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EFFECT OF RADIATION, DIFFERENT TYPES CHLORINE AND SULFATE SALTS ON THE DYNAMICS OF NITRATE REDUCTASE AND CARBONIC ANHYDRASE ENZYMES ACTIVITIES CHANGES DURING THE ONTOGENY OF COTTON PLANTS

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Abstract: In this study, the effect of γ-irradiation, different doses (K, 5, 10, 50, 100, 200 Gy), and concentrations (K, 5, 10, 50, 100, 200, mM) of different types of chlorine (NaCl, $FeCl_3$) and sulfate salts (Na_2SO_4, $ZnSO_4$) on the dynamics of changes in the activities of nitrate reductase (NR) and carbonic anhydrase (CA) enzymes in the roots and leaves of Ganja-182 variety of Gossypium hirsitum L cotton species at separate stages of ontogenesis was studied. Firstly, after finding the optimal dose and concentration limit at each stage of ontogenesis of the plant, the dynamics of change of enzyme activity at these doses and concentrations were examined every 10, 20, and 30 days during the period of budding and preparation for flowering of the plant, and interesting results were obtained.

Keywords: Gossypium hirsitum L., radiation, salts species, NR-KA activities, adaptation

1. Introduction

One of the most important problems of agriculture is the development of new methods of increasing the productivity of cultivated plants and their practical application. It is known that the use of ultraviolet (UV) rays in the practice of creating high-yielding plant varieties is one of the promising areas. In the modern world, a large amount of material has been collected showing the positive effect of seed treatment with UV rays on the yield and quality of cultivated plants. Irradiation of seeds in a certain dose before sowing is based on the stimulation of the regulatory system of the embryo, which allows them to get out of the state of physiological dormancy, resulting in accelerated cell division during seed germination. With this method, the increase in grain yield reached 10-15%.

In higher plants, the control of the organogenesis of cultivated plants by exposure to ultraviolet radiation is of great interest. This method allows a significant increase in yield, which is ~25% for cereals and ~50% for potatoes. However, it should be noted that the stimulation effect under conditions of natural growth after irradiation strongly depends on several environmental factors. In general, when studying the stimulating effect of radiation on cultivated plants, the lack of unified principles related to the radiation regime so far reduces the value of the works. From this point of view, it is of great importance to study the mechanisms of adaptive reactions occurring in plant metabolism against the effects of radiation and various salts as an abiotic factor, separately and together, at different stages of organogenesis [Liu et al., 2015].

Plants usually absorb nitrogen as a nutrient from the soil in the form of ammonium (NH_4^+) and nitrate (NO_3^-), which are inorganic forms of nitrogen. After absorption, the assimilated nitrate is converted into ammonium in the plant tissue and then joined in the metabolism and converted into amino acids. The first stage of this process is catalyzed by the enzyme of nitrate reductase (NR) by the given reaction $NO_3^- + NADH + H^+ \rightarrow NO_2^- + NAD^+ + H_2O$. NR is a substrate-inducible enzyme, and plants differ in their ability to induce NR. NR activity is measured by the amount of nitrite formed as a product of the reaction. Worldwide, very little work has been done on the inventory of plants for NR activity [Kim, Seo, 2018; Koyama et al., 2020].

Gambarova and Asadova show that a high degree of drought and salinity reduces the productivity of cultivated plants [Gambarova, Asadova, 2010]. Plants are more resistant to drought and salinity in the early stages of ontogenesis [Weiping et al, 2010]. In recent years, salinity, which is a natural stress factor on our planet, covers 20% of the area [Blum, 1986].

Taking into account all that has been said, we have studied the effect of γ-irradiation, different doses and concentrations of chlorine and sulfate salts on the dynamics of changes in the activities of nitrate reductase (NR) and carbonic anhydrase (KA) enzymes in the roots and leaves of the cotton plant at different stages of its ontogenesis.

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 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 NaCl, 5) Planting of non-irradiated seeds at 5, 10, 50, 100 and 200 mM concentrations of $ZnSO_4$, 6) Planting of non-irradiated seeds at 5, 10, 50, 100 and 200 mM concentrations of Na_2SO_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, IV, V and VI group plants, $FeCl_3$, NaCl and $ZnSO_4$, Na_2SO_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 Bradford colorimetric method [Bradford, 1976]**.**

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 number of pigments of photosynthesis. The number of photosynthesis pigments (chl a, b, and car) was determined in the phases of ontogenesis and leaves on the 10th, 20th, and 30th 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 CA activity. CA activity was determined by the electrometric method according to Wilbur Anderson, based on the change in the release activity of H+ ions formed by the reaction $CO_2 + H_2O \rightarrow H^+ + HCO_3^-$ [Wilbur, Anderson, 1948]. To obtain the enzyme extract, the roots were collected, the flag leaves were separated from the stem, washed separately with distilled water, dried with filter paper, and then homogenized at +4ºC for 30 seconds after adding 7 ml of homogenization solution with the following composition - 1 mM EDTA, 5 mM DTT, 0.01 M NaCl, 0.05 M Tris-HCl buffer with 0.5% Triton X-100 and 1% PVP, pH 8.4 to one g of plant material. After the homogenate was filtered through 2 layers of Capron, the filtrate was centrifuged at 1000g for 10 minutes to remove non-dissolving plant tissues. After re-centrifuging the supernatant liquid at 5000 g for 15 min, the obtained supernatant liquid was used to determine the activity of the enzyme.

Enzyme activity was determined by the electrometric method. For this, the reaction was started by adding 10-250 µl of enzyme preparation to the activity medium and then adding 3 ml of saturated CO_2 solution to it. Enzyme activity was calculated in conventional units according to the following formula [Rickli et al., 1964]:

$$U=10(T_o/T-1)$$

Here, T_o is the time (sec) spent on the pH change during the non-enzymatic (control) reaction, and T is the time spent (sec) on the pH change during the enzymatic (experimental) reaction.

Determination of NR activity. 2 ml of 100 mM Tris-HCl buffer solution (pH 7.5) (extraction solution) containing 1 mM vinyl acetate was added to 0.5 g of leaves and homogenized in the presence of quartz sand in a mortar at +4ºC. After the obtained homogenate was centrifuged at 5000 g for 10 minutes, the precipitate was discarded, and the supernatant liquid was used as an unpurified enzyme preparation. NR activity was determined in the reaction medium with the following composition. 0.5 ml 0.12 ml 0.167 M phosphate buffer (pH 7.5); 0.04 ml 0.1 M KNO_3, 0.02 ml 2 mM FMN, 0.02 ml Na_2SO_4, 8 mg/ml 0.095 M $NaHCO_3$ and 0.2 ml enzyme preparation. Test tubes are still stored in the ice bath. Each test tube is shaken separately to mix the components well and reduce the FMN (at this time, the color of the solution changes from yellow to light yellow). After that, the test tubes are placed in the water bath at 250ºC to start the reaction. A drop of paraffin oil is added to each test tube. As the paraffin forms a thin layer on the reaction medium, it prevents oxidation of the reducing agent by air oxygen. To stop the reaction after half an hour, the reaction mixture should be shaken vigorously until all the reducing agents have oxidized during this time (indicated by a color change from light yellow to yellow). The amount of nitrite formed by the enzymatic reduction of nitrate is determined by first adding 0.3 ml of 1% sulfonamide prepared from 3 N HCl, followed by 0.3 ml of 0.02% N-1-naphthylenediamine dihydrochloride solution. After the obtained

mixture is centrifuged at 5000g for 15 minutes, its optical density is determined at a wavelength of 540 μm. The amount of nitrites was determined according to the standard calibration curve [Ferrari, Varner, 1969].

Determination of the activity of H^+-pumps. This determination was performed using the usual pH meter (pH-meter HI 122, Romania). To make the discussion effective, the rate of separation of protons in roots (V_{H+}), maximum (ΔH_{max}) and minimum (ΔH_{min}) value of hydrogen ion concentration, leaf growth rate (V_l), and length (L_l), root length (L_r), the ratio of leaf length to root length (L_l/L_r) were measured. Measurements were always carried out at the same time to study the mineral nutrition of plants by root based on ion exchange.

Statistical analysis. 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

Based on recent global climate changes, the increase in the radiation background of the Earth, and the gradual reduction of fertile land areas as a result of salinization have led to the destruction of biological diversity and valuable plant species [FAO, 2012; Khan et al., 2010]. Therefore, the study of physiological and biochemical processes occurring in plant tissues is of great scientific and practical importance for the breeding of salinity-resistant plant varieties that can develop in an unfavorable ecological environment [Galvani, 2007; FAO, 2012].

The results of studies carried out for this purpose are shown in Figures 1 and 2 and Table 1. Our previous results showed that $ZnSO_4$ and $FeCl_3$ salts were more effective on NR enzyme activity at the beginning of ontogenesis than NaCl and Na_2SO_4 in the concentration range of 50-100 mM in cotton roots and leaves (results not given). Therefore, in the current work, we continued the study at salt concentrations of 50 and 100 mM, taken as optimal, and irradiation doses of 50 and 100 Gy.

For this purpose, we compared the activity of NR and CA enzymes in the leaves and roots of cotton with a C_3 photosynthesis mechanism and the activity of proton pumps localized in the root system of plants, as well as the speed of photosynthesis and assimilation of CO_2 in leaves under the influence of chlorine and sulfate salts of different composition. was analyzed. In the end, the perspectives of using the obtained results in the breeding of new plant species that are resistant to the effects of stress and marker properties were discussed.

Figure 1 shows the dynamics of changes in the activity of NR enzyme depending on the doses of γ-radiation (K, 5, 10, 50, 100, and 200 Gy) and the stages of ontogenesis in the roots and leaves of cotton plants grown in different concentrations (K, 5, 10, 50, 100 and 200 mM) of different types of salts (NaCl, $FeCl_3$, Na_2SO_4, $ZnSO_4$). If we pay attention to Figure 1A, we can see that the activity of NR increases in all stages of ontogenesis up to the dose of 50 Gy, at the next doses (100 and 200 Gy), the activity of the enzyme begins to decrease first weakly and then rapidly, and in the maturation phase, it decreases more than in the remaining phases. At this time, the greatest decrease was observed in the KL and BD phases.

The results obtained during the effect of different concentrations of NaCl, $FeCl_3$, Na_2SO_4, and $ZnSO_4$ on NR activity are shown in Figure 1B, 1C, 1D, and 1E, respectively. As can be seen from the figures, NR enzyme showed the highest concentration at 50 mM concentration of each salt. Therefore, in our subsequent work, we specified the dose limit and continued our work by taking only concentrations of 50 and 100 mM.

As can be seen from the figures, the NR enzyme showed the highest activity at concentrations of 50 mM and sometimes close to 100 mM in BP and FP stages in each variant (Figure 1 A, B, C, D, E).

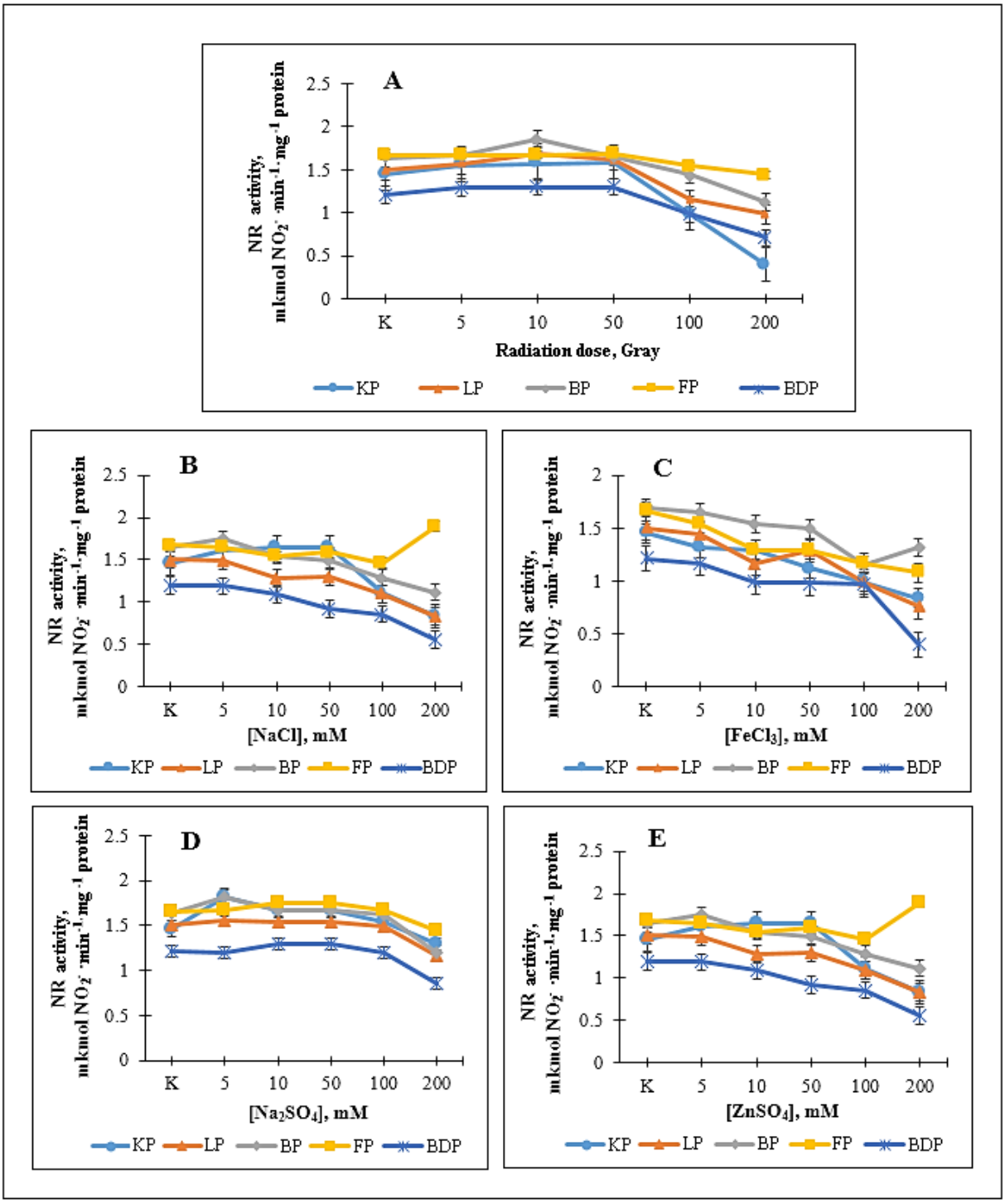

Fig. 1. Effects of radiation, chlorine, and sulfate salts on the dynamics of change of NR enzyme activity in cotton plant ontogeny. A - radiation, B - $FeCl_3$, C - NaCl, D - Na_2SO_4, E - $ZnSO_4$

$FeCl_3$ and $ZnSO_4$ also affect the absorption of mineral nutrients by roots. We found that in the first stage, in the presence of 50 mM $FeCl_3$, the amount of absorbed NO_3 increased by

~127.5%, PO_4^- by only ~22.4%, and Ca^{2+} by ~67% compared to the control. In this context, the amount of mineral elements absorbed by cotton roots in the presence of 50-100 mM $ZnSO_4$ is higher than that of 50 mM $FeCl_3$ (Results not given).

Our previous results show that the intensification of root elongation occurs in the early periods of cotton plant growth and development. In the conditions of nitrogen deficiency, metabolism in plants weakens, as the synthesis of nitrogenous substances, as well as other constituents, weakens, there is observed a decrease in the biometric indicators of terrestrial organs.

The obtained results show that in the presence of Cl^- and SO_4^{2-} salts, their concentrations of 50 mM (Cl^-) and 50-100 mM (SO_4^{2-}) increase the activity of nitrate reductase and the number of proteins, as the metabolism in the root system and terrestrial organs of plants, is accelerated. This increase has an adaptive property by accelerating synthesis processes in the organs of the cotton plant.

We have determined from our previous experiments that chlorine and sulfate salts, regardless of their composition, have a more regulatory effect on the intensity of photosynthesis and the number of photosynthetic pigments at concentrations of approximately 50 mM. When analyzing those results, we determined that $ZnSO_4$ at a concentration of 50 mM has more effect on biometric indicators of plants, the number of proteins and pigments of photosynthesis in leaves, gas parameters, and KA activity compared to the same concentration of other salts (NaCl, $FeCl_3$, Na_2SO_4).

As can be seen from Table 1, P_n increased over time by 10.5 μmol CO_2 $m^{-2}s^{-1}$ and reached 17,4 μmol CO_2 $m^{-2}s^{-1}$ in the presence of $ZnSO_4$ in 50 mM concentration. After that, the effect of Na_2SO_4 is in the second place, NaCl is in the third place, and $FeCl_3$ is in the 4th place (Table).

Table 1

Dynamics of changes in gas exchange parameters and activity of H^+-pumps under the influence of chlorine and sulfate salts in the leaves of the cotton plant

Stage	Type	Variant	Parameters of gas exchange				The activity of the H^+-pump	
			P_n	C_i	g_s	T_r	pH	$C_{H+} \cdot 10^{-3}$
Day 10, 50 mM	Cotton	Control	10.8	233.0	0.36	1.29	3.95	0.11
		NaCl	10.6	229.0	0.33	1.29	3.92	0.12
		$FeCl_3$	10.2	227.0	0.321	1.27	3.94	0.11
		Na_2SO_4	10.9	218.0	0.27	1.19	3.90	0.13
		$ZnSO_4$	10.5	216.0	0.23	1.70	3.73	0.19
Day 20, 50 mM	Cotton	Control	14.3	243.0	0.49	1.58	3.81	0.15
		NaCl	15.1	242.0	0.46	1.56	3.81	0.15
		$FeCl_3$	14.5	241.0	0.43	1.55	3.83	0.15
		Na_2SO_4	15.9	235.0	0.37	1.51	3.85	0.14
		$ZnSO_4$	16.2	232.0	0.32	1.51	3.82	0.15
Day 30, 50 mM	Cotton	Control	16.9	246.0	0.53	1.64	4.63	0.33
		NaCl	16.9	241.0	0.53	1.64	0.55	0.55
		$FeCl_3$	16.3	236.0	0.51	1.64	0.66	0.66
		Na_2SO_4	17.01	236.0	0.51	1.63	0.56	0.56
		$ZnSO_4$	17.4	233.0	0.50	1.63	0.46	0.48

Note: P_n-the rate of photosynthesis (amount of absorbed CO_2) (μmol CO_2 $m^{-2}s^{-1}$), g_s -permeability of stomatal cells (mol CO_2 $m^{-2}s^{-1}$), C_i- concentration of CO_2 in intercellular spaces (μmol CO_2 mol^{-1}), T_r -transpiration rate (mmol CO_2 $m^{-2}s^{-1}$). C_{H+}-concentration of hydrogen ions at appropriate pH (amount), mkev/day
Accuracy indicator is less than 3%.

Different results were obtained on the amount of CO_2 in the intercellular spaces. Thus, C_i received the highest value in the control and maintained this result on the 10th, 20th and 30th days of plant development. Regarding the comparison of the effect of salts, due to the high amount of CO_2, NaCl is in the 1st place, $FeCl_3$ is in the 2nd place, Na_2SO_4 is in the 3rd place, and $ZnSO_4$ is in the 4th place. As it can be seen, $ZnSO_4$, which ranks first in terms of P_n, ranks last in terms of C_i. The change in the value of G_s was completely in accordance with that in C_i, and the intensity of T_r-transpiration occurred adequately to P_n.

Accordingly, the activity of H^+-pumps operating in the roots of the cotton plant increased adequately to P_n and T_r on the 10th and 20th days of development, and on the 30th day of plant development, it increased compared to $ZnSO_4$ in all taken salt types and concentrations (Table).

The concentration of $ZnSO_4$ at 50 mM increased gradually according to the 10th, 20th, and 30th day of cotton plant development. Nevertheless, the effect index of $ZnSO_4$ received a low value compared to the effect of other salts during the experiments.

After analyzing all the above, it can be concluded that $ZnSO_4$ at a concentration of 50 mM leads to an increase in the intensity of P_n and T_r by activating the CA enzyme in comparison with NaCl, $FeCl_3$, and Na_2SO_4. As a result, the organism is protected from the effects of stress for a certain period of time (Table; Figure 2).

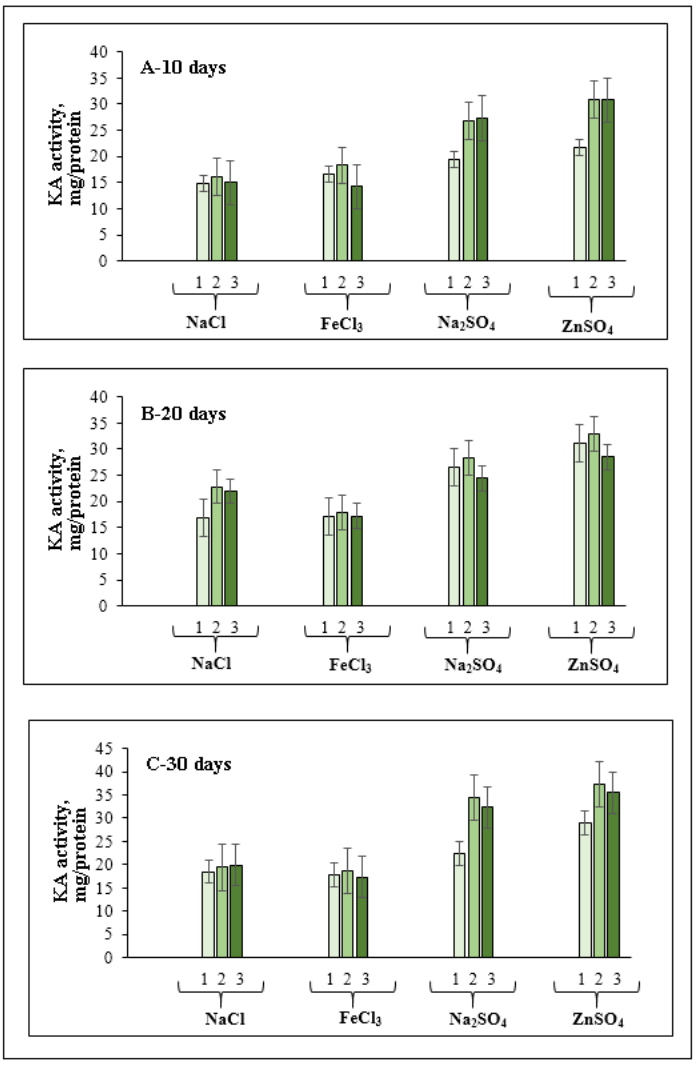

Fig. 2. Effect of chlorine and sulfate salts on the dynamics of change of CA enzyme activity in the leaves during the ontogeny of the cotton plant. 1 - control; 2 - 50 mM salt; 3 - 100 mM salt.

The active and stimulating effect of $ZnSO_4$ can be explained by the presence of Zn^{2+} ions in its composition. So, since the Zn^{2+} ion is a coenzyme of the CA enzyme, the CA enzyme localized in the root and leaf cells becomes more active in the presence of this ion and ensures the high speed of photosynthesis. At low concentrations of $ZnSO_4$, the decrease in CA activity leads to the weakening of CO_2 diffusion (Fig. 2).

It is shown in the literature that salt stress causes the closure of stomata for photosynthesis, the weakening of CO_2 diffusion due to the thickening of the mesophyll, etc. [Flexas et al., 2008].

Different ways of adaptation of organisms to external environmental factors have arisen in the process of evolution. The conducted studies show that plants can fully adapt to the environment by inducing genes responsible for some biochemical, and morpho-physiological changes while adapting to stress [Chaves et al., 2003].

Due to the accumulation of excess Na^+ and Cl^- ions in chloroplasts during salt stress, the thylakoid membranes are damaged, the amount of chlorophyll pigment is reduced due to its disintegration, in this connection, the electronic transport cycle is disrupted and photophosphorylation is inhibited [Akram, Ashraf, 2011].

The above results are closely related to the mineral nutrition of plants. From this point of view, the dynamics of changes in the activity of H^+-pumps operating in the roots over time and under the influence of various salts were considered. As can be seen from Table 1, the activity of H+-pumps increases over time under conditions where the concentration of salts does not change. The increase in the activity of the pump was completely adequate to the activity of NR and CA (Table 1; Figure 1, 2).

Iyengar and Redi show that the effect of salinity on the intensity of photosynthesis is related to 1. decreased CO_2 permeability as a result of dehydration of the cell membrane; 2. ion toxicity; 3. reduction of CO_2 concentration due to closing of stomata; 4. early cell aging and structural disorders; 5. changes in the enzymatic activity due to changes in the structure of the cytoplasm [Iyengar, Reddy, 1996].

Iyengar and Reddy effect of salinity on photosynthesis intensity reduction of CO2 permeability as a result of cell membrane dehydration; Ion toxicity; A decrease in CO2 concentration due to the closing of the mouthpieces; Early cell aging and structural disorders; They show that changes in the structure of the cytoplasm are related to changes in enzymatic activity [Iyengar, Reddy, 1996].

Since the carbonic anhydrase enzyme carries out the diffusion of CO_2 from the stomata cells and its transport to the carboxylation centers in photosynthesis, it increases its intensity by having a stimulating effect on photosynthesis. These results show that CA has adaptive properties (Figure 2).

4. Conclusion

It was determined that sulfate salts at a concentration of 50 mM have a more stimulating effect on the growth and development of cotton plants, and this effect is more intense. 50 mM $ZnSO_4$ stimulates plant growth, development, and yield by increasing carbonic anhydrase enzyme activity up to 50% compared to 50 mM NaCl, 50 mM $FeCl_3$, and 50 mM Na_2SO_4. We can consider that the intensification of the NR enzyme activity in the root and leaf, depending on the radiation dose and the concentration of salts, plays an important role in the growth and development of the plant, as well as increasing its yields due to the values of biometric indicators.

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ВЛИЯНИЕ РАДИАЦИИ И РАЗЛИЧНЫХ ВИДОВ ХЛОРНЫХ И СУЛЬФАТНЫХ СОЛЕЙ НА ДИНАМИКУ ИЗМЕНЕНИЯ АКТИВНОСТИ ФЕРМЕНТОВ НИТРАТРЕДУКТАЗЫ И УГЛЕРОАНГИДРАЗЫ В ОНТОГЕНЕЗЕ ХЛОПКА

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Резюме: В этом исследовании изучено влияние как γ-радиации в различных дозах (К, 5, 10, 50, 100, 200 Гр), так и хлорных (NaCl, $FeCl_3$) и сульфатных (Na_2SO_4, $ZnSO_4$) солей в различных концентрациях (К, 5, 10, 50, 100, 200, мМ) на динамику изменений активности ферментов нитратредуктазы (НР-аза) и карбоангидразы (КА) в корнях и листьях хлопка вида Гянджа-182 рода *Gossypium hirsitum* L. на разных этапах его онтогенеза. При этом сначала были определены оптимальные дозы и значения концентрации на каждом этапе онтогенеза растения. Далее в период бутонизации и цветения в этих дозах и концентрациях была исследована динамика изменения активности этих ферментов через каждые 10, 20 и 30 дней. Были получены впечатляющие результаты.

Ключевые слова: Gossypium hirsitum L., радиация, виды солей, активность НР-КА, адаптация

PAMBIQ BİTKİLƏRİNİN ONTOGENEZİNDƏ RADİASİYANIN, MÜXTƏLİF NÖV XLOR VƏ SULFAT DUZLARININ NİTRATREDUKTAZA VƏ KARBOANHİDRAZA FERMENTLƏRİNİN AKTİVLİKLƏRİNİN DƏYİŞMƏ DİNAMİKASINA TƏSİRİ

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Xülasə: Bu işdə γ-şüalanmanın, müxtəlif növ xlor (NaCl, $FeCl_3$) və sulfat (Na_2SO_4, $ZnSO_4$) duzlarının müxtəlif doza (K, 5, 10, 50, 100, 200 Qr) və qatılıqlarının (K, 5, 10, 50, 100, 200, mM) Gossypium hirsitum L. pambıq cinsinin Gəncə-182 növünün ontogenezinin ayrı-ayrı mərhələlərində onun kök və yarpaqlarında nitratreduktaza (NR-aza) və karboanhidraza (KA) fermentlərinin aktivliklərinin dəyişmə dinamikasına təsiri tədqiq edilmişdir. Əvvəlcə bitkinin ontogenezinin hər bir mərhələsində optimal doza və qatılıq həddi tapıldıqdan sonra həmin doza və qatılıqlarda bitkinin inkişafının qönçələmə və çiçəkləməyə hazırlıq dövründə hər 10, 20 və 30 gündən bir fermentlərin aktivliyinin dəyişmə dinamikasına baxılmış və diqqəti cəlb edən nəticələr alınmışdır.

Açar sözlər: Gossypium hirsitum L., radiasiya, duz növləri, NR-KA aktivliyi, adaptasiya