	3.5	10.1	1.1
22	59	11.9	3.4	23.7	33.9	18.6	1.7	1.7	5.1	0.0
23	48	0.0	2.1	64.6	16.7	12.5	0.0	2.1	0.0	2.1
24	56	1.8	1.8	57.1	21.4	1.8	1.8	8.9	1.8	3.6
25	69	2.9	1.5	47.7	20.3	7.3	13.0	0.0	5.8	1.5
26	136	2.2	3.7	55.2	22.1	2.9	2.9	2.9	7.4	0.7
27	176	8.0	2.3	45.5	24.4	0.0	5.1	0.0	13.6	1.1
28	544	5.0	2.6	48.6	23.4	5.0	4.4	2.0	7.7	1.3

Notes: *serial number is similar tothatinTable 2;
**figure 1 means chloroticity of cotyledons; 2 – boat-like leaves; 3 – shooting from theprimary points of growth; 4 – shooting after appearance of rosette-like top; 5 – tigellum; 6 – trifoliate cotyled on leaves; 7 – rosette-like top; 8 – cotyled on leaves with out points of growth; 9 – partially chlorotic leaves.

Seedlings with shooting from the primary points of growth had relatively high frequency (Figure 3). We believe that this is due to the separation of the point of growth in the cotyledon phase resulting in the formation of two stems. The data obtained indicate the effect of radiation exposure on this process. In comparison with the control greater part of such deviations was revealed in all variants and the difference in case of using the radiation dose of 200 Gy was 8.6%.

Among the nine accounting indicators which were characterized by the specificity of growth and development of seedlings on the first stages the maximum frequency of deviations – four times occurred when seeds were treated with the dose of 200 Gy. It was twice observed in the variant with the dose of 150 Gy and only once (the formation of tigellum) in the case of irradiation with a dose of 100 Gy.

Despite the fact that the reproduction of potatoes occurs both with the use of vegetative parts of plants – tubers and through botanical seeds evolutionarily and practically they both play an important role. Without the formation of hybrid botanical seeds it is impossible to recombine hereditary factors in a number of generations. They are used to produce marketable products as well as to prevent self-pollination (Eshonkulov et al., 2015). At the same time obtaining high crop yields is possible only with the use of tuberous seed material.

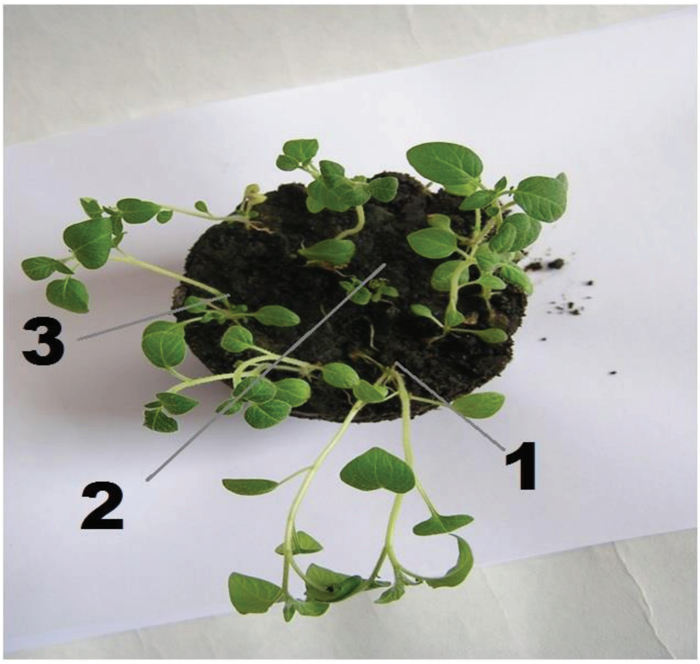

Figure 3. The most frequent deviation satthein itial stage of grow thand developmen to the first-year seedlings
1 – shooting from the primary point of growth; 2 - trifolia tecotyledons; 3 - shooting after the formation of a rosetteofleaves

Potatoes (Podhaietskyi and Hnitetskyi. 2017). like other crops (Macherchandani, 1975) are often characterized by poor germination of botanical seeds. Different methods are used to stimulate the process. At the same time unlike tubers we do not know any studies on the use of radiation exposure to stimulate seed germination.

In certain studies (Lopez-Mendoza et al., 2012) no significant effect of the use of radiation exposure with its doses of 20. 40. 60. 80. 100 and 120 Gy on the germination of *Capsicum annuum* L. seeds was revealed. In our studies the least effect of the method application occurred when using the dose of 150 Gy at the same time the specificity of the mutual influence of the origin of seeds and radiation doses on the germination energy field germination was revealed that was also confirmed in the works of other researchers (Komolprasert, 2004).

The radiation doses of 100 and 200 Gy were also found to stimulate sunflower seed germination (Diaz et al., 2018). Its increase including 900 Gy had a negative impact on growing plants from seeds. In contrast to small doses (from 100 Gy) large ones (more than 500 Gy) reduced the germination of maize seeds (Marcu et al., 2013).

According to individual scientists (Medina et al., 2011) the variability of offspring as a result of radiation exposure depends on numerous reasons: parts of plants involved in the experiment external conditions, activity of life processes radiation doses etc. However in our opinion the main thing is the mutual influence of radiation doses and the studied genotype that is confirmed in our work and the works of the above mentioned authors.

CONCLUSIONS

The use of hybrid potato seeds of complex origin for radiation exposure on the interspecies basis has enabled to identify different types of mutual influence of methods at the stages of seed germination and the initial phases of growth and development.

The genetically specific reaction of hybrid seeds of different origin with respect to the germination energy was revealed in a significant difference in the manifestation of the indicator in the control and the studied variants. This difference between the combinations of 91.318-6 x Svitanok kyivskyi and 81.397s50 x Barbara was 2.9 times. The influence of the maternal form on the indicator manifestation with the difference of 1.8 times was revealed in the populations of 89.24s34 x Kalynivska i 90.673/48 x Kalynivska.

The highest seed germination energy compared to the control was observed in all variants of seed irradiation in the combinations of 91.318-6 x Svitanok kyivskyi, 89.24s34 x Kalynivska and 90.673/48 x Kalynivska although with the difference of 1.5; 2.1 and 1.9 times, respectively between the variants indicating a different degree of positive mutual influence on the value of the indicator of the application of methods. However in some combinations, the manifestation of the character in the control was higher than in other variants that indicated the opposite of interaction of the methods used.

In the five combinations of six the maximum effect of seed germination energy is found in the variant with the radiation dose of 200 Gy which compared to the control is in the range of 3.0-8.0 %.In three populations the minimum values of the indicator in some variants are lower than in the control.

The similar although not always identical data were obtained on laboratory seed germination. The average value of the indicator compared with germination energy is 1.7-2.2 times greater.

The maximum proportion of deviations from normal seed germination the growth and development of seedlings was observed when irradiated with a dose of 200 Gy: in four out of the nine indicators. It was twice less frequently observed in the variant with the dose of 150 Gy and only once with a minimum dose of radiation. Shooting was more often observed from the primary point of growth or after the formation of rosette-like top as well as the formation of cotyledons without the point of growth.

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