UDC: 633.16:631.524.8
original scientific paper

Acta Agriculturae Serbica, Vol. IV, 7 (1999) 61-65

Gamma-rays Influence on the Growth and Leaf Gas-exchange in Young Plants of Barley /*Hordeum* L./

Nevena Stoeva
Higher Institute of Agriculture - Plovdiv, Bulgaria

Tzvetanka Bineva
Central Lab of Radiation Protection and Toxicology - Sofia, Bulgaria

Abstract: The objective of the current study was to trace the gamma-rays influence on the growth and gas-exchange of young barley plants, as a result of pre-sowing irradiation of the seeds.The results of the research show that the applied irradiation doses of 150 and 200 Gy inhibit the growth of the young barley plants. There is a tendency towards reduction of the photosynthesis rate and the transpiration intensity. The results show insignificant changes in the concentration of and the correlation between the plastid pigments, which participate in the light reactions of the photosynthesis.

Key words: barley plants, gamma-irradiation, growth, leaf gas-exchange, plastid pigments.

Introduction

The problem of the irradiation influence on plants is becoming more and more important, as a result of the growing threat of radioactive contamination of the environment.

It was determined that gamma-rays influence the synthesis of DNA /Long at all, 1993/, the amino acids /Choubey at all, 1990/, the plants growth and hormone balance /Rabie at all, 1996/, and high doses of irradiation have a negative effect on these processes. The irradiation increases the peroxidase activity and reduces that of the catalase /Shi-Jan xin, 1993/.

The study of the physiological response of the plants under the condition of gamma-irradiation stress, not only provides an idea of the scale of the radioactive damage, but also shows the possibilities for restoration of the damaged plants by means of stimulation of the inhibited physiological processes.

The objective of the current study was to trace the gamma-rays influence on the growth and gas-exchange of young barley plants, as a result of pre-sowing irradiation of the seeds with gamma rays.

Material and Methods

For this purpose, the dry barley seeds of cultivar Hemus were irradiated with γ-rays Co^{60} with doses of 150 and 200 Gy. The irradiated and the control seeds were superficially treated with a 1% (w/v) solution of calcium hypo chloride - $Ca/OCl/_2$ in 10% (w/v) ethanol. The plants were grown as substrate crops /Perlit/ in 50% nutrient solution of KNOP, and micro elements from A to Z /Hogland/, in a climatic box under the following conditions: 120 μ moll H_2O $m^{-2}s^{-1}$, photo period 14 h /light /10 h /darkness/, temperature of 18± 2 °C day/night and relative humidity of the air 60-70%. On the 30th day of their development , an analysis of the growth /Poorter,1989/, the leaf gas-exchange- by means of a Photosynthetic measuring system LCA-4 /UK/, and the content of plastid pigments /Lichtenthaler, 1987/, was made .

Results and Discussion

The obtained data on the basic growth components are represented in Table 1. It is evident that the irradiation doses of 150 and 200 Gy inhibit the growth of the young barley plants. The relative growth rate /RGR/ decreases by 17% at 150 Gy, and by 25% at 200 Gy.

Tab. 1. Influence of the gamma-rays on the basic growth components in the young barley plants, cultivar Plovdiv 10, /in brackets- the percent difference from the non-irradiated control - O Gy/.

Variants and Indexes	O Gy	150 Gy		200 Gy	
RGR (g/g/d)	0.048±0.002	0.040±0.002	(83)	0.036±0.003***	(75)
LAR (cm^2/g/d)	0.320±0.008	0.290±0.020	(88)	0.270±0.04	(85)
NAR (mg/cm^2)	0.154±0.025	0.131 ±0.016	(90)	0.122±0.002*	(80)
SLA (cm^2/g/d)	0.449±0.009	0.419±0.009	(93)	0.400±0.02**	(80)
RWR (g/g)	0.414±00036	0.348±0.021*	(84)	0.302±0.052*	(72)
LA (cm^2)	15.33±0.32	12.15±0.42***	(79)	10.93±0.28***	(71)

*p<0.05% **p<0.01% ***p<0.001%

The changes in the index NAR, characterising the netophotoassimilation rate in the plants, follow the RGR tendency, regardless of the fact that the quantitative value of the inhibition is smaller- at 150 Gy-10% and at 200 Gy - by 20%, below the control. The decrease of the relation leaf area/dry mass /LAR/ is at about 12 - 15%, and is adequate to the decrease of the specific leaf area /SLA/. The obtained data on the inhibition of NAR indicate that the processes of photosynthesis and respiration in the dark were disturbed, and the reduced relative share of the roots /RWR/, as well as the reduced values of /SLA and LAR/, give us a reason to assume the presence of disturbances in the process of water-exchange of the plants, obtained from irradiated seeds.

There is a well-expressed tendency towards an inhibition of the photosynthetic leaf area, and at an irradiation dose of 200 Gy it is 29% of the control. Therefore, the applied gamma-rays effect strongly suppresses the growth processes in the young barley plants.

Tab. 2. Transpiration intensity (E) and stomata conductivity (g_s) in the control and test plants /in brackets - the percent difference from the non-irradiated control - O Gy/ .

Variants and Indexes	O Gy	150 Gy		200 Gy	
E (mmol H_2O $m^{-2}s^{-1}$)	1.21±0.10	0.53±0.08***	(52)	0.48±0.06***	(40)
g_s (mol $m^{-2}s^{-1}$)	0.06	0.04	(66)	0.04	(66)

***p<0.001%

Table 2 represents the results of the transpiration intensity and the stomata conductivity. They indicate a tendency towards a decrease of those indexes, and at the higher dose of 200 Gy there is a more considerable inhibition - 60% /E/ and 34% /gs/ with regard to the control, respectively. The greater inhibition at a higher dose is probably due to the suppressed growth of the root system, and hence the disturbed water-supply and the closure of the stomata cells.

Tab. 3. Photosynthesis rate (A) and plastid pigments content (mg/g fr.w.) in the leaves of young barley plants /in brackets - the percent difference from the non-irradiated control - O Gy / .

Variants and Indexes	O Gy	150 Gy		200 Gy	
A (μmol CO_2 m^{-2} s^{-1})	4.53±0.12	3.26±0.21	(71)	1.93±0.06**	(47)
chlorophill 'a'	0.680±0.04	0.658±0.06	(96)	0.648±0.03	(100)
chlorophill 'b'	0.278±0.01	0.268±0.01	(96)	0.256±0.02	(95)
carotinoids	0.213±0.02	0.208±0.01	(98)	0,200±0,02	(94)
ch. 'a' + ch.'b'	0.958±0.01	0.920±0.06	(96)	0.904±0.04	(94)
ch. 'a' / ch.'b'	2.44	2.49	(102)	2.53	(103)
chlorophills/ carotinoids	4.49	4.42	(98)	4.52	(101)

**p<0,01%

The results in Table 3 indicate once more the tendency towards a decrease of the photosynthesis rate, and at the higher irradiation dose of 200 Gy it is 53%. The reason for this, besides the reduced transpiration intensity /60%/, can as well be the changes in the concentrations of and the correlations between the plastid pigments, which participate in the light reactions of the photosynthesis.

The data, representing the changes in the plastid apparatus of the young barley plants subjected to moderate and strong radiation stress, did not differ considerably from the control. According to us, on the one hand, this may be due to the fact that along with the inhibition of the photosynthetic area, there occurs a "concentration" of the pigments per a unit of biomass, as a result of the increase of the specific leaf weight, and on the other hand due to the changes in the stomato apparatus. The concentration of and the correlation between the pigments are within the limits of the norm and are not the reason for the observed tendency towards a decrease of the photosynthesis rate.

Conclusion

The results of the research show that the applied irradiation doses of 150 and 200 Gy inhibit the growth of the young barley plants by 17 and 25% respectively. The leaf area was reduced considerably too.There is a tendency towards reduction of the photosynthesis rate, and at a dose of 200 Gy, the rate is reduced by 33%. Similar are the changes in the transpiration intensity - 26%. The results show insignificant changes in the concentration of and the correlation between the plastid pigments, which participate in the light reactions of the photosynthesis. Probably, they are not the reason for the observed tendency towards reduction of the photosynthesis rate, which is due to the decreased LAR / Leaf Area Ratio/ and hence SLA /Specific Leaf Area/.

References

Choubey, R., J. L. Tarar, (1990): Annals of Plant Physiology, 4,2, p. from 133 to 138, 9 ref.

Lichtenthaler, H. K., A.R.Welburn, (1987): Determination of total carotenoids and chlorophylls a and b of leaf extracts in different solvents, Biochem. Soc. Trans. Ac., 603, from 591 to 592.

Long Y.S., D.Y. Xu, Z.L. Wan, (1993): Journal of Southwest Agric. University, 15, 2, p. from170 to 174, 12 ref.

Poorter, H., (1989): Plant growth analysis: towards a synthesis of the classical and the functional approach, Physiol. Plant., 75, from 237 to 244.

Rabie, K.A., S.A. Shenata, M.A. Bandok, (1996): Annals of Agricul. Science, Ain Shame Univ. Egypt. v.41 /2/, p. from 551 to 566, Rec. 1966.

Shi-Jan Xin, (1993): Journal of Southwest Agricul. University, 15, 2, from 157 to 161, 10.

UTICAJ GAMA ZRAČENJA NA RAST I RAZMENU GASOVA PREKO LISTAKOD JEČMA (*Hordeum* L.)

-originalni naučni rad-

Nevena Stoeva
Viši poljoprivredni institut - Plovdiv, Bugarska

Cvetanka Bineva
Centralna laboratorija za zaštitu od radijacije i toksikologiju - Sofija, Bugarska

Rezime

Cilj ovog istraživanja je bio da se utvrdi uticaj gama-zračenja na rast i razmenu gasova preko lista ječma, kao rezultat predsetvenog ozračivanja semena. Rezultati istraživanja pokazuju da zračenje u dozama od 150 i 200 Gy inhibira rast ječma. Postoji tendencija smanjenja brzine fotosinteze i intenziteta transpiracije. Rezultati pokazuju neznatne promene koncentracije i korelacije izmedju plastidnih pigmenata, koji učestvuju u svetlosnim reakcijama fotosinteze.