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PHENOLIC BIOCHEMICAL PATHWAY IN PLANTS CAN BE USED FOR THE BIOINDICATION OF HELIOGEOPHYSICAL FACTORS

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Abstract. The ecological significance of secondary plant metabolites of phenolic structure in adaptation of boreal plants to environmental changes induced by definite geophysical events or processes is considered. According to results obtained, the total flavonoids in some indicative plant species can be used as a geophysical factor dependent bio indicator for either monitoring background natural environment or assessment of biological effects of the industrial electromagnetic emissions.

Introduction

The further development of the ways of informative monitoring and assessment of the suggested biological effects caused by diversity of geophysical factors induced in turn by solar activity or galactic processes dictates needs in control of at least the key physiological processes running in the dominant plant organisms which create the architecture of terrestrial ecosystems in subarctic and the required base for various food webs of higher levels. The environmental changes can produce the definite adaptive changes in ordinary biochemical pathways in a plant organism some of which may be of special interest for environmentalists and be practically used as a bio indicator system. Our results and other available data allow one to state that some secondary polyphenolic metabolites in plant can be used as useful and very sensitive tool for the reliable ecological bio-indication (Borman and Teramura, 1993; Kashulin *et al*., 1999; Zhiboedov *et al*., 1999). In spite of the findings that both proteins and polyphenols may be originated from the same precursors, it was found that the definite environmental events or processes can induce the triggering of the protein synthesis on to the phenolic pathway. The triggering occurs via biochemical bifurcation mechanism without any supplement external energy consumption and might result in the 10-15 fold change of polyphenols original basal level that in turn underlie the sensitivity of such reactions to external influence. The sensitivity provide the required experimental base for the background monitoring of the physiological state of the plant organism. It is known that the living organisms in natural environment are periodically undergone by effects of some bio-active weak environmental abiotic climatic and geophysical factors. The general significance of the definite geophysical and heliogeophysical or galactic events or/and processes for biological systems with the accent on temporal and cyclic aspects is the matter of BIOCOS (The BIOsphere in the COSmos) project supervised by F. Halberg and G. Cornelissen. Earlier, we have initiated the application of these chronobilogical approaches for the bio-systems located in auroral and polar cap zones in the northern hemisphere (Kashulin and Roldugin, 2000) where the typically enhanced mean ground level of geomagnetic, solar, galactic proton rays and other activities take place. The ecological significance of the geophysical factors on the long-tern temporal scale for the northern ecosystems should be really evaluated in terms of specific *ad hoc* and sufficiently sensitive to expected effects bio-sensor objects. It is known that the enhanced levels of physical factors, for instance, UV-radiation may result in several structural and functional modifications in plants. Among a whole plethora of plant responses on UV rays and other physical factors there are common and non specific ones which can specifically trigger the alternative biochemical pathways which are as follows: the increased synthesis of UV absorbing compounds, such as flavonoids and other polyphenols, with protective functions, the generation of oxygen activated forms species simultaneously with activation of photo-reactivation systems and defensive mechanisms on the basis of synthesis of antioxidants and the specific scavengers of free radicals. The enhancement in antioxidant activity with an increased UV-B component in solar radiation or some other physical effects may be considered as beneficial. Recent data suggest that changes in flavonoids composition with exposure to enhanced UV-B (280-315 nm) radiation can, in some plant species preferentially result in a shift towards major antioxidant compounds (Borman, and Teramura, 1993; Cen 1993; Borman *et al*., 1997; Olsson *et al*., 1998).

Here we consider the possibility to use one kind of plant phenolic constitutes, namely flavonoids, as a possible sensitive integral index to monitor the terrestrial background long-term geophysical effects caused by the enhanced fluctuations in solar activity or any others external sources and their significance in adaptive reactions in some subarctic alpine forest-tundra plants.

The biological role of possible effects of the abrupt sudden changes in solar activity and respectively induced disturbances in global atmospheric processes in the long-term existence which are typically greatest at high latitudes has been poorly understood until now. Earlier, it had been shown that the multiannual year-to-year dynamics of perennial plant species survival in the Kola subarctic (Kashulin *et al*., 2000), annual bio-mass stem increments in coniferous species (Raspopov and Shumilov, 2000), and some medical indices in humans are supposedly modulated

by solar activity (Halberg et al., 2000; Weidahl *et al*., 2001). These and other available data suggest the cause-effects links between solar or geophysical events and responses in living organisms but the suggested physiologo-biochemical mechanisms of their reception are still to be determined.

Methods of research

In the study the standard methods of determination of total flavonoids in plants (Zaichikova et al., 1983) with slight modification according to (Zhiboedov, 1991) were used. The quantification of flavonoids was carried out via measurement of the absorption of died complex of their ethanol crude fraction (extracted from preliminary dried samples) with aluminium near 410 nm with UV-VIS P-450 lab spectrophotometer using a routine from «Sigma» as calibration standard. The total flavonoids throughout the paper is presented as a per cent fraction of the dry plant weight.

Results and discussion

The results of quantitative determination of total flavonoids in some arboreal and herbaceous plants for background long-term and diurnal monitoring are presented in fig. 1 and fig 2, respectively.

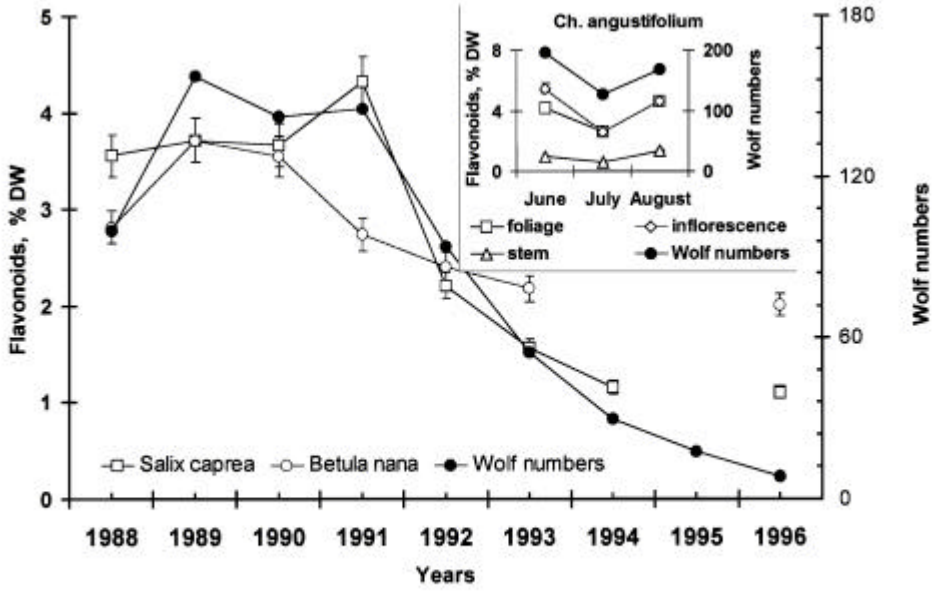

Fig.1

The results obtained show that the long-term time-course accumulation of total flavonoids in some indicator species of plants follows the definite uneven temporal patterns. In arboreal shrubs *Salix caprea* and *Betula nana* vegetated under conditions of alpine tundra region 500 m a.s.l. of Khibiny mountains environment within dominant *Ericaceae* family dwarf shrubs biocoenosis the year-to year flavonoids change is induced by Schwabe cycles in solar activity which it presented here via annual means of Wolf numbers (R) in fig. 1. The respective correlation between flavonoids accumulation and R values for *Salix caprea* and *Betula nana* was $r = 0.942 \pm 0.48$ and $r = 0.868 \pm 0.50$, respectively. The monthly mean values for this period depicted on insert for herbaceous perennial plant *Chamaenerion angustifolium*. In spite of apparent relation between the level of solar activity and flavonoids pool in considered plants the identification of the direct bio active intermediate solar-terrestrial carrier is a matter of the special supplement studies and now it is hindered by the involvement in a plant response of a wide diversity of plausible non-photic factors. The attempts to reveal some features responsible for the bio activity in relation to plants of model, artificial and natural electromagnetic fields considered as a possible intermediate carrier for the registered links were undertaken earlier (Kashulin and Pershakov, 1995; 1996). The biological activity of the industrial 50 kHz alternating current electromagnetic emission in relation to flavonoids synthesis in aboriginal *Ericaceae* plants was found earlier (Kashulin *et al*., 1999), but the data regarding the plausible effects of weak background field of natural origin are unknown so far. Further the diurnal monitoring of the time-course flavonoids accumulation in indicative species of *Vaccinium* family was carried out. The plant samples of normal population were picked out in background averaged zones within uniform biocoenosises for 24 hours in the mid July of 2000. The results of flavonoids determination are presented in fig.2. The respective diurnal pattern shows an uneven

distribution with two explicit peaks of increased flavonoids contents for the plants vegetated in remote background regions. According to our theoretical prerequisites the plausible reactions in plant organisms on the fine geophysical background environment should be at least disturbed by industrial electromagnetic effects if not completely diminished. To check out this suggestion the zones undergone the industrial electromagnetic emission of high

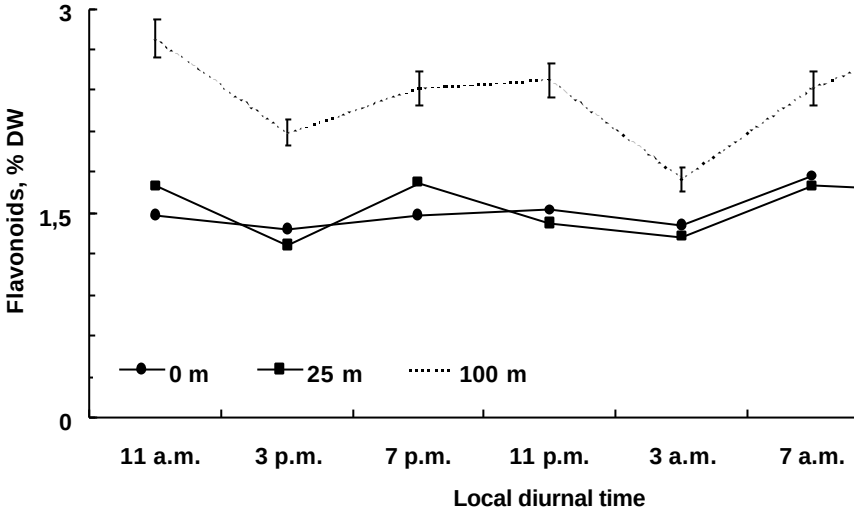

Fig. 2

voltage power lines (130 kV) and situated nearby or within the ground vertical lines projection were used. It was found that the two «morning» and «evening» (local times) peaks in diurnal distribution of flavonoids accumulation disappeared in impact zones within 100 m of industrial electromagnetic source (fig. 2). The temporal characteristics of the peaks are not unique and they were found among various biological species including humans, the fact which can supposedly be prescribed to geophysical diurnal variations.

The results presented show that the physiologo-biochemical pathways related to the environmentally dependent changes in flavonoids biosynthesis in some species of arboreal plants can be used as rather a sensitive bio-indicator system for the assessment and monitoring of geophysical and heliogeophysical factors. On the other hand, the further investigation of the biochemical aspects of intracell plant responses can provide the required basis for deciphering the underlying physiologo-biochemical mechanisms for reception of the energetically weak environmental physical cues and predict the long-term behavior of plant communities.

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