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Plant Physiology

Influence of unfavourable natural factors and pollutants on the complex of tomato photosynthetic pigments

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The influence of unfavourable natural factors and pollutants on the complex of tomato photosynthetic pigments was investigated at the Physiology Laboratory of LIH. It was established that lead stops and copper stimulates synthesis of pigments at medium temperatures. No negative influence of lead on the amount of pigments in tomato leaves was revealed at low temperatures. The amount of carotenoids in tomato leaves remained more stable under more intensive competition and at low temperatures. Substrate of higher acidity had no significant effect on the amount of pigments in tomato leaves. Under these conditions the amount of pigments changed under the effect of density and low temperatures.

Key words: tomato, chlorophylls, carotenoids, low temperatures, Cu, Pb, acidity, density

INTRODUCTION

In recent decades environmental pollution has become a very important factor, which strongly influences the state and development of various natural communities not only locally, but also regionally or even on a world scale [1]. Lately more and more attention is given to investigations of growth and development of cultured plants [2–4]. In nature, the intensity of organism's vital reactions are influenced by several factors at a time, therefore if conditions are insufficient with respect to one of the external factors, the interval of individual tolerance of other factors gets narrow [5]. When environmental pollution increased, investigations of the influence of complex natural and antropogenic factors on living organisms took particular importance. These investigations showed directly and indirectly that under the influence of pollutants as an additional stress plant resistance to unfavourable natural factors decreased, *i.e*. their range of tolerance to temperature, humidity, etc. narrowed [6–8]. Other authors point out that in some cases resistance of live organisms to natural factors can increase under the influence of pollutants [9–10]. In complex investigations of the effect of various factors on plants, one of the main parameters can be photosynthesis and the amount of pigments in leaves, determining its intensity [11–13]. A complex of chlorophylls and carotenoids is the basic for a chain of electron transport binding energy of light quanta in photosynthesis. Thus, amounts and relations of these pigments cannot be limiting factors for normal photosynthesis.

The objective of this work was to establish the influence of unfavourable natural factors and pollutants on a complex of tomato photosynthetic pigments.

MATERIALS AND METHODS

The object of investigations was tomato (variety *Svara*) grown to 8^{th}–9^{th} stages of organogenesis (according to F. Kuperman [14]) at the Physiology Laboratory of LIH. Tomatoes with the first true leaf were transplanted to tumblers (52 x 34 x 15 cm) with different density (from 6 to 340 plants/m^2) in three replications. Investigations of pigments in tomato leaves were carried out in variants, where plant density was 160 plants/m^2 and 35 plants/m^2 at a medium temperature and 160 plants/m^2 and 50 plants/m^2 at a low temperature. Tumblers were laid out on the principle of "Latin square" in the greenhouse.

The first trial stage lasted 41 days. After that, part of tumblers were transferred to chambers of a phytotron for estimation of the effect of low temperatures on tomato growth. Temperatures were being decreased for three days until the average day temperature became +8.5 °C (10 °C day; 7 °C night). The photoperiod was 14 h. In the second stage of the trial, tomato which grew at different temperatures (in the greenhouse the average was +20 °C, in the chambers of phytotron +8.5 °C) were watered: 1) with solution of H_2SO_4 with pH 3 (3 l for one tumbler) to estimate the influence of substrate acidity; 2) solution of 0.3 mM $Pb(NO_3)_2$, which corresponded to the amount of 10.3 mg(Pb)/kg (0.3DLK), and 3) with solution of 0.4 mM $CuSO_4 \cdot 5H_2O$, which corresponded to the amount of 4 mg(Cu)/kg, for estimation of the influence of heavy metals. The amount of chlorophylls and carotenoids in green leaves was established by the colorimetric method in a 100% extract of acetone according to Wetshtein [15].

RESULTS AND DISCUSSION

How substrate acidity and heavy metals influenced the amount of pigments after 10 days is seen in Fig. 1. Tolerance of pollution with heavy metals with respect to accumulation of pigments shifted to the positive side under less competition. Moreover, in sparse seeding copper stimulated accumulation of pigments, meanwhile the density of plants had no influence on this feature in acid substrate.

The same investigations were carried out 24 days later. They showed (Fig. 2) that in general the trend was the same as after 10 days, only a more negative impact of Pb was revealed. Generally, processes of chlorophyll synthesis slowed down, meanwhile the amount of carotenoids did not under more intensive

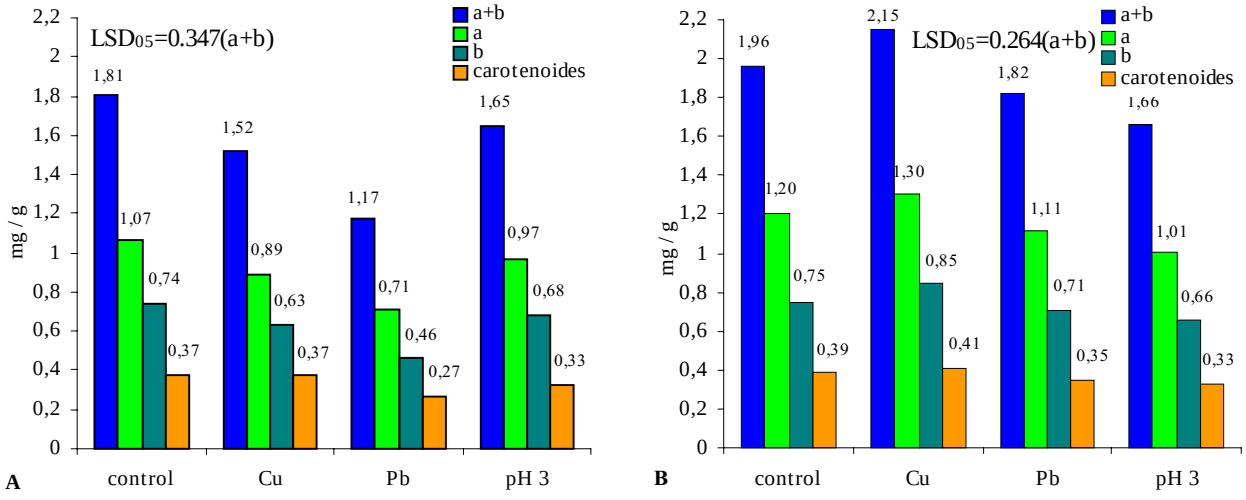

Fig. 1. Effect of heavy metals and acidity on the content of pigments in tomato leaves at medium temperatures (D/N 23/16 °C) after 10 days of exposure. **A** – density 160 plants/m^2, **B** – density 35 plants/m^2

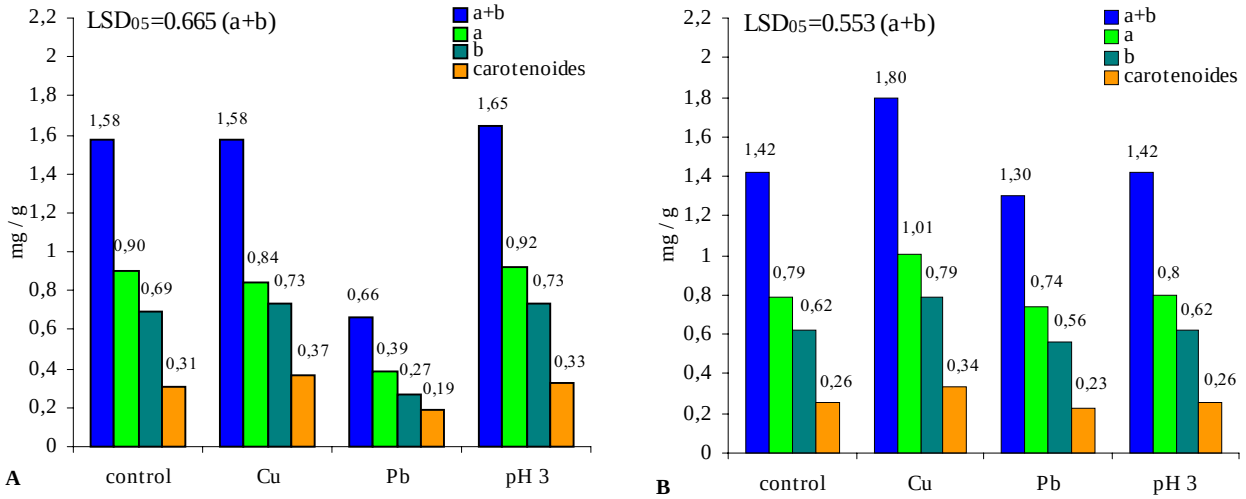

Fig. 2. Effect of heavy metals and acidity on the content of pigments in tomato leaves at medium temperatures (D/N 23/16 °C) after 24 days of exposure. **A** – density 160 plants/m^2, **B** – density 35 plants/m^2

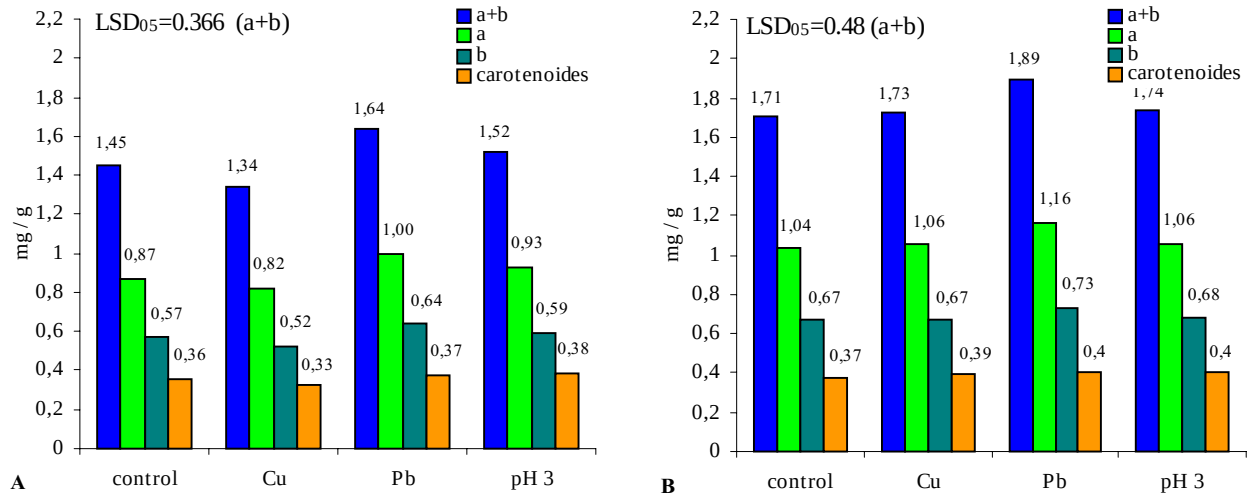

Fig. 3. Effect of heavy metals and acidity on the content of pigments in tomato leaves at low temperature (D/N 10/7 °C) after 10 days of exposure. **A** – density 160 plants/m^2, **B** – density 50 plants/m^2

competition in variants with Cu and with higher acidity, and in control it changed insignificantly. The amount of carotenoids in tomato leaves under less competition in these variants slowed down quicker.

Data in Fig. 3 show that pigments accumulated in tomato leaves in significantly lower amounts at a low than at a medium temperature. No negative influence of lead was established at low temperatures, though this factor of pollution was the inhibitor of pigments at medium temperatures, maybe because of a slower metabolism and digestion of water and other materials in these conditions, so that only a small amount of lead could get into a plant and did not inflict great injury on the process of pigments synthesis. Other wise the conformity was similar as under medium temperatures.

After two weeks (Fig. 4) the amount of chlorophylls in tomato leaves decreased by about one third in all variants under low temperatures. Other authors also established a similar influence of low temperatures on the amount of chlorophyll in plants leaves [12, 13]. The tendency of influence of other pollutants on the amount of chlorophyll in tomato leaves remained similar as after 10 days. At low temperatures, also, the amount of carotenoids in tomato leaves changed little under the influence of pollutants under more intensive competition.

Summarizing, it is possible to affirm that lead stopped the synthesis of chlorophylls, especially chlorophyll a, at medium temperatures, therefore plants affected by this metal accumulated less chlorophylls. Copper, on the contrary, stimulated synthesis of both

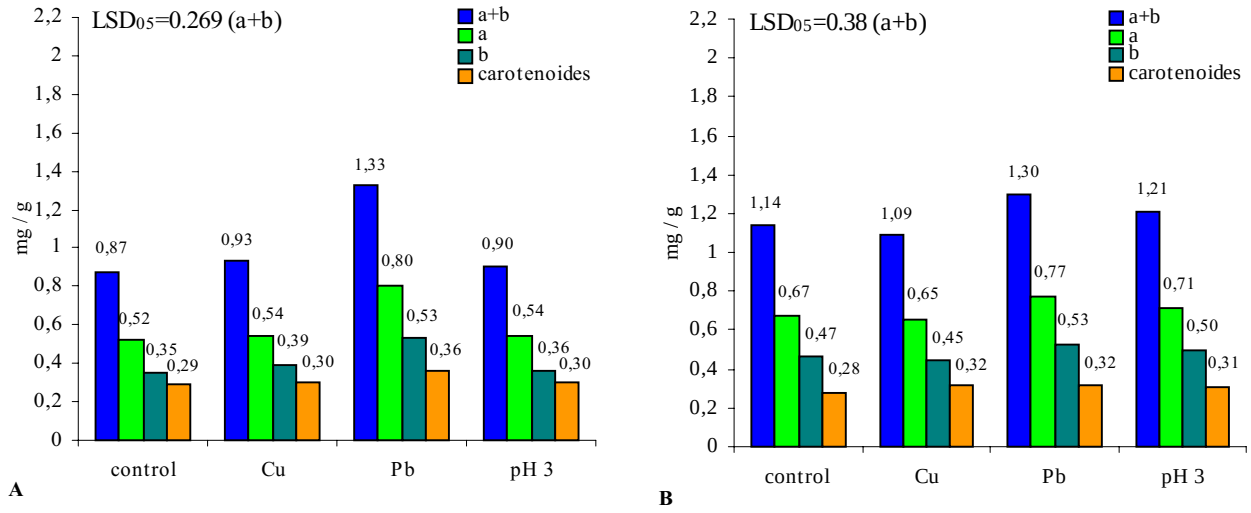

Fig. 4. Effect of heavy metals and acidity on the content of pigments in tomato leaves at low temperatures (D/N 10/7 °C) after 24 days of exposure. **A** – density 160 plants/m^2, **B** – density 50 plants/m^2

chlorophylls, especially of chlorophyll a. The amount of carotenoids in tomato leaves changed little under the influence of Cu. In these conditions copper acted as a microelement improving the synthesis of pigments. According to findings of Gedz [11], the content of chlorophylls, chlorophyll a in particular, in potato leaves increased 1.5-fold under the influence of copper.

No negative influence of pollutants on the content of pigments in tomato leaves was observed at low temperatures. Under these conditions destruction of pigments occurred in control. Generally, the amount of carotenoids in tomato was found to remain more stable in dense seeding under the influence of pollutants and low temperatures. Maybe the fluctuation of their amount with changes of the environmental factors, could be one of the indices of stress resistance.

CONCLUSIONS

1. Lead stops and copper stimulates the synthesis of pigments at medium temperatures.

2. No negative influence of lead on the amount of pigments in tomato leaves was revealed at low temperatures.

3. The amount of carotenoids in tomato leaves remained more stable under more intensive competition and under the influence of low temperatures.

4. Substrate of higher acidity had no significant influence on the content of pigments in tomato leaves. The amount of pigments in them changes because of density and low temperatures.

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NEPALANKIŲ GAMTINIŲ VEIKSNIŲ IR TERŠIANČIŲ MEDŽIAGŲ POVEIKIS POMIDORŲ FOTOSINTETINIŲ PIGMENTŲ KOMPLEKSUI

S a n t r a u k a

LSDI Fiziologijos laboratorijoje tirtas teršiančių bei nepalankių aplinkos veiksnių poveikis fotosintetinių pigmentų kompleksui pomidorų lapuose. Nustatyta, kad vidutinių temperatūrų sąlygomis švinas stabdė pigmentų sintezę pomidorų lapuose, o varis skatino. Žemų temperatūrų sąlygomis švinas skatino chlorofilų sintezę. Karotinoidų kiekis pomidorų lapuose išliko stabilesnis intensyvesnės konkurencijos sąlygomis ir veikiant žemoms temperatūroms. Didesnio rūgštingumo substratas pigmentų kiekiui pomidorų lapuose didesnės įtakos neturėjo. Šiomis sąlygomis pigmentų kiekis kito dėl tankio ir žemų temperatūrų.