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THE RESPONSE OF DIFFERENT PLANT LIFE FORMS TO NATURAL ENVIRONMENT CHANGES

This paper contains test results revealing norm and stress reactions of various life-form plants: trees — Betula pendula Roth, Tilia platyphyllos Scop., Pinus sylvetris L; water-plant -Galium palustre L.; grass — Solidago Canadensis; cereal — Secale cereale L. Collection and processing of the material was made in the area of Berlin/Brandenburg, Germany. Clark sensor-based method made it possible to determine the amount and rate of the oxygen evolution by plants in the dark and light phase.

Under the reaction norm the average amount of the oxygen evolved and the average rate of metabolism processes during dark and light phases are changing simultaneously. Parabolic and periodic dependences of these changes during the vegetation period has been found. Under the stress reaction (drought, illness) the rate of metabolism dark reactions is increased by 2—3 times as compared with light reactions. The obtained results may be use for bioindication of the climate change in the Baltic Region.

Key words*:* oxygen, photosynthesis, bioindication, stress, norm.

Introduction

The physiological process is conditioned by a number of environmental factors which determine the biosystem response to stress. It is known that biosphere can have both rapid response, for example to drought, and slow response, when changes are accumulating [1].

Indication of the living system state in terms of time makes it possible to discover survivability of the biosystem during phenological stages with ongoing changes in the environment surrounding this system. Photosynthesis is a cumulative and dominant physiological process in the plant. Oxygen evolved in the course of the photosynthesis is an indicator of organelles and plant cells response to external and internal changes, its seasonal rhythm within the vegetation year is a result of the organism adaptation of many years.

Research methods

The photosynthetic activity was assessed on the basis of oxygen evolved by a photosynthetic plant (by cells containing chloroplasts) in dark and light phase with the help of Plant Vital 5000 device, which works on the basis of Clark sensor. To estimate photosynthetic activity the following measurable parameters were applied: 1) R (mg/l*s) — oxygen evolving activity rate during the dark phase; 2) S (mg/l*s) — oxygen evolving activity rate during the light phase between the minimum and maximum points; 3) N_av (mg/l) — average amount of the oxygen evolved during the light phase from the minimum moment for the period of 600 sec. Analysis and visual representation of the measurements was carried out with the help of Plant Vital, Excel and Word software.

The first experiment. The objective: to discover natural vegetation process of changes in optimal environment taking into account the sampling method, temperature, and age. The experiments were carried out in July of 2006 and

July 2007. The measurement conditions were as follows: a constant object under observation — one detached tree or one plot for collecting a meadow plant; permanent location for getting material from the plant. The age of plant was identified by a method developed for the forest zone of Russia [2].

Two methods were used for sampling and measurement. In the first case, a bit of the photosynthetic material was cut out from a plant leaf or needle, put on the sensor and fixed by a cuvette. The measurements were performed in a growth chamber at temperatures of 15, 25, 35 °C, light absorption wave of a length of 630—650 nm. In the second method, a clamp was used and measurement was performed in the wild in the daylight.

The measurement relating to trees of different ages (*Betula pendula Roth*) were performed with the help of the first sampling method.

The second experiment. The objectives: to identify the natural vegetation course of reactions in plants of different life forms and its changes under stressing environmental factors. To reveal the natural background measurements were performed within the vegetation period of 2006 (May-November). Sampling was conducted with the help of the first method. In the course of research activities the following cases were noticed: ground fire under birches and damage of the lime tree by *Cercospora microsora*.

The age of trees was estimated with the help of the above-mentioned method. The average diameter growth of the birch for ten years makes up 1—2 cm, for the lime tree — 5—6 cm, for the pine — 2—3 cm at the height of 120 cm. The trees of 28, 38 and 53 cm were measured. The diameter, 9, 12 and 17 cm respectively, was calculated according to the circumference. The trees were about 45, 19 and 56 years.

Oxygen evolving activity of plants and optimal conditions

Conducting of this experiment makes it possible to discover and estimate reaction of plants to the method of taking samples, the temperature factor, and age.

Three measurements were performed for each variant of the experiment conditions. The variants were as follows: air temperature (using the clamp), 15, 25 and 35 C temperature (using the growth chamber).

The material contact in the clamp is less tight than in the cuvette. In the clamp variant with no material damaged the results shown in (fig. 1) give allow making a conclusion that R and S parameter values are equal or close to each other. In the growth chamber variants the least difference between R and S parameters is revealed for the following temperature conditions: *Betula pendula Roth* 15—25 C; *Solidago canadensis* 25—35 C; *Secale cereale L* 25—35 C; *Galium palustre L.* 25—35 C; *Pinus sylvestris L.* 25 C. In the case of growth camera at a temperature of 25°C, *Betula pendula Roth* trees of different ages — 14, 25, and 45 years old — exhibit similar reactions (fig 2).

Thus, the conditions with no damage of the plant are characterized by minimum values of R, S and N_av as compared with the variants where samples were taken by means of removing the material from the plant. When taking a sample with a clamp R and s parameters are close in values. The optimum for plants researched in the growth chamber variants, where the minimum difference in R and S parameter values was registered, was obtained for the variant with 25 C temperature. The values of photosynthesis activity are the nearest in the trees of the age of 25 and 45.

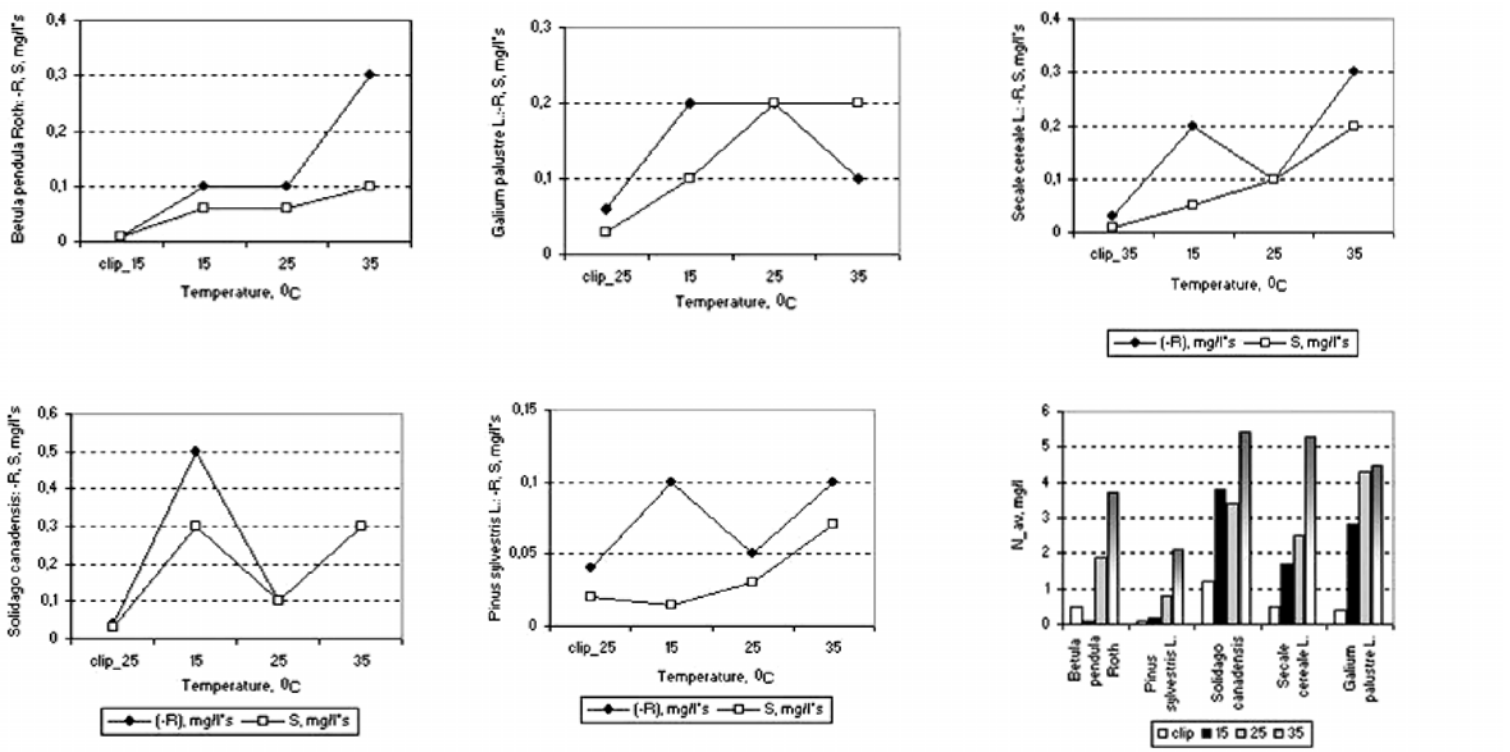

Fig. 1. Changes of the average values of the R, S, N_av parameters during the realization of the measurements with the clip under air temperature and with the cuvette under the temperatures in the climatic chamber are 15, 25, 35 0C. The measurements were made: Betula pendula Roth — 04.06.06; Solidago canadensis — 06.06.06; Secale cereale L — 08.06.06; Galium palustre L — 11.06.06; Pinus sylvestris L — 13.06.06

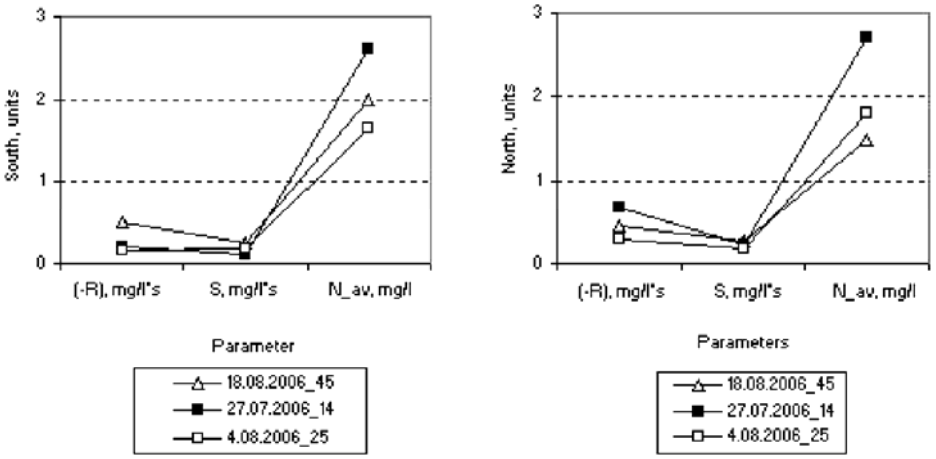

Fig. 2. Changes of the average meanings of the R, S, N_av parameters during the realization of the measurements from the northern and the southern part of the trees of different age by *Betula pendula Roth*

Seasonal oxygen rhythms of plants and environment stress factors

Conducting of this experiment is relevant at this time in terms of monitoring the current state of biosystems as part of the environment in order to update local scenarios of biosystems' reaction and local rhythms in nature. The experiment included species observed in phenology and more climate-sensitive [3].

Betula Pendula Roth. Measurements were started at the phenological blooming stage; they are shown in figure 3. The variation of mean values of R, S and N_av parameters in time is simultaneous except for R parameter for the northern part of the tree on August 1, 2006. These measurements were taken after the ground fire which happened at the northern side of the tree. The rate of reactions evolving oxygen during the dark phase (R) increases by 2—3 times as compared with light reactions (S). Distribution of mean values of the analyzed parameters R and S records increase of metabolism rate in spring and autumn periods from 0,4 to 0,7 mg/l*s; in summer it becomes stable within the range of 0,15—0,25 mg/l*s. Parabolic dependence of changes in mean values of R and S parameters during the vegetation period (5 days of measuring) is also typical for N_av parameter with maximum values from 4 to 5 mg/l in spring and autumn, and from 1 to 2,5 mg/l in summer.

Tilia platyphyllos Scorp. Within the vegetation period there were 3 days of measuring which is illustrated by figure 4. The first measurement, on the 18th of May, was taken at the blooming stage. The last measurement — 15th

of August was performed when the tree got ill and leaves were attacked by *Cercospora microsora.* At the beginning of September the leaves fell off. The analysis of these measurements shows that on the 6th of July when no damage of the leaves was observed, S parameter decreased and R parameter increased. The measurements conducted on August 15 (leaves damaged) shower a greater variation in the initial R and S parameters. The metabolism rate increase in dark and light phases gives reasons to say that these processes are stimulated and premature aging takes place. The change of mean values of S and N_av parameters within the vegetation period is described with parabolic dependence.

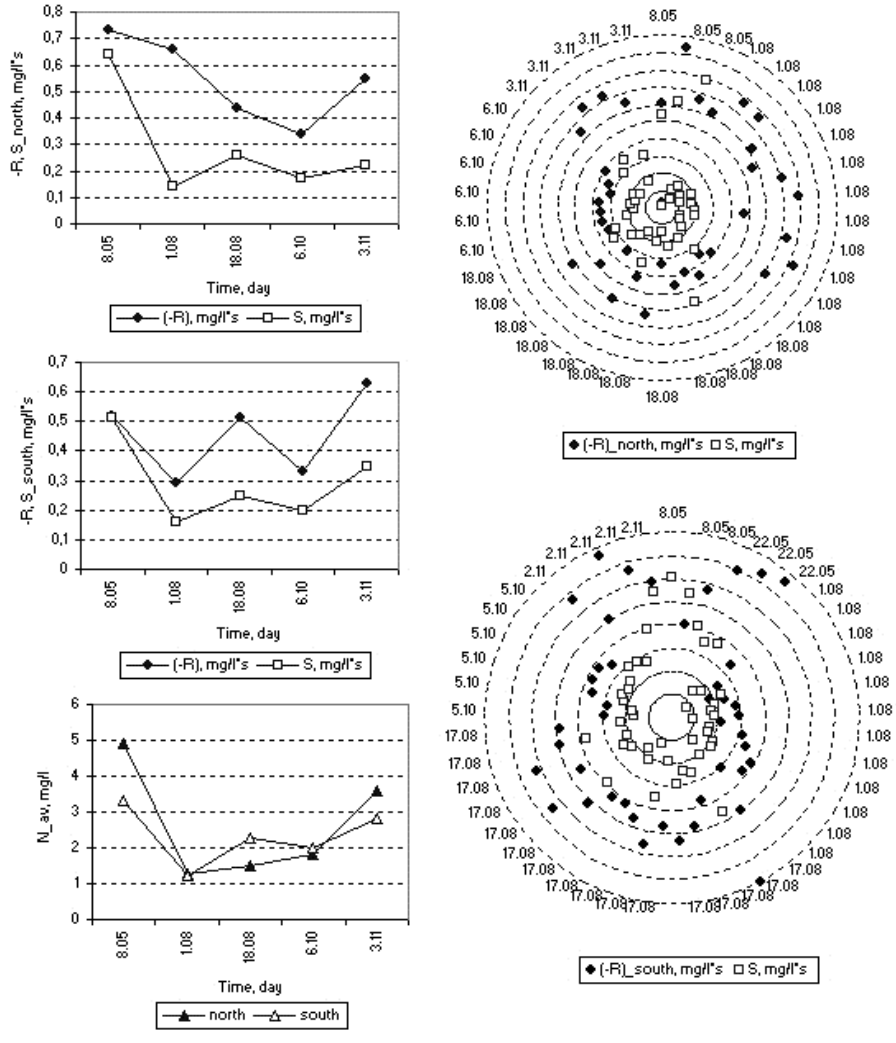

Fig. 3. Betula *pendula Roth.* Changes in time of the average and initial meanings of the R, S, N_av parameters, for the northern and the southern part of the tree

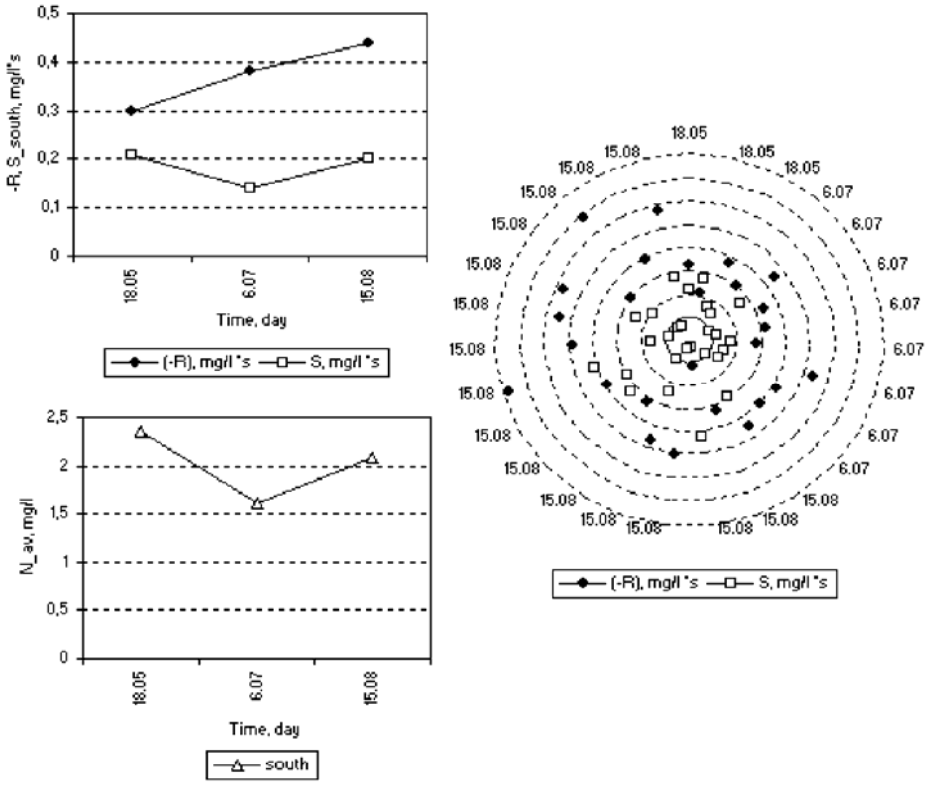

Fig. 4. *Tilia platyphyllos Scorp.* Changes in time of the average and initial meanings of the R, S, N_av parameters, the southern part of the tree

Pinus sylvestris L. Measurements were started at the shoot growing phase, there were 3 days of measuring within the vegetation period. The results are reflected in figure 5. R and S parameters obtained for the northern side of the tree are characterized by values close to 0, 15 mg/l*s in spring. In summer S parameter values go down to 0, 05 mg/l*s, dark process rate values according to R parameter remain at the spring level. In autumn R parameter values increase twofold and S parameter keeps going down. The results of R and S parameters obtained for the southern side of the tree are described with parabolic dependence. Similar mechanisms of changes in time for the northern and southern sides of the tree are also displayed in N_av parameter. Light reaction rate decrease (S) at the northern side of the tree was accompanied by the decrease of oxygen amount evolved (N_av). Increase of R values with respect to S by 203 times makes it possible to register a stress reaction for the northern side of the tree.

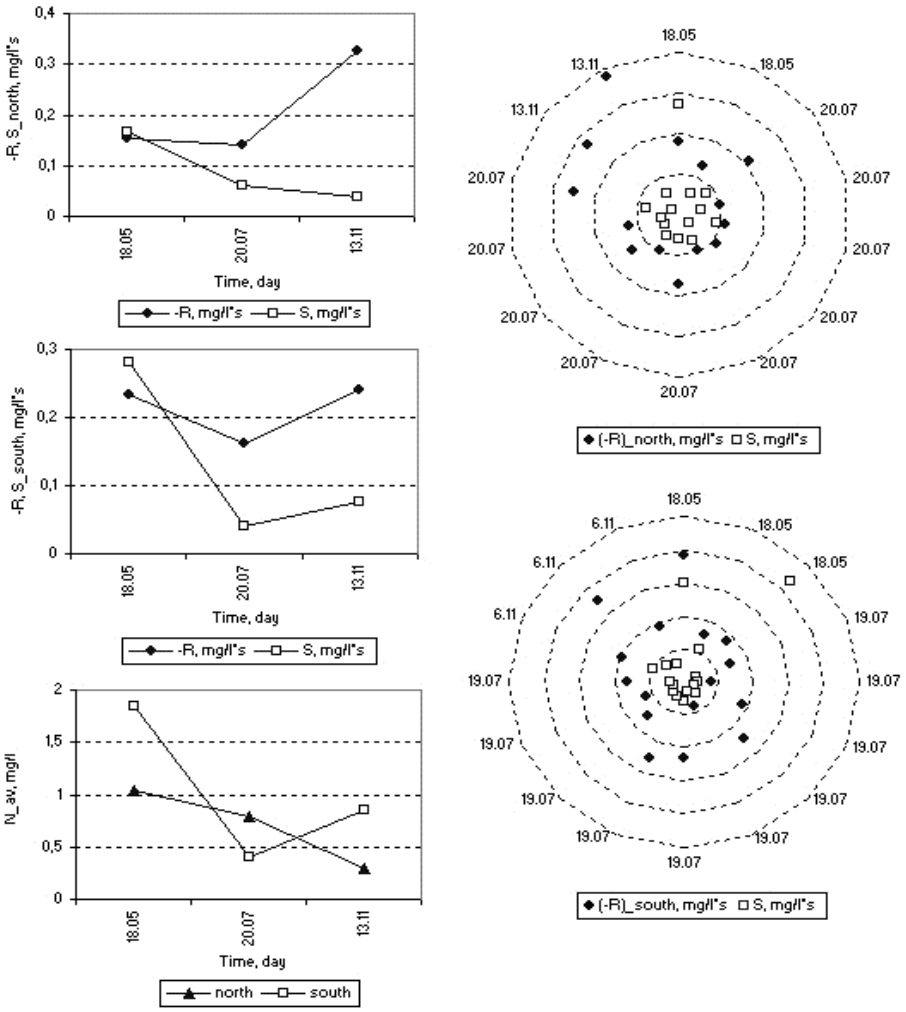

Fig. 5. *Pinus sylvestris L.* Changes in time of average and initial meanings of the R, S, N_av parameters, the northern and southern part of the tree

Solidago canadensis. Measurements were started at the beginning of Canadian goldenrod vegetation (fig. 6); there were 5 days of measuring. S and N_av parameter changes in time are coordinated and described with periodic dependence. At the beginning of the vegetation period and after the blooming stage parameter values increase. The opposite tendencies are typical for R parameter at the beginning and ending of the vegetation period which allows to register a stress reaction. In compliance with initial values in these stages we record increase of the oxygen evolving activity rate in dark reactions by 2—3 times. The same result is characteristic for the blooming stage.

The first experiment results make it possible to speak about changes in mean values of R, S and N_av parameters within the vegetation period: it is described with parabolic dependence for trees; for meadow perennial plants

periodic dependence was obtained. It is ascertained that under reaction norm the group of plants considered is characterized by simultaneous changes of R, S and N_av parameter values; S and R parameters have almost the same value. Stress reaction takes place with R parameter increasing by 2—3 times with respect to S parameter and S and N_av parameter changes in time are concordant. Ground fire caused random stress reaction followed by rapid adaptation. In case of the lime tree drought must have become a directed stress factor leading to the damage of leaves and early leaf fall.

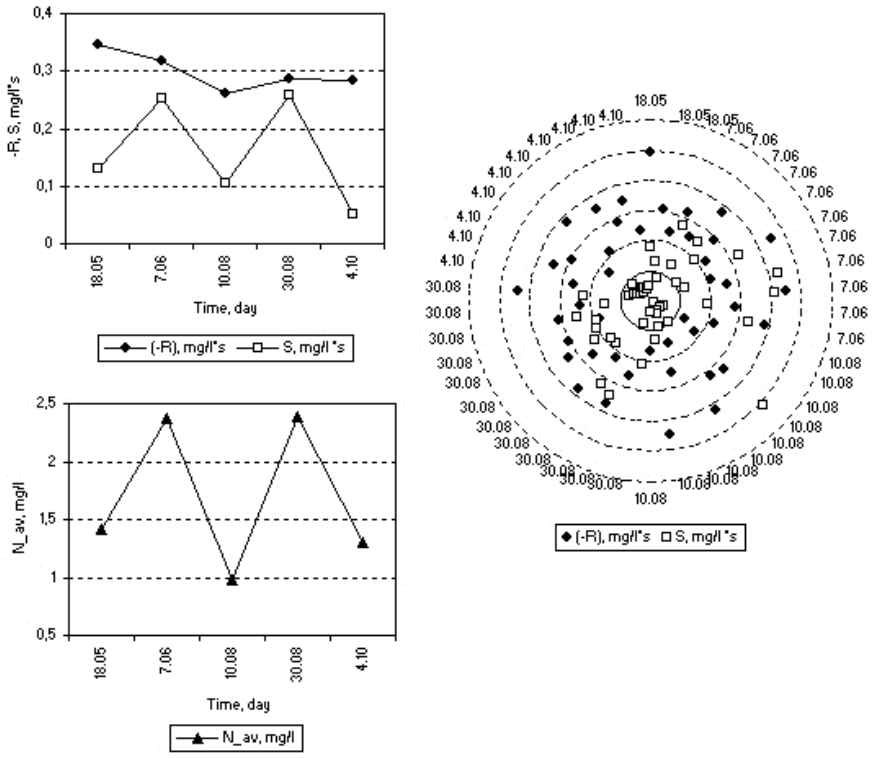

Fig. 6. *Solidago canadensis*. Changes in time of the average and initial meanings of the R, S, N_av parameters.

Discussion of the results

The temperature optimum for the plants exhibiting the minimum range of R and S parameters is 15—25 C. This ecological temperature optimum is between average values and absolute temperature maximum for Berlin-Dahlem which is shown in table 1.

Modern tendency for air temperature increase sets local variations of climate [1; 4]. Such climate variation becomes a stress factor for detached trees in mid-summer (*Betula pendula Roth, Tilia platyphyllos Scop., Pinus sylvestris L.),* and moreover we register increase of oxygen evolution rate in dark reaction by 2—3

times as compared with light reaction (R › S). In case of water plants (*Galium palustre L.)* temperature rise can stimulate synthesis processes (R ‹ S).

The air temperature in ^{0}C in Berlin-Dahlem, May — November, (Heise, 2006). The average meanings: A — 1961—1990, B — 1991—2005; the meanings of absolute maximum: C — 1961—1990; the meanings of absolute minimum: D — 1961—1990.

	M	J	J	A	S	O	N
A	13,5	16,7	17,9	17,2	13,5	9,3	4,6
B	14,3	16,8	19,1	18,8	14,2	9,3	4,3
C	33,2	35,0	37,8	37,7	34,2	27,5	19,5
D	-2,9	0,8	5,4	4,7	-0,5	-9,6	-16,1

The research presents a number of the experiments making it possible to carry out bio-indication of the environment considering norm and stress reaction of plants, time of taking a sample, age of plants, temperature factor and method of taking samples.

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