THE INFLUENCE OF γ AND β RADIATIONS EMITTED BY ^{60}Co AND ^{89}Sr ON GROWTH AND RNA SYNTHESIS IN MAIZE

Bura Giani Cătălin*

**University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea; Romania*

Abstract

Seeds of Turda Super and Fundulea 376 maize hybrids were irradiated with ^{60}Co and ^{89}Sr (doses: $2x10^2$, $1.2x10^3$, $4x10^3$ rod) and sown on field. Unirradiated seeds were sown in an area exposed to irradiation emitted by a waste dump (Câmpani-Fânaţe). The length of shoots was recorded on plants of 35- 145 days and the dynamics of RNA was followed in roots. High doses of radioactivity inhibited the shoot growth of both hybrids. RNA synthesis was stimulated in roots by low doses of radiation in both hybrids, especially in younger plants, high doses inhibited this process. In the exposed area (Câmpani-Fânaţe) RNA content of the samples showed in both hybrids values closed to the control, slightly lower, but the growth of plants was not much affected.

INTRODUCTION

Among the multiple aspects raised by radiobiology, the study of synthesis and dynamics of nucleic acids, especially RNA, under the γ and β irradiation emitted by ^{60}Co and ^{89}Sr, constitutes a field of investigation with great theoretical and practical importance [1].

Beside the establishment of optimal conditions for the growth of plants, it is necessary the detailed investigation of the influence of γ and β irradiation emitted by ^{60}Co and ^{89}Sr on the growth of plants and on the biochemical aspects of metabolic processes.

The interaction of γ and β radiation with different compounds, like nucleic acids, constitutes a complex aspect, strongly influenced and correlated with external and internal factors [2-3].

The objective of the present work was to study the effect of γ and β radiation on the growth and RNA synthesis of two maize hybrids (Turda Super and Fundulea 376) originated from irradiated seeds and to compare this results with the influence of radioactive waste dump on the same parameters, in an exposed area (Câmpani-Fânaţe).

MATERIALS AND METHODS

Experiments on field conditions were carried out using maize plants (Turda Super and Fundulea 376 hybrids). The seeds of these hybrids were irradiated with γ and β radiation emitted by ^{60}Co and ^{89}Sr, using the following doses and time of exposure:

2×10^2 rad.....30 s
1.2×10^3 rad.....3 min
2×10^3 rad.....5 min
4×10^3 rad.....10 min

Irradiated and control seeds were sown on an unexposed area (SCAZ Oradea) and parallel, control seeds were sown in the area Câmpani-Fânațe, closed to the radioactive waste dump. Each experimental series occupied $10m^2$, the distance between plants was 40 cm.

Physiological and biochemical parameters were recorded on plants of *35,* 50, 66, 82, 105 and 145 days. The growth (shoot length) was recorded at the mentioned ages of plants and the results interpreted in correlation with the climatic conditions of the year 2010 when the experiment was run. RNA content was determined according to the method of Cherry (1962) [4] by extracting RNA with perchloric acid followed by UV spectropliotometric measurement (260 nm), using a standard curve built up with known concentrations of pure RNA (Merck).

RESULTS AND DISCUSSION

The analysis of experimental studies on field conditions with maize hybrids shows the following:

The hybrids Turda Super and Fundulea 376 have grown and developed in good conditions in 2010, especially in the last period of vegetation (fig. 1, 2, 3 and 4), when the water deficit of soil, generated by the climatic factors (low amount of rainfall in spring) was recovered (Table 1).

High radioactivity had an inhibitory effect on growth, while low doses did not change the growth of plants, comparing to control, or had a slight stimulatory effect on Fundulea 376 hybrid (fig. 1,2, 3 and 4).

The determination of RNA in roots (the hairy zone), carried out through the vegetation period, showed normal values in the controls of both hybrids (fig. 5, 6, 7 and 8). Fundulea 376 had a slightly higher RNA content in all phases, comparing to Turda Super hybrid.

The plants originated from irradiated seeds - with γ and β radiation emitted by ^{60}Co and ^{89}Sr- showed in the case of low doses ($2x10^2$ rad) a more intensive RNA synthesis in the first period of vegetation (60- 80 days) (fig. 5, 6, 7 and 8). As the plants became older, the positive influence of low doses of radiation disappeared. This fact is showed by the very similar values of RNA content of control and irradiated plants.

In the case of plants originated from seeds exposed to high γ and β radiation doses, an inhibition of RNA synthesis of roots was recorded. This effect is more accentuated in young plants in both hybrids (fig. 5, 6, 7 and 8).

Similar results were found in the case of RNA from maize leaves [5].

Table 1.

Characterization of rainfalls during the year 2010 According to the Meteorological Station Oradea

	I	II	III	IV	V	VI
Rainfall (mm)						
Monthly average	8.6	35.9	13.0	17.9	24.7	49.5
Multianual average 1931-2010	34.7	33.7	34.5	46.7	62.1	87.1
Deviation	-26.1	+2.2	-21.5	-28.8	-37.4	-37.6

	VII	VIII	IX		XI	XII
Rainfall (mm]						
Monthly average	49	81.8	84.4	4.8	43.2	24.7
Multianual average 1931-2010	72	56.6	44.7	47.1	49.5	50.5
Deviation	-23	+25	+39	-42.3	-6.3	-25.8

Maize plants cultivated in the area Câmpani-Fânaţe (closed to the radioactive waste dump) showed in both hybrids lower RNA content of roots, comparing to controls from the unexposed field.

The obtained values highlight the unfavorable influence of radiation emitted by the waste dump on the growth and development of maize plants (fig. 1, 2, 3 and 4) and on synthesis and dynamics of RNA in roots (fig. 5, 6, 7 and 8).

All data showed that as plants became older, the RNA content in the root decreased and at the end of vegetation the recorded values were very low. This is in perfect correlation with the much lower synthetic activity of root sells, at the end of vegetative phase.

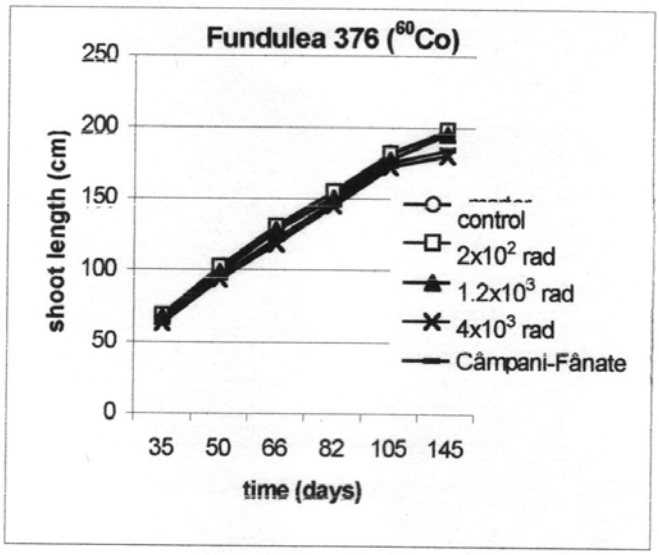

Figure nr.1 - The effect of γ radiation on the growth of maize shoot (Fundulea 376 hibrid)

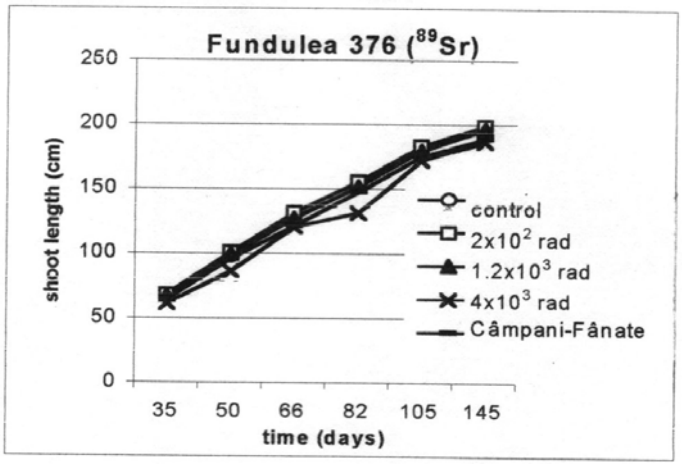

Figure nr.2 - The effect of β radiation on the growth of maize shoot (Fundulea 376 hibrid)

However it is noticed that in plants originated from seeds, which were irradiated with low doses of γ and β radiation, the RNA content of root, during vegetation is higher, proving the stimulatory action of low doses of radiation on RNA synthesis.

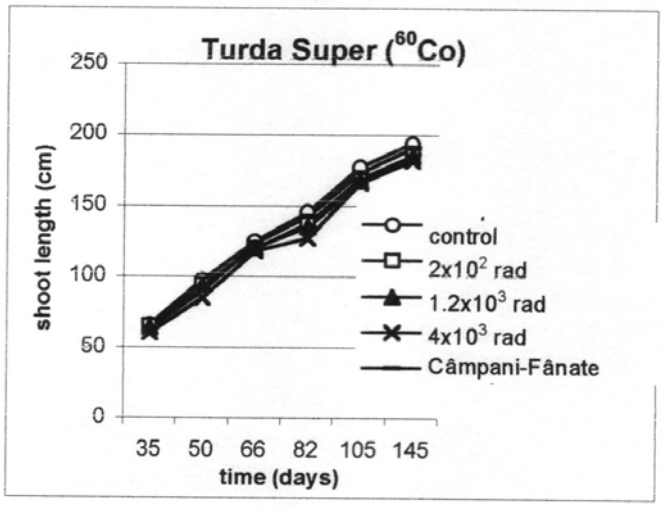

Fig. 3. The effect of γ radiation on the growth of maize shoot (Turda Super hybrid)

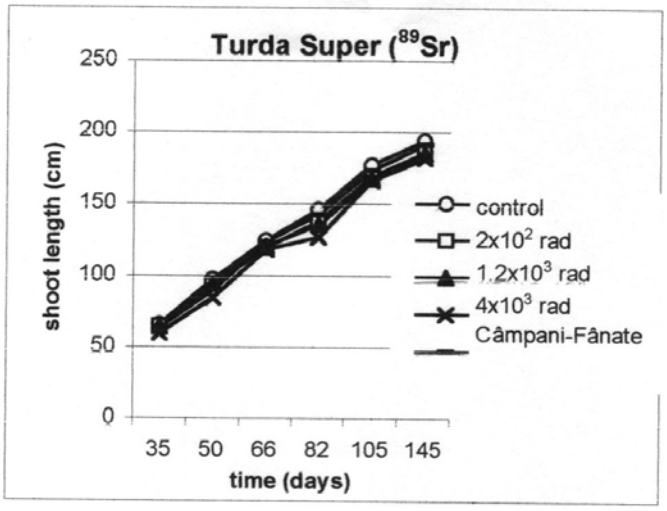

Fig .4. The effect of β radiation on the growth of maize shoot (Turda Super hybrid)

We consider that, due to the fact that under the influence of low doses of γ and β radiation plants synthesise and accumulate higher RNA quantities in root hairs zone, roots are enabled to absorb the nutrients more intensive. The more intensive mineral nutrition lead to better growth and development of plants.

The relationship between RNA synthesis and mineral nutrition is in agreement with the theory of the absorption mechanism of ions [6-7]. According to this theory RNA is a very efficient ion carrier.

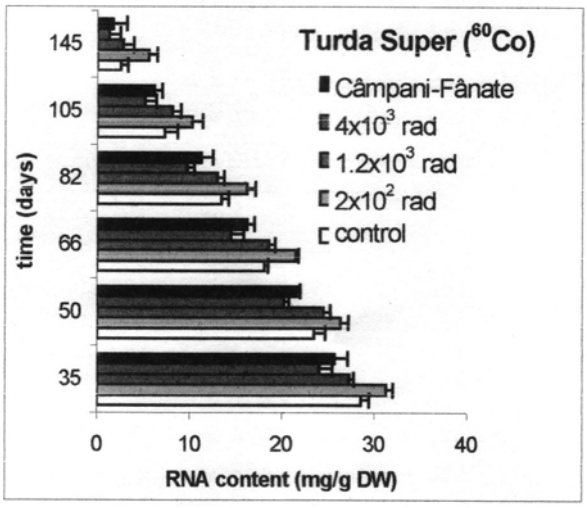

Fig. 5. RNA content of maize roots (Turda Super hybrid) under the influence of γ radiation (averadge ±std, n=3)

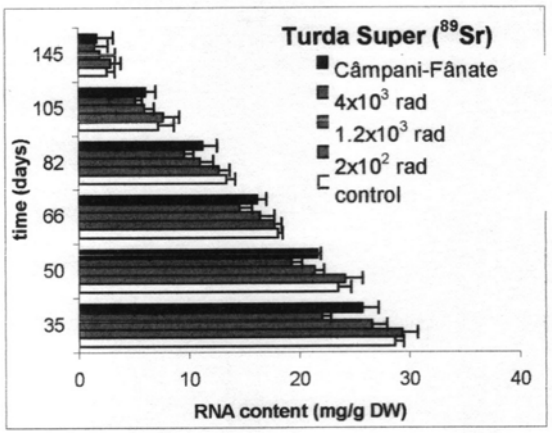

Fig. 6. RNA content of maize roots (Turda Super hybrid) under the influence of β radiation (averadge ±std, n=3)

Our previous experiments concerning the influence of γ and β radiation on the absorption and dynamics of N and P on the same maize hybrids (Turda Super and Fundulea 376) showed the positive influence of low doses on the mentioned process (data not shown) [8]. These results, in correlation with the founding that RNA dynamics is influenced in the same manner by radiation, bring new arguments for the theory of absorption involving RNA.

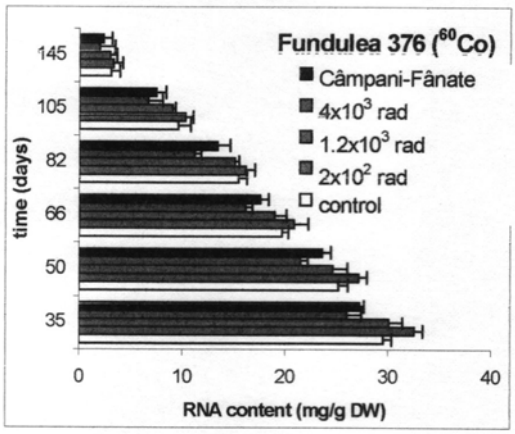

Fig. 7. RNA content of maize roots (Fundulea 376 hybrid) under the influence of γ radiation (averadge ±std, n=3)

It was found that RNA is very sensitive to radiation, and this sensitivity is explained by the disturbed ratio of the bases under this kind of stress, which led finally to the alteration of the composition of proteins and inhibition of growth [1]. The effect of radiation on plant growth is also the consequence of the unbalanced synthesis of phytohormones under or after radioactive exposure [1,5].

The positive effect of low doses, radiostimulation, is useful in agricultural production and it was introduced as a technique for obtaining better crops [1,9]. Radiostimulation is explained by an earlier depression of genes involved in physiological processes, so low doses of radiation can influence the speed of some processes [1].

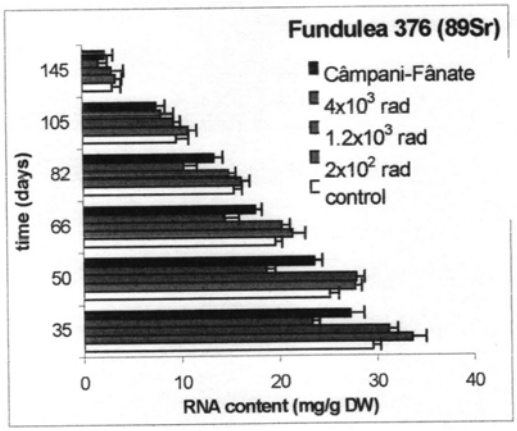

Fig. 8. RNA content of maize roots (Fundulea 376 hybrid) under the influence of β radiation (averadge ±std, n-3)

CONCLUSIONS

Low doses of radiation ($2x10^2$ rad) emitted by ^{60}Co and ^{89}Sr stimulated RNA synthesis of roots in both Turda Super and Funduiea 376 maize hybrids. The stimulation is more obvious at biochemical level and less traduced as the stimulation of whole plant growth. High doses of radiation ($4x10^3$ rad) had inhibitory effect on both studied aspects. The influence of radioactive waste dump in Câmpani-Fânaţe area is not remarkable (showing that the radioactive elements, in time, are washed out from the soil), but the presence of it is showed, in some extent, by physiological and biochemical parameters of plants cultivated in that area.

REFERENCES

1. Ghiorghiţă I.G., 1987, Radiobiologie vegetală, Ed. Acad. RSR, Bucureşti, p. 31-75.
2. Tuţuianu O., Energia nucleară, alternativă ecologică a energiei clasice? Mediul Înconjurător 5, (1), p. 34.
3. Marcu G., 1997, Introducere în radiochimie, Ed. Tehnică, Bucureşti, 25-41.
4. Cherry I.H., 1962, Nucleic acid determination in storage tissues of higher plants, Plant Physiol, 37, 5, 670-678.
5. Trifu M., Dan M., 1977, Influenţa tratamentului complex cu radiaţii γ emise de ^{60}Co, acid β-indolil acetic şi bor asupra dinamicii ARN la porumb, Contrib. Bot, Univ. Babeş-Bolyai Cluj-Napoca, 183-189.
6. Sutcliffe J.F., Baker D.A., 1974 Plant and Mineral Salts, Edward Arnold, London.
7. Trifu M., Bărbat I., 1997, Fiziologia Plantelor- Capitole alese, Ed. Viitorul Românesc, p. 30-64.
8. Trifa M., Osvath T., 1978, Influenţa tratamentului complex cu radiaţii gama emise de ^{60}Co, cu microelemente şi cu substanţe de creştere asupra nutriţiei cu fosfor a porumbului, Contrib. Bot., Univ. Babeş-Bolyai Cluj-Napoca, 277-281.
9. Drăgănescu I., 1983, Radiostimularea, o aplicaţie a tehnicilor nucleare în agriculrură, Ed. Ştiinţifică şi Encilopedica, Bucureşti, p. 5-230.
10. Dalea A., 2003, Influenţa radiaţiilor asupra fiziologiei porumbului, Ed. Universitatea din Oradea.