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EFFECT OF RADIATION, $FeCl_3$ AND $ZnSO_4$ ON THE AMOUNT OF PHOTOSYNTHETIC PIGMENTS IN COTTON LEAVES

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Abstract: In the article, the growth and development of seedlings obtained from cotton seeds under the influence of different doses of radiation, different concentrations of $FeCl_3$ and $ZnSO_4$ salts, and the dynamics of changes in the amount of photosynthesis pigments during ontogeny were studied. Doses of γ-radiation above 100 Gy were found to have a slowing effect on the photosynthesis rate, including the amount of photosynthetic pigments. It was observed that the parameters shown in radiation doses of 5-50 Gy are regulated at a high level. At concentrations of 5-50 mM of $FeCl_3$ and $ZnSO_4$, the photosynthesis rate and the amount of pigments increase in the phases of the formation of cotyledons (CP), leaves (LP) of the seedling, and this increase is gradual in the budding (BP) and flowering (FB) phases of plant development. In the subsequent phases of plant development, the amount of pigments remains relatively constant but gradually decreases. This weakening process continues at concentrations of 100-200 mM of salts. In contrast to chlorophylls, the amount of carotenoids in plant leaves increases at high radiation doses, high salt concentrations, and at the last stages of plant ontogenesis, which can be associated with their adaptive functions in plant organisms.

Keywords: *Gossypium hirsitum* L., radiation, $FeCl_3$, $ZnSO_4$, pigment, photosynthesis rate, adaptation

1. Introduction

One of the most important tasks related to the increase in the efficiency of the photosynthetic apparatus at the genetic level is the optimization of mineral nutrition, which allows the plant to absorb moisture and mineral elements more efficiently to increase its productivity and stability. However, the influence of extreme environmental factors limits the productivity of the plant by weakening the photosynthesis rate in higher plants, including the cotton plant. From this point of view, it is of great interest to study the nature of photosynthetic changes. This problem has been studied in very few agricultural plants. Due to the influence of abiotic factors such as radiation and salt stress, the photosynthetic apparatus and its pigment systems are damaged, and as a result, the growth and development of plants, photosynthesis and respiration, protein and amino acid metabolism, including the activity of a number of enzymes, are gradually reduced due to a number of disturbances in metabolism [Thomas, 1984; Akram, Ashraf, 2011].

Salt stress also affects the pigments of photosynthesis [Akca, Samsunlu, 2012]. The activity of the chlorophyll pigment depends on the position of the chloroplasts in the cell, their structure, and the level of the chlorophyll-protein-lipid complex. Under the influence of NaCl, chlorophylls are degraded by distributing evenly along the side wall of columnar parenchyma cells of chloroplasts. The amount of chlorophyll pigment depends on the nature of the plant, its development phases, and also on the concentration of salts. From this point of view, there is a

change in the amount of green pigments in the leaf at a concentration of 0.7-1.0% of NaCl. Salts have a more toxic effect on the chlorophyll pigment a than on chlorophyll b [Stroganov and others, 1970].

It is known that carotenoids perform a protective function under the influence of extreme factors. The rate of accumulation of carotenoids varies depending on the type of salts in the medium. It was determined that the amount of carotenoids collected in plants under the conditions where NaCl concentration is superior is the same as in control plants. In contrast, the amount of carotenoids significantly increases in the presence of Na_2SO_4 in the medium [Babu et al., 2011].

Saline soils also affect the structure of plant organs and tissues. It has been established that chloride soils produce succulents in plants. At this time, the vacuole and cytoplasm of leaves absorb water, so the cell swells, and the main importance of this is to conserve water. In sulfate soils, plants acquire xeromorphism. In plants with such properties, the leaf surface area is very small and they supply themselves with water through intensive root development. At the same time, plants growing on chloride soils differ from plants growing on sulfate soils due to the low photosynthesis rate and respiration and the gradual separation of water. These indicators are high in plants growing in soils that are saline due to sulfate salts. An increase in the amount of Na^+ ions in the soil reduces its water permeability [Rashidi, Seilsepeur, 2011]. Saline soils are usually alkaline in nature. Cultivated plants grow and develop normally in the pH range of 5.0-7.0, but in such areas, the pH is in the range of 8.5-10.0.

When evaluating the assimilation capacity, lability, and resistance of plants, it is necessary to take into account the activity of the photosynthesis apparatus under extreme conditions. Light is the most important abiotic factor for photosynthesis. As a result of the effect of light on the rate of electron transport in photosynthesis, the ENZ of photosynthesis, the biosynthesis of pigments, the translation of phytochrome and some proteins' mRNA, the activity of enzymes are disturbed [Anderson, 1989]. Efficient absorption of light is determined by leaf morphology and light reflectance, and absorption properties of internal tissues are determined by their anatomical structures. The mandatory component that plays the main role in these processes is pigmented [Avratovshukova, 1980].

There are conflicting opinions regarding the effects of salt stress on tissue respiration. According to some researchers, the short-term effect of salt stress increases the respiratory rate, while long-term salt stress has the opposite effect and reduces respiratory intensity. In addition, there are considerations that salt in low concentrations stimulates the rate of respiration, and in high concentrations, they gradually inhibit it. In research plants under extreme conditions, the ratio of the rate of respiration to the rate of photosynthesis increases in the dark. According to this regularity, it is possible to characterize the energy balance of organisms, to evaluate the potential productivity of sprouts and the physiological state of the plant [Maghsoudi, Maghsoudi, 2008]

Taking these into account, the main goal of the work is to study the changes in the amount of photosynthesis pigments in the leaves of the cotton plant under the influence of radiation, different doses and concentrations of chloride and sulfate salts, and the disturbances caused by this change in the metabolism of the plant.

2. Materials and methods

Ganja-182 variety of *Gossypium hirsitum* L. cotton species was taken as the object of research and measurements were made in the CP – cotyledon formation phase, LP - leaves formation phase, BP - budding or sympodial branch formation phase, FP-flowering phase, and

BOP – ripening (or boll-opening) phases of the ontogenesis of the plant. The seeds are planted according to the following scheme. 1) Planting of non-irradiated cotton seeds as a control sample, 2) Planting of seeds irradiated with γ-rays at doses of 1, 5, 10, 50, 100, and 200 Gray under normal conditions, 3). Planting of non-irradiated seeds at 5, 10, 50, 100, and 200 mM concentrations of $FeCl_3$, 4) Planting of non-irradiated seeds at 5, 10, 50, 100, and 200 mM concentrations of $ZnSO_4$. Cotton seeds germinate within 5-6 days under natural conditions. After the first leaf stage of sprout development (we consider this stage as the zero-day or control), irrigation was continued until the end of vegetation in the I and II group samples shown in the scheme, but in the III and IV group plants, $FeCl_3$ and $ZnSO_4$ solutions of different concentrations were added according to the scheme, and increasing salt concentration variations were created. All samples were planted in natural conditions. On the days of the experiments, air temperature and relative humidity, photoperiod, and intensity of light flux were recorded.

Irradiation of seeds in different doses of radiation. Cotton seeds were irradiated using a Co^{60}-irradiation source in the RUXUND 20.000 - irradiation unit at the "Isotopic Radiation Sources" scientific experimental department of the Institute of Radiation Problems of ANAS. The seeds irradiated in doses of 1, 5, 10, 50, 100, and 200 Gy were disinfected in 0.3% H_2O_2 solution for 15 min, then rinsed 2-3 times with distilled water to remove H_2O_2, and germinated in Petri dishes thermostat. All the seedlings obtained according to the variants were periodically watered, and in the salt variants, the seedlings were transferred to salt solutions of different concentrations according to the variants. Then the vegetation dishes were placed in special chambers with a temperature of 25-28ºC, a photoperiod of 14 hours, a relative humidity of 60-70%, and a light intensity of 15-20 lux.

The total amount of proteins was determined by Lowry's colorimetric method [Lowry et al., 1951].

The photosynthesis rate (P_n) and the rate of transpiration were measured with an infrared gas analyzer LI COR-6400 XT Postable Photosynthesis System (Biosciences, USA).

Determination of the amount of pigments of photosynthesis. The amount of photosynthesis pigments (chl *a*, *b*, and *car*) was determined in the leaves on the 5th, 25th, 45th, and 65th days of plant ontogenesis. For this, the leaves were extracted in 96% ethyl alcohol and each pigment was measured according to its absorption spectrum in an Ultraspec 3300pro (USA) spectrophotometer. The amount of xl, a, b were measured by [Wettstein, 1957] and carotenoids by the method of [Wintermans, De Mots, 1965].

Chl a (mg/l) = $12.7 \cdot D_{663} - 2.69 \cdot D_{645}$ Car (mg/l) = $4.695 \cdot D_{440.5} - 0.268 \cdot$(Chl (a+b), mg/l) Chl b (mg/l) = $22.9 \cdot D_{645} - 4.68 \cdot D_{663}$ Chl (a+b) (mg/l) = $29.0 \cdot D_{652}$

Determination of the transpiration rate. The transpiration rate (T_r) means the amount of water (in grams) evaporated by wet substance (g) or leaf surface (cm^2, m^2) in 1 hour and is determined by Ivanov's method [Ivanov and others, 1950]. For this, the leaves are weighed immediately after being taken and weighed again after keeping them for 3-4 minutes. To complete this process, it is also necessary to determine the leaf area and the intensity of free evaporation. For this purpose, the studied leaf is placed on a square whose area is known in advance on graph paper, cut to its size, and weighed.

The leaf area is calculated by the following formula:

$$a/b=c/s$$

where: a is the weight of square paper; b-weight of the paper figure; c- is the area of the square; s - is the leaf area.

To determine the evaporation intensity, the weight of a chemical glass filled with water is determined at room temperature. After 30 minutes, the glass is weighed again and the amount of evaporated water is measured. T_r ($g/m^2 \cdot h$) is determined by the following formula:

$$T_r = n \times 10000 \times 60/(s \times t)$$

where: n is an amount of evaporated water (g); s - leaf area (cm^2); t – retention time (min); 10000 – conversion factor of cm^2 to m^2; 60 – conversion factor of minute to an hour.

Statistical analyses. The values shown in the tables are mathematical averages and reflect the mean square deviation. Average mathematical errors and deviations (M±m) were taken into account during the analysis of the research results [Babayev et al., 1999]. Differences were considered significant when the accuracy probability was $R \leq 0.05$. The obtained results were processed using "Statistica for Windows 10.0" and "Microsoft Office Excel 2010" computer programs.

3. Obtained results and their analysis

As we know, in recent years, numerous research studies have been conducted on the study of resistance mechanisms of higher plants against the effects of various types of abiotic factors. From this point of view, the study of the effect of radiation, salts of different composition, which are considered abiotic stress factors, on the growth and development of plants, biometric parameters, photosynthesis, and respiration processes at the center of metabolic processes, and enzyme systems of these metabolic pathways is of great scientific and practical importance.

In this work, we conducted research on the cotton plant, which is considered a typical technical plant for our republic. It is known that a large part of the lands of our republic became saline due to various reasons and remained out of cultivation. In order to restore the natural fauna and flora of those areas, there is a great need to create salt-resistant cultivated plant varieties through breeding.

We conducted our experiments in three directions and in five variants for each direction. 5, 10, 50, 100, and 200 Gray doses of γ-radiation were taken as the first direction, 5, 10, 50, 100, and 200 mM concentrations of FeCl3 as the second direction, 5, 10, 50, 100, and 200 mM concentrations of ZnSO4 as the third direction. Some of the obtained results are given in Table 1. As can be seen from the table, the influence of radiation and salts on the dynamics of the quantity change of the pigment systems of photosynthesis took place on a different spectrum, depending on the time, that is, on the separate phases of the ontogenesis of the plant. Thus, the amount of chlorophyll a, chlorophyll b, and carotenoids, which are pigments of photosynthesis, changed in a wide aspect and to a certain extent in different phases of the ontogenesis of the cotton plant. From the table, it can be seen that radiation, FeCl3, and ZnSO4 had a more toxic effect on the amount of pigments in the phase of cotyledon formation (CP) of seedling development. If we pay attention to the table, we will see that radiation with 5-50 Gy doses and both salts at concentrations of 5-10 and in some cases 50 mM stimulates the development of pigments in leaves. Higher concentrations of both chloride and sulfate salts caused a serious decrease in chlorophyll a. Although the general spectrum of the effect of ZnSO4 is similar to the general spectrum of the effect of FeCl3, it differs from it in terms of the intensity of the effect. Changes in the amount of chlorophyll a due to the influence of all 3 factors occurred similarly in the phases of ontogenesis (Table 1).

Table 1

Dynamics of changes in the amount of pigments in the leaves of the cotton plant under the influence of radiation, chloride, and sulfate salts at different phases of ontogenesis

ontogenesis	K	Radiation, Gy					$FeCl_3$, mM					$ZnSO_4$, mM				
		5	10	50	100	200	5	10	50	100	200	5	10	50	100	200
Chlorophylla (mg/gwetmass)																
CP	0.49	0.56	0.58	0.42	0.06	0.02	0.53	0.49	0.32	0.19	0.11	0.61	0.62	0.45	0.27	0.01
LP	0.65	0.71	0.83	0.74	0.49	0.19	0.74	0.79	0.79	0.41	0.22	0.77	0.84	0.81	0.24	0.18
BP	0.83	0.88	1.01	0.96	0.62	0.18	0.82	0.84	0.81	0.53	0.23	0.90	0.92	0.77	0.38	0.15
FP	0.87	0.90	1.71	1.28	0.66	0.09	0.99	1.07	0.99	0.49	0.18	1.04	1.11	0.95	0.4	0.13
BOP	0.88	0.96	1.23	1.13	0.36	0.04	0.99	1.05	0.96	0.61	0.11	1.05	1.13	0.95	0.41	0.07
Chlorophyllb (mg/gwetmass)																
CP	0.86	0.42	0.45	0.3	0.08	0.01	0.49	0.36	0.24	0.11	0.09	0.34	0.35	0.2	0.11	0.09
LP	0.31	0.44	0.58	0.5	0.28	0.09	0.39	0.47	0.48	0.17	0.11	0.36	0.41	0.44	0.23	0.14
BP	0.49	0.45	0.64	0.64	0.53	0.15	0.61	0.71	0.52	0.48	0.2	0.37	0.51	0.39	0.29	0.11
FP	0.52	0.51	0.96	0.73	0.69	0.06	0.74	0.83	0.89	0.44	0.17	0.49	0.60	0.63	0.35	0.08
BOP	0.54	0.76	0.88	0.79	0.31	0.04	0.74	0.95	0.87	0.1	0.11	0.5	0.60	0.88	0.40	0.07
Chlorophyll(a+b) (mg/g wetmass)																
CP	0.75	0.97	103	0.72	0.24	0.03	1.42	0.85	0.56	0.3	0.2	0.95	0.97	0.65	0.38	0.02
LP	0.96	1.15	1.41	1.24	0.77	0.28	1.13	1.26	1.27	0.58	0.33	1.13	1.25	1.25	0.57	0.32
BP	1.32	1.33	1.65	1.6	1.15	0.33	1.43	1.55	1.33	1.01	0.43	1.27	1.45	1.16	0.67	0.26
FP	1.39	1.41	2.67	2.01	1.35	0.15	1.73	1.9	1.88	0.93	0.35	1.53	1.71	1.58	0.75	0.21
BOP	1.42	1.72	2.11	1.92	0.67	0.08	1.78	2.0	1.83	0.71	0.22	1.55	1.73	1.83	0.81	0.14
Chlorophyll(a/b)																
CP	1.88	1.33	1.29	1.4	2.0	2.0	1.08	1.36	1.33	1.73	1.11	1.79	1.77	2.25	2.45	1.11
LP	2.1	1.61	1.43	1.48	1.75	2.11	1.9	1.68	1.65	2.4	2.0	2.1	2.05	1.84	1.48	1.29
BP	1.69	1.96	1.58	1.5	1.17	1.2	1.31	1.66	1.56	1.1	1.15	2.43	1.8	1.97	1.31	1.36
FP	1.67	1.76	1.78	1.75	1.25	1.5	1.34	1.55	1.11	1.11	1.05	2.1	1.85	1.51	1.14	1.63
BOP	1.63	1.26	1.39	1.43	1.16	1.0	1.34	1.11	1.1	6.1	1.0	2.1	1.88	1.08	1.03	1.0
Carotenoids(mg/gwetmass)																
CP	1.21	1.49	1.61	1.62	1.28	1.21	1.38	1.53	1.62	1.23	1.21	1.5	1.59	1.67	1.75	1.82
LP	1.28	1.5	1.62	1.68	1.44	1.3	1.39	1.6	1.69	1.31	1.28	1.55	1.68	1.75	1.89	1.97
BP	1.33	1.58	1.71	1.80	1.38	1.3	1.45	1.67	1.78	1.35	1.33	1.53	1.7	1.83	1.99	2.2
FP	1.46	1.65	1.84	1.97	1.51	1.46	1.68	1.87	1.99	1.52	1.47	1.64	1.82	1.95	2.01	2.11
BOP	1.58	1.7	1.91	2.1	1.93	1.85	1.72	1.89	2.03	1.67	1.59	1.72	1.87	2.2	2.23	2.27
Chlorophyll(a+b)/Carotenoid																
CP	0.62	0.65	0.64	0.44	0.15	0.02	1.74	0.56	0.35	0.24	0.08	0.63	0.61	0.39	0.22	0.01
LP	0.75	0.77	0.87	0.74	0.53	0.22	0.81	0.79	0.75	0.44	0.26	0.72	0.74	0.71	0.3	0.16
BP	0.99	0.84	0.96	0.89	0.85	0.25	0.99	0.93	0.75	0.75	0.32	0.83	0.85	0.63	0.34	0.12
FP	0.95	0.85	1.45	0.89	0.89	0.1	1.03	1.14	0.95	0.61	0.24	0.93	0.94	0.81	0.19	0.1
BOP	1.03	0.43	1.1	0.68	0.35	0.04	1.03	1.06	0.9	0.25	0.14	0.9	0.92	0.83	0.36	0.06

Note: CP- cotyledon formation phase, LP- leaf formation phase, BP-budding or sympodial branch formation phase, FP-flowering phase, BOP- ripening (or boll opening) phase. The values given in the table are the average value of the results obtained from three repeated measurements.

If we look carefully at the table, it can be seen that the amount of both chlorophyll a and chlorophyll b changes along a similar spectrum due to the influence of radiation, chlorine, and sulfate salt. Thus, due to the influence of all three factors, the amount of photosynthesis pigments increased in low doses of this factor until the FP of ontogenesis, and sometimes it decreased a little, sometimes a lot in 50 Gy and 50 mM depending on the phase of ontogenesis. This reduction was more intense at 100 Gy dose and 100 mM salt concentrations, and due to the effect of 200 Gy and 200 mM $FeCl_3$ and $ZnSO_4$ salt concentrations, the amount of the studied

pigments decreased more and approached the lowest limit. As can be seen from the table, the influence of $ZnSO_4$ salt on the dynamics of changes in the amount of photosynthesis pigments increased more intensively than the influence of other factors. Nevertheless, at high concentrations (100-200 mM), the amount of pigments decreased faster under the influence of $ZnSO_4$ than under the influence of radiation and $FeCl_3$. It can be concluded from this that radiation, $FeCl_3$, and $ZnSO_4$ increase until the FP of vegetation, and this increase was more intense in the presence of $ZnSO_4$, but at higher doses and concentrations, it occurred faster than radiation and $FeCl_3$. Among these factors, $FeCl_3$ had the most inhibitory effect on the amount of pigments.

During the boll-opening phase (BOP) of vegetation development, it was significantly increased in control samples and samples at low radiation and concentrations of salts (5-10 Gy, 5-10 mM), and decreased at higher doses (Tab. 1). Despite the fact that the figures obtained in the chlorophyll a/b ratio differ from each other, this ratio was always higher than one, which indicates the increase in the photosynthesis rate under those stress conditions and the further activation of the processes taking place in the reaction center of PS II.

During the quantitative analysis of carotenoids, it was determined that, unlike chlorophyll a and b, its amount increases until the end of vegetation depending on the growth phases of the plant and the doses of stress factors. This form of an increase in the amount of carotonoids seems to be related to their protective function.

Table 2 shows some biometric indicators of vegetative organs of cotton at 10 Gy radiation dose, 10 mM $FeCl_3$, and 10 mM $ZnSO_4$ salt concentrations, and the obtained results were compared with the results of Table 1. It was determined that the height and weight of the plant, the area and weight of the leaf, and the length and weight of the root in the optimal radiation dose and concentration of $ZnSO_4$ were higher compared to the same dose of $FeCl_3$. Among these factors, $ZnSO_4$ had a more optimal effect and the plant had more productivity. The effect of chloride salts on plant growth and development was weak compared to that of sulfate salts. These obtained results correspond to changes in the amount of pigments in the leaves. So, as can be seen from table 1, the amount of pigments also have a relatively high amount in the control, the sample in the presence of radiation and $ZnSO_4$ compared to $FeCl_3$ concentrations (Table 2).

Table 2

Effects of radiation, $FeCl_3$, and $ZnSO_4$ salts on biometric indicators and productivity in the BOP of cotton plant ontogeny

Parameters	Stress factors		
	Radiation, 10 Gy	$FeCl_3$, 10 mM	$ZnSO_4$, 10 mM
Plantlength (L_p), cm	71.0±8.32	69.0±7.73	78.0±8.34
Plantweight (M_p), g	793±30.4	776±28.9	801±39.3
Leafarea (A_l), cm^2	10.7±0.99	7.6±0.77	9.9±0.97
Leafweight(M_l), g	3.4±0.23	3.2± 0.29	4.0±0.47
Rootlength (L_r), cm	26.5±3.68	21.0±3.95	32.8±3.55
Rootweight (M_r), g	18.1±2.33	18.0±2.13	29.3±3.29
L_p/L_r	2.68	3.29	2.66
M_p/M_r	43.8	43.1	27.3
A_l/M_l	3.15	2.38	2.48
M_l/M_r	0.19	0.18	0.14
Thenumber of plants, number/m^2	8.0±1.01	8.0±1.01	8.0±1.01
Productivity of theplant, g/m^2	102.0±9.20	104.0±11.8	116.0±14.3

The effect of radiation doses and different concentrations of salts on the photosynthesis rate in cotton plants was also studied in a comparative manner with chlorophylls, carotenoid, and biometric parameters. As can be seen from the table, P_n decreased by 29, 38, and 62% in CP, BP, and FP, respectively, compared to the control, and the change of T_r occurred synchronously with it.

Table 3

Changes in photosynthesis rate and transpiration rate in cotton leaves under radiation and salt stress conditions

Phase	Variant	P_n	T_r
CP	K	22.5±10.2	3.34±3.4
	Radiation	23±8.4	3.99±1.7
	$FeCl_3$	17.4±8.7	3.44±3.8
	$ZnSO_4$	31.7±6.8	4.21±2.2
BP	K	21.9±10.1	4.03±4.1
	Radiation	22.0±7.6	4.1±2.7
	$FeCl_3$	19.8±8.3	3.92±2.3
	$ZnSO_4$	36.3±7.2	4.27±2.8
FP	K	17.6±8.9	2.2±1.9
	Radiation	19.3±8.7	3.26±0.9
	$FeCl_3$	12.9±6.8	2.89±1.7
	$ZnSO_4$	36.4±6.9	3.93±2.2

Note: P_n-photosynthesis rate (μmol $CO_2 \cdot m^{-2}.s^{-1}$);
T_r-transpiration rate, (mmol $H_2O \cdot m^{-2} \cdot s^{-1}$)

Our previous results show (results not given) that only the amount of carbon in the intercellular spaces (C_i) increases from the gas parameters. If T_r decreases for any reason, the diffusion of CO_2 into the intercellular spaces becomes difficult, which ultimately leads to a weakening of P_n and a decrease in biological productivity (Table 3). According to some literature data, mesophyll conductance has a superior role in the regulation of P_n [Siddique et., 1999]. During long-term salt stress, due to the disruption of photochemical processes, ATP synthesis is weakened, and the reserve of CO_2 acceptor RBF and the activity of enzymes decreases. In the later phases of vegetation, the gas exchange indicators are lower in the control variants as well, which can be explained by the aging of the leaf. All this means that the inhibition of the oxidation of the substrates of photosynthesis and respiration on the electron transport chain (ETC) leads to the cessation of synthesis processes in plants as a whole.

Thus, the simultaneous change of the amount of chlorophylls and carotenoids, biometric indicators, the photosynthesis rate, and the amount of gas parameters is a sign of adaptation in higher plants and serves to create signs of high resistance and avoid the effects of stress in plants.

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ВЛИЯНИЕ РАДИАЦИИ, $FeCl_3$ И $ZnSO_4$ НА КОЛИЧЕСТВО ФОТОСИНТЕТИЧЕСКИХ ПИГМЕНТОВ В ЛИСТЬЯХ ХЛОПЧАТНИКА

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Резюме: В статье рассмотрены рост и развитие проростков, полученных из семян хлопчатника под действием различных доз радиации, различных концентраций солей типа $FeCl_3$ и $ZnSO_4$, а также динамика изменения количества пигментов фотосинтеза в течение 75 дней онтогенеза. Установлено, что дозы γ-лучей выше 100 Гр оказывают замедляющее действие на интенсивность фотосинтеза и количество пигментов фотосинтеза. Было замечено, что параметры, показанные в дозах облучения 5-50 Гр, регулируются на высоком уровне. При концентрациях $FeCl_3$ и $ZnSO_4$ 5-50 мМ интенсивность фотосинтеза и количество пигментов увеличиваются в фазах листообразования (ФЛО), образования настоящих листьев (ФЛ), причем это увеличение происходит постепенно в бутонизации (ФБ) и фазы цветения (ФЦ) растений. В последующие фазы развития растений количество пигментов остается относительно стабильным, но его количество постепенно уменьшается. Это уменьшение продолжается при концентрациях солей 100-200 мМ. В последующих фазах онтогенеза растения, количество каротиноидов в отличие от хлорофиллов в листьях растения увеличиваются при условиях высоких дозах γ-облучения, высоких концентрациях солей. Это может быть связано с защитными функциями каротинидов в растительных организмах.

Ключевые слова: *Gossypium hirsitum* L., радиация, $FeCl_3$, $ZnSO_4$, хлорофилл, каротиноиды, интенсивность фотосинтеза, адаптация

RADİASİYANIN, $FeCl_3$ VƏ $ZnSO_4$-ün PAMBIQ BİTKİSİNİN YARPAQLARINDA FOTOSENTETİK PİQMENTLƏRİN MİQDARINA TƏSİRİ

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Xülasə: Məqalədə normal, radiasiyanın müxtəlif dozaları, $FeCl_3$ və $ZnSO_4$ duzlarının müxtəlif qatılıqlarının təsiri şəraitində pambıq toxumlarından alınan cücərtilərin böyümə və inkişafı, fotosintezin piqmentlərinin miqdarının dəyişmə dinamikası ontogenezdə öyrənilmişdir. Müəyyən olunmuşdur ki, γ-şüaların 100 Qr-dən yuxarı dozaları fotosintezin intensivliyinə, o cümlədən fotosintezin piqmentlərinin miqdarına ləngidici təsir göstərir. Radiasiyanın 5-50 Qr dozalarında göstərilən parametrlərin yüksək səviyyədə tənzimləndiyi müşahidə olunmuşdur. $FeCl_3$ və $ZnSO_4$-ün 5-50 mM qatılıqlarında cücərtinin ləpə yarpaqların əmələ gəlməsi (LF), əsl yarpaqların yaranması (YF) fazalarında fotosintezin intensivliyi və piqmentlərinin miqdarı artır,bitkinin inkişafının qönçələmə (QF) və çiçəkləmə fazalarında (ÇF) bu artım tədrici olur. Bitkinin inkişafının bundan sonrakı fazalarında piqmentlərin miqdarı nisbi sabit qalsa da getdikcə azalır. Duzların qatılığının 100-200 mM qatılıqlarında isə bu zəifləmə davam edir. Bitkinin yarpaqlarında isə karotinoidlərin miqdarı xlorofillərdən fərqli olaraq yüksək radiasiya dozalarında, yüksək duz qatılıqlarında və bitkinin ontogenezinin son mərhələlərində artır ki, bu da onların bitki orqanizmlərində adaptiv funksiyaları ilə əlaqələndirilə bilər.

Açar sözlər: *Gossypium hirsitum* L., radiasiya, $FeCl_3$, $ZnSO_4$, piqment, fotosintezin intensivliyi, adaptasiya