EFFECT OF TIDIAZURON AND DIETHILENTRIAMINE ON GAMMA-IRRADIATED OATS AND TRITICALE PLANTS

ЕФЕКТ НА ТИДИАЗУРОНА И ДИЕТИЛЕНТРИАМИНА ПРИ ГАМА-ОБЛЪЧЕНИ РАСТЕНИЯ ОВЕС И ТРИТИКАЛЕ

Nevena STOEVA[1], Malgojata BEROVA[1], Andon VASSILEV[1], Zlatko ZLATEV[1], Tzvetanka BINEVA[2] , Donka STANEVA[2]

[1]Agricultural University, Department of Plant Physiology and Biochemistry, 12 Mendeleev Str., Plovdiv, Bulgaria

[2] Institute N. Pushkarov, 7 Shousse Bankya Str. Sofia, Bulgaria

e-mail:stoeva_au_bg@yahoo.ca

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ABSTRACT

The potential modifying effect of the synthetic growth regulators Tidiazuron and poliamine diethilentriamine, applied after gamma-irradiation stress on oats and triticale plants, was studied.

Pot vegetative experiments with spring oats, cultivar Hanza 152, and triticale, cultivar 7251, were carried out. The plants were grown under controlled conditions and in the phase of stem extension they were irradiated with Cesium-137 gamma rays, at a dose rate of 6 Gy (oats), and 4 Gy (triticale), and dose intensity of 2 Gy/min. On the day after the irradiation the plants were sprayed with a radioprotector for the purpose of decreasing the radiation damage. Two types of protectors were tested: tidiazuron and diethilenthriamine.

The irradiation of oats and triticale plants in the phase of stem extension caused stress, which was detected by the disorganization of the cardinal physiological processes. The tested synthetic plant growth regulators reduced the negative effect of the irradiation. The peroxidase activity and the lipid peroxidation were reduced, while the plant productivity and the photosynthetic pigments were increased, both photosynthesis and transpiration activation were increased. Independently of the similar effect of both of the substances, polyamine DETA was characterized with a better modifying effect.

Key words: oats and triticale plants, gamma-irradiation stress, synthetic growth regulator, leaf gas-exchange, photosynthetic pigments, enzymes.

РЕЗЮМЕ

Изследван беше модифициращият ефект на синтетичния растежен регулатор Тидиазурон и полиамина Диетилентриамин. Изведен беше вегетационен съдов опит с пролетен овес, сорт Ханза и тритикале сорт 72 51. Растенията бяха отгледани при контролирани условия и във фаза вретенене бяха облъчени с гама-лъчи (Cs-137), доза 6 Gy (овес), и 4 Gy (тритикале), при мощност на дозата 2 Gy/min. На следващия ден бяха третирани с посочените растежни вещества.

Установено беше, че облъчването на овес и тритикале предизвиква стрес в растенията, който се изразява в подтискане на физиологичните процеси. Приложените вещества намаляват негативния ефект от облъчването. Липидната пероксидация и активността на ензима пероксидаза намаляват, докато продуктивността, скоростта на фотосинтезата и съдържанието на фотосинтетичните пигменти се повишава при третираните растения. Независимо от сходния характер на веществата, полиаминът диетилентриамин се характеризира с по-добър модифициращ ефект.

Ключови думи: овес и тритикале, гама-радиационен стрес, синтетични растежни регулатори, листен газообмен, фотосинтетични пигменти, ензими.

INTRODUCTION

The importance of the problem of the radioactive contamination of agricultural products is determined by the necessity to find ways of restricting and reducing the effects of this phenomenon.

The irradiation of plants with high doses of gamma-rays disturbs the synthesis of nucleic acids [8], proteins [14], hormone balance [10], leaf gas-exchange [12], water exchange, and enzyme activity [13]. The morphological, structural, and functional changes depend on the intensity and the duration of the gamma-irradiation stress.

In the case of moderate stress, the adaptability capacity of the plants is preserved and the observed changes are reversible. The plant growth regulators (auxines, gibberellines, cytokinins, etc.) and their synthetic analogues stimulate the plants physiological and biochemical processes. This provides an opportunity to use them as antidotes to different types of stress [1, 9]. There are only few studies on the effect of the synthetic plant growth regulators and polyamines on plants, that have already been subjected to gamma-irradiation stress [11, 12, 13].

The potential modifying effect of the synthetic growth regulator Tidiazuron and polyamine DETA, applied after gamma-irradiated stress on oats and triticale plants, was studied.

MATERIAL AND METHODS

Pot vegetative experiments with spring oats, cultivar Hanza 152, and triticale, cultivar 7251, were carried out. The plants were grown under controlled conditions and in the phase of stem extension they were irradiated with Cesium-137 gamma rays, at a dose rate of 6 Gy (oats), and 4 Gy (triticale), and dose intensity of 2 Gy/min. On the day after the irradiation the plants were sprayed with a radioprotector for the purpose of decreasing the radiation damage. Two types of protectors were tested: tidiazuron (TDZ) and diethilenthriamine (DETA) in a concentration of 10^{-5} M.

The experimental pattern included: control plants, irradiated plants, irradiated and TDZ-treated plants, irradiated and DETA-treated plants.

On the 15th day after the irradiation the leaf gas exchange elements were determined by means of a portable infrared gas analyzer LCA-4 (Analytical Development Company Ltd., Hddesdon, England) equipped with a PLCB-4 chamber. The plastid pigments content was determined according to Lichtenthaler, [7].

For the purpose of measuring the lipid peroxidation, the thiobarbituric acid (TBA) test, which determines malondialdehyde (MDA) content, was applied [4].

Peroxidase (POD; EC 1.11.1.7) activity was determined according to Herzog and Fahimi [5]. The POD activity was expressed as ΔA_{470} g^{-1} (FM) min.

The degree of the irradiation damage and protection was recorded at the end of the vegetation period following some productivity indexes: height, average grain number, grain weight, productivity.

Three independent experiments, each with 5 repetitions per treatment, were conducted. The results showed similar tendencies. The present research provides data from a single representative experiment. The significance of the differences between control and each treatment was analyzed by Student's criterion [15].

RESULTS AND DISCUSSION

The results representing the changes in the parameters of the leaf gas exchange in the control, irradiated and recovered triticale plants are shown in Table 1.

It is evident that in the plants, irradiated in the phase of stem extension, a tendency to slow down the leaf gas exchange was observed. The photosynthesis rate in triticale plants was suppressed by 31% and this inhibition was stronger than the transpiration intensity – 23%. In the treated plants an increase of the photosynthesis rate was observed, and in the case of TDZ treatment it reached 90%, while in the case of DETA treatment it was 85%. The same tendency was recorded with respect to the transpiration intensity.

The data obtained with regard to the oats leaf gas exchange showed similar tendency. The transpiration intensity in the irradiated plants was lower – 25%. For both TDZ and DETA a recovery effect was recorded. After the DETA treatment it remained only 2% below the control level.

There could be several reasons for the reduced transpiration in the irradiated plants: reduction of the photosynthetic leaf area, suppressed growth of the root system, and the consequent disturbed water supply and stomata cells closure.

The data on the condition of the stomata apparatus show that in the irradiated plants the stomata conductance suffered negative changes. The quick loss of water in the leaf tissues caused hydro-passive stomata closure, aimed at restricting the water loss. This, in turn, had negative effect on the photosynthesis rate due to the restricted access of CO_2 to the mesophyll cells. In the treated plants, a tendency towards an increase of the stomata conductance was observed, and in triticale it was with 20-25% above the control, while in oats, it was near the control.

The functional activity of the photosynthetic apparatus depends to a great extent on the content of and the

Table 1. Effects of TDZ and DETA on the Net photosynthesis rate (P_N -[μmol (CO_2) m^{-2} s^{-1}]). Transpiration rate E- [mmol (H_2O) m^{-2} s^{-1}]); Stomata conductance (g_s -[mol m^{-2} s^{-1}]) Chl “a” and “b”and Car (mg/g). All parameters were measured 5 d after application. Means ± SE n = 5 * P < 0.1. ** P < 0.01. *** P < 0.001.

Таблица 1. Ефект на TDZ и DETA върху скоростта на фотосинтезата (P_N -[μmol (CO_2) m^{-2} s^{-1}]). Транспирацията E- [mmol (H_2O) m^{-2} s^{-1}]); Устичната проводимост (g_s -[mol m^{-2} s^{-1}]) и съдържанието на пигменти Chl “a” , “b” Car (mg/g). Всички показатели са от 5 измервания, ± SE n = 5 * P < 0.1. ** P < 0.01. *** P < 0.001.

Parameters	P_N	E	g_s	Chl. “a”	Chl. “b”	Carotenoids
		Triticale				
Control	6.15 ± 0.45	3.95 ± 0.18	0.025	0.831±0.02	0.368±0.03	0.275±0.04
4 Gy	4.25 ± 0.38**	3.05 ± 0.15	0.020	0.845±0.02	0.372±0.02	0.290±0.06
4 Gy+ TDZ	5.25 ± 0.28	3.55 ± 0.30	0.042	0.830±0.04*	0.355±0.01*	0.265±0.01**
4 Gy+ DETA	5.52 ± 0.26*	3.85 ± 0.18	0.045	0.842±0.03**	0.370±0.03	0.260±0.02*
		Oats				
Control	6.55 ± 0.55	3.85 ± 0.15	0.060	0.855±0.01	0.372±0.05	0.278±0.02
6 Gy	4.95 ± 0.18	2.95 ± 0.15	0.045	0.820±0.04	0.372±0.06	0.280±0.03
6 Gy+ TDZ	6.25 ± 0.28*	3.75 ± 0.40	0.056	0.842±0.05	0.325±0.03	0.265±0.01**
6 Gy+ DETA	6.22 ± 0.35**	3.65 ± 0.21*	0.059	0.850±0.02**	0.375±0.02**	0.270±0.01**

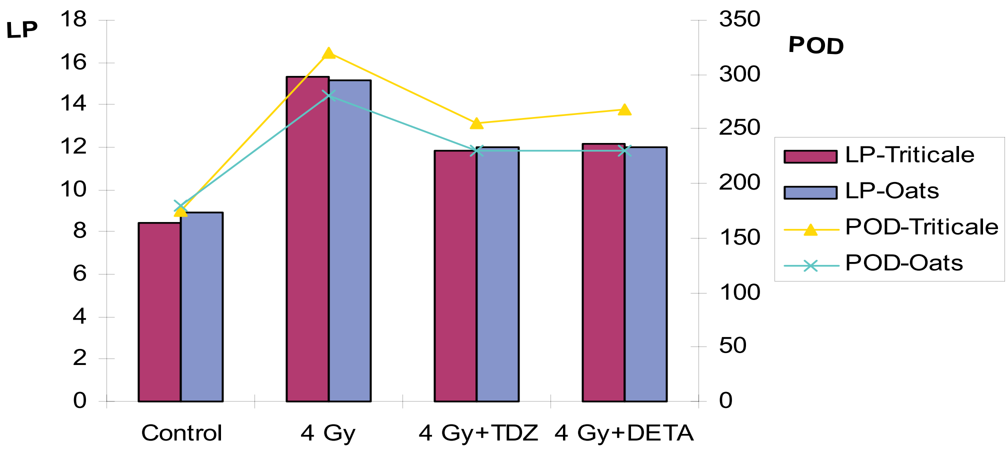

Fig. 1. Effect of TDZ and DETA on lipid peroxidation (LP-[nmol (MDA) g^{-1} (FM)]) and peroxidase activity (POD-[ΔA_{470} g^{-1} (FM) min^{-1}]) in gamma-irradiatiated plants of triticale and oats.

Фигура 1. Ефект на TDZ и DETA върху липидната пероксидация (LP-[nmol (MDA) g^{-1} (FM)]) и активността на пероксидазата (POD-[ΔA_{470} g^{-1} (FM) min^{-1}]) в гама-облъчени растения тритикале и овес.

interaction between the photosynthetic pigments, participating in the light reactions of the photosynthesis itself. The results regarding the plastid pigments content show that both TDZ and DETA were characterized with a modifying effect in the irradiated triticale and oats plants with respect to the three indexes – chlorophyll a, b, and carotinoides (Table 1). Apart from stimulating the pigments biosynthesis, they at the same time restricted their decomposition.

The results from the analysis of the lipid peroxidation and the peroxidase activity are presented in Figure1 and show similar tendency in both plants.

It is evident that under the stress conditions the activity of the antioxidizing enzyme peroxidase (60-70%, in oats and triticale, respectively), as well as the lipid peroxidation, were increased. The physiological role of the peroxidase

Table 2: Effect of TDZ and DETA on the some parameters of the productivity in the gamma-irradiated triticale and oats plants in the phase of stem extension.

Таблица 2: Ефект на TDZ и DETA върху някои показатели на продуктивността на тритикале и овес, облъчени във фаза вретенене.

Parameters	Height of plants (cm)	Number of grains/plant	Weight of grains/plant(g)	Productivity (%)
Triticale				
Control	56.93 ± 0.85	40.42±0.55	1.04±0.10	100
4 Gy	42.37 ±0.62	27.20±0.72	0.70±0.09	43.75
4 Gy+ TDZ	52.17 ± 0.82 **	30.80±0.44**	0.75±0.05	53.9
4 Gy+ DETA	53.37±1.11**	35.11±0.25***	0.92±0.02**	69.23
Oats				
Control	58.38 ± 0.43	35.73 ± 0.74	0.86 ± 0.04	100
6 Gy	38.05 ± 0.50	25.45 ± 0.78	0.51 ± 0.02	40.90
6 Gy+ TDZ	41.20 ± 1.05**	28.20 ± 0.80**	0.65 ± 0.04**	53.99
6 Gy+ DETA	48.36 ± 0.60***	30.08 ± 0.62***	0.71 ± 0.03***	71.70

** $P < 0.01$; *** $P < 0.001$

found expression in neutralizing the “harmful” oxygen radicals which oxidize substances important to the cells. The increased lipid peroxidation, as a reaction of the plants to the gamma-irradiation, showed that free oxygen radicals (ROS) were produced, which damaged the cell membrane. After treatment with TDZ and DETA a positive change occurred – the deviation amplitude from the control decreased considerably for both indexes. For the peroxidase it was 15-20%, and for the lipid peroxidation – from 30 to 40%. The plant growth regulators reduced ROS and decreased the peroxidase intensity. This tendency was more clearly expressed in oats. According to some authors, the greater the plant radioresistance is, the greater the radiomodificator effect is.

The results from the elements of productivity of triticale and oats plants are shown in Table 2. It is evident that severe gamma-irradiation received during the most radiosensititive phase of the ontogenesis of the cereal plants strongly reduced the basic indexes determining the plant productivity. The irradiation suppressed the growth, as a result of which, the height of the irradiated plants was reduced.

The greatest level of reduction was observed with respect to the number and weight of the grains per plant – they were reduced with 33% (triticale), and 29% and 41% (oats), respectively, in comparison with the non-irradiated control plants. The gamma-irradiation in the phase of stem extensions strongly affected the formation processes in the raceme (cluster), as a result of which the productivity was reduced considerably – with 56% (triticale) and 59% (oats), in comparison with the control.

According to some authors [2, 3], there is a certain correlation between the radiosensitivity of the plants during the different development phases and their capacity for postirradiation recovery. According to them, during the plants ontogenesis, the morphogenesis phases, connected with the appearance of the generative organs, are characterized with the lowest radioresistance. The considerable decrease of the triticale productivity as a result of the irradiation is an indicator of strong suppression of the meiotic processes and of damage of the generative organs, in case of impact during this ontogenesis phase. The pretreatment of the plants with TDZ and DETA increased considerably the height of the irradiated variants. The number and weight of the obtained grains were increased as well. As a result of this, the productivity of triticale plants increased with 9% (TDZ) and 25% (DETA), in comparison with the non-treated irradiated variants. The application of DETA had a similar effect on the productivity of oats. The obtained results confirmed the already existing data about the application of the synthetic growth regulators TDZ and polyamine DETA as antidotes of gamma-irradiation stress. They had positive effect on the damaged physiological processes in the gamma-irradiated plants and increased the productivity. The exogen applications of them can partially compensate the endogen deficiency of these substances [6].

CONCLUSIONS

The irradiation of oats and triticale in the phase of stem extension caused stress in the plants, which found expression in disorganization of the physiological processes.

The tested synthetic plant growth regulators reduced the negative effect of the irradiation.

This found expression in both photosynthesis and transpiration activation, as well as in the increased amount of the photosynthetic pigments. The peroxides activity and the lipid peroxidation were reduced, while the plant productivity was increased.

Independently of the similar effect of both of the substances, polyamine DETA was characterized with a better modifying effect.

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