# RESULTS OF *ZEA MAYS* SEEDS $\beta^-$ IRRADIATION IN 0–5 Gy RANGE*

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In this study young plants, obtained from the control and beta irradiated seeds, were studied in laboratory experiments. *Zea mays* seeds with uniform genophond were irradiated with $^{90}$Sr source in the 0–5 Gy range. Increased germination percentage was observed under the influence of different radiation doses. We found that small doses of $\beta^-$ radiation have a stimulating effect on the growth of the plantlets, the maximum simulation (among the doses we used) being induced by 0.615 Gy and is statistically significant. We investigated the chlorophyll a to b ratio and the average length variations with the irradiation dose and present the results.

*Key words:* $\beta^-$ radiation, *Zea mays*, germination rate, plants growth, photo-assimilatory pigments, nucleic acids.

## 1. INTRODUCTION

Radionuclides are released into the environment from various sources such as planned discharges from the nuclear power industry, disposal of radioactive waste, medical use, nuclear weapons development and nuclear accidents. Ionizing radiations are able to cause toxic and genotoxic effects on organisms, because radionuclides accumulate in biotic and abiotic components of the environment [1–2]. These can directly disturb plant respiration, photosynthesis, growth, active transport as well as ionic balance and enzyme synthesis [3]. Biological impact of radionuclides depends on their accumulation level and localization in the organism and cells [4]. Radionuclides may enter the inner cell compartments, and sometimes bind to the DNA molecule. It is known that nuclear radiation can stimulate morphogenetic changes manifest in the early development stages [5]. Very low doses of ionizing radiations can stimulate cell proliferation, as shown in *Paramecium* [6–7] or in *Cyanobacteria* [8]. On these plant species there was found that the stimulating effect on cell proliferation affects the initial growth phase, but the exponential growth rate remains unchanged. Recently, new studies

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of the influence of ionizing radiation in vegetal organisms and animals and relevant data for environmental radiation protection have been reported in literature [9]. In order to progress in the evaluation of the environmental impact of ionizing radiation, it is necessary to establish the relationship between exposure (dose rate, accumulated dose) and the possible effects induced in living organisms (plants and animals). For this purpose, we investigated the beta radiation influence on the *Zea mays* seeds and induced effects in early ontogenetic stages of plant obtained by germinated irradiated seeds.

## 2. MATERIALS AND METHODS

Young plants, obtained from the control and beta-irradiated seeds, were studied in laboratory experiments. The *Zea mays* seeds were irradiated one at a time in an irradiation chamber that was build for this purpose, with doses ranging between 0.6 and 5 Gy. The hole in the upper part fits a glass tube than can be easily inserted and extracted. The tube is used to place the seed in the proximity of the $\beta^-$ source. The schematic of the irradiation chamber is presented in Fig. 1. The dose debit through the glass tube, in the very location where the *Zea mays* seeds were placed one by one, was measured using a RFT - KD27012 dosimeter with an ion chamber. Batches of 35 seeds were irradiated for 15, 30, 45, 60 and 120 minutes.

The $\beta^-$ source was $^{90}$Sr and decays by the scheme:

$$^{90}\mathrm{Sr} \xrightarrow{\beta^-} {}^{90}Y, \quad T_{1/2} = 28.79 \text{ y}$$

having $E_{\beta^-}$ = 546 keV, with a branching ratio of 100% [10]. The daughter nucleus, $^{90}$Y, is unstable as well. It decays by the scheme:

$$^{90}\mathrm{Y} \xrightarrow{\beta^-} {}^{90}\mathrm{Zr}, \quad T_{1/2} = 64.00 \text{ h}$$

with the energies, branching ratios and half-lives presented in Table 1.

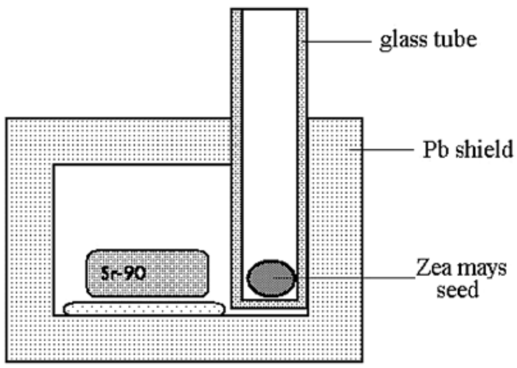



Fig. 1 – The beta-irradiation chamber.

*Table 1*

The β energies, branching ratios and half-lives of the $^{90}$Y [10]

| $E_{\beta^-}$ [keV] | $I_{\beta^-}$ [%] | Half-life |
|---|---|---|
| 93.83 | 0.0000014 | 64.00 h |
| 519.39 | 0.0115 | 64.00 h |
| 642.77 | 0.0018 | 3.19 h |
| 2280.1 | 99.9885 | 64.00 h |

12 days old plantlets, obtained from the control and beta-irradiated seeds were studied. The irradiated seeds germinated on a support consisting of porous paper impregnated with deionized water, in darkness and closed Petri dishes. After germination the young plantlets growing was conducted in the same controlled conditions of temperature (23÷24°C), illumination (10 h: 14 h light/ dark cycle) and the culture medium of young plantlets was 12mL of deionized water daily.

Chlorophylls and total carotenoids in the *Zea mays* young plants were extracted in 85% acetone. The absorption was measured using a CECIL 1000 spectrophotometer at the typical wavelengths of 663, 645 and 472 nm after filtration. The assimilatory pigment levels were calculated according to the Meyer Bertenrath's method modified by Ştirban [11] using spectrophotometric measurements. The average nucleic acid level was measured using 6% perchloric acid extracts and the Spirin's method [12]. The extract was centrifuged at 3000 rot/min for 15 minutes. The UV light absorption was measured using a CECIL 1000 spectrophotometer at the typical wavelengths of 270 and 290 nm. Plant individual length was measured with 1mm precision and germination percentage was determined as well.

## 3. RESULTS AND DISCUSSIONS

The effect of $^{90}$Sr beta-irradiation on seeds germination of *Zea mays* was compared with the control by means of germination rate. Increased values for germination percentage were observed under the influence of increasing beta-irradiation doses ranging 0.6 and 1.8 Gy. The lengths of the 12 days plantlets were carefully measured. The average lengths and the standard deviations were calculated for each batch of seeds. The confidence interval was calculated for each batch of plantlets using the Student test, for a confidence level P = 90% and the results are presented in Table 2, together with the $\beta^-$ irradiation doses. Fig. 2 presents the average plants batch length for each irradiation dose. We found that small doses of $\beta^-$ radiation have a stimulating effect on the growth of the plantlets. The maximum stimulation was induced by 0.615 Gy and is statistically

*Table 2*

Statistical analysis on plantlets length data

| Sample | Control | P1 | P2 | P3 | P4 | P5 |
|---|---|---|---|---|---|---|
| Irradiation time (min.) | 0 | 15 | 30 | 45 | 60 | 120 |
| Irradiation dose (Gy) | 0 | 0.615 | 1.23 | 1.845 | 2.461 | 4.921 |
| Average length (mm) | 65.0 | 89.8 | 82.2 | 78.1 | 76.9 | 70.1 |
| Standard deviation | 34.4 | 26.8 | 27.1 | 22.3 | 35.2 | 28.1 |
| Confidence interval, cm P = 90% | 11.0 | 8.6 | 8.7 | 7.1 | 11.3 | 9.0 |

significant, as resulted from the average comparison performed by the Fisher test and from Fig. 2. Increased irradiation doses had a smaller stimulating effect as can be noticed from the plant length averages.

The levels of the assimilatory pigments were comparatively studied on the basis of graphical representations of chlorophyll a, chlorophyll b and total carotenoids (Fig. 3) as well as by means of the chlorophylls ratio (Fig. 4). We found that the chlorophyll a to b ratio has a slight variation with the irradiation dose, different than the average length variation with the dose.

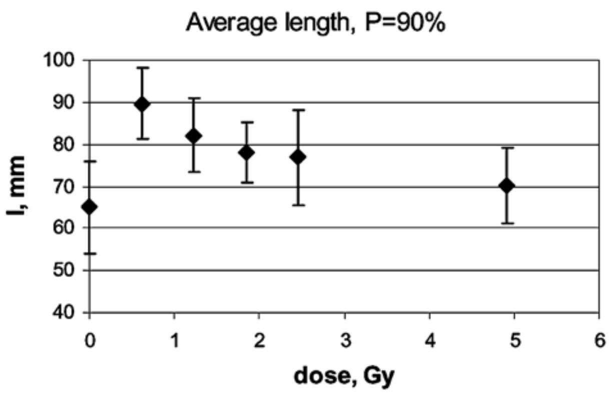



Fig. 2 – The average length *versus* irradiation dose.

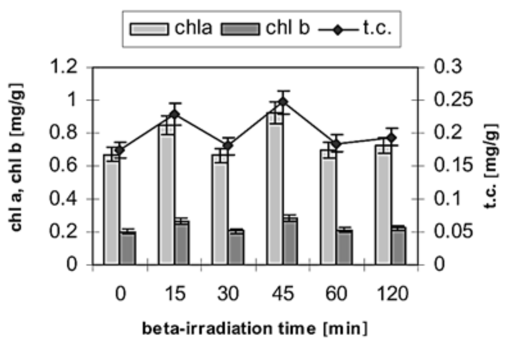
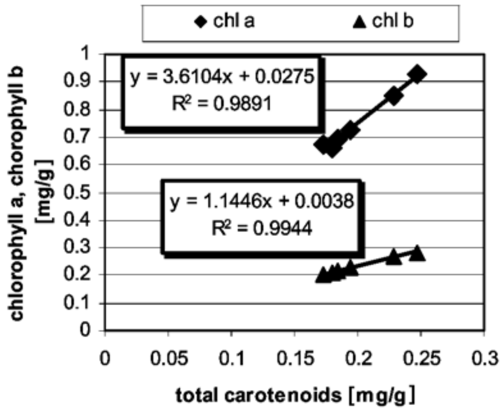



Fig. 3 – Assimilatory pigments level in *Zea mays* plantlets grown from beta-irradiated seeds.

Fig. 4 – The correlation between chlorophyll a and b and total carotenoids levels.




The total assimilatory pigments contents have the same variation with the beta-irradiation dose that was observed for all assimilatory pigments level. The data provided by the chlorophylls ratio measurement offered the main insight into the photosynthesis complex processes since they revealed the response of the **LHC II** system (**L**ight **H**arvesting **C**omplex II) to the external stress.

We also found that the increasing beta-irradiation doses not induce considerable changes in chlorophylls ratio. The ratio values of the irradiated samples were slightly lower than the ratio for the control sample, suggesting that beta radiation does not significantly influence the photosynthesis process.

Another thing we found is a very good linear correlations with the irradiation dose for all assimilatory pigments that were analyzed (two of these correlations are presented in Fig. 4). The average nucleic acid level of the irradiated samples decreases with the irradiation dose (Fig. 5). We notice that beta irradiation study does not produce evident biochemical changes on early development stages of *Zea mays* plantlets provided by irradiated seeds.

The basis of the biological effect of nuclear radiation is ionization, which can result in breakage of covalent bonds and damage of DNA, RNA, proteins and other molecules in the cell. The ions generated in this manner are reactive

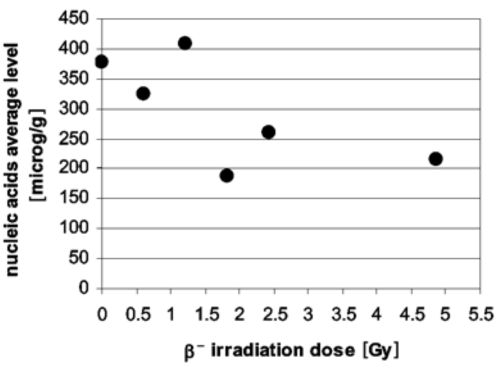



Fig. 5 – The average nucleic acid levels in *Zea mays* plantlets.

species that can react with biological molecules in the cell, causing damage. Due to their high propensity to react, the charged particles of beta radiations tend to lose their energy rapidly while passing through tissue, and are not highly penetrating. Diversity in dose-effect dependences due to low irradiation doses has been explained [13] as a change in the ratio between genetic damage and repair. According to Burlakova *et al*. [13], repairing systems are not activated by low doses, because it takes longer for them to get activated.

## 4. CONCLUSIONS

We found that low doses of beta irradiation exposure stimulated the seeds germination and the growth of young plantlets obtained from irradiated seeds. Beta irradiation doses, ranging between 0.5 and 5 Gy do not produce significant biochemical changes in the early development stages of *Zea mays* plantlets obtained from irradiated seeds.

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