

Seasonal changes of pigments concentration in the leaves of *Vaccinium myrtillus* and *Vaccinium vitis-idaea* and the influence of industrial emissions

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Abstract

The current-year leaves of both *Vaccinium* species show a similar chlorophyll *a* level in summer, ca. 3.0 mg/g d.w., however, they differ in the earliest period of possible analysis. The *Vaccinium myrtillus* leaves showed at that time a level of ca. 6 mg/g d.w., decreasing by one half in mid June, i.e. in the period in which the fastest increase in leaf dry matter was noted. Autumn depression reaches about 20%. The pigment level in biennial leaves of *Vaccinium vitis-idaea* is rather constant and typical of the current year ones, in the triennial leaves it is lower by ca. 20%. Zinc-plant emissions influence differently the two species, both showing some defence reaction. Chlorophyll *b* level, in summer in the range of 1.6-1.9 mg/g d.w., shows seasonal changes rather similar to those of chlorophyll *a*.

INTRODUCTION

The investigations of the buffer capacity of aqueous homogenates of leaves of *Vaccinium myrtillus* and *Vaccinium vitis-idaea* collected from areas influenced by industrial emission show considerable differences between the two species (Czuchajowska, 1979). Studies on heavy metal content in *Vaccinium* species (Huttunen, 1975; Czuchajowska et al., 1980) also led to the conclusion that they accumulate metals to a different degree. It seemed, therefore, interesting to check the seasonal changes of the content of chlorophylls and carotenoids in the leaves of the two species and investigate the influence of pollution originating from a zinc-plant. This could help, in the future, to answer the question, whether the accumulation of metals in leaves of different

Vaccinium species is connected with the content and state of pigments in them. Substantial differences in the anatomy of the leaf of *Vaccinium myrtillus* and *Vaccinium vitis-idaea* and the different behaviour of these dwarf shrubs in the highly industrialised region (Buszman, Lorek, 1979) made the present authors' approach even more justified.

It is worth mentioning that seasonal changes of the pigment level and the influence of the emissions on them is so far not known for the *Vaccinium* species. Gorishina and Zabolina (1977) and Schultz (1972) investigated only the effect of shadowing on the concentration of chlorophylls and carotenoids in *Vaccinium myrtillus* leaves.

MATERIAL AND METHODS

The leaves of both *Vaccinium* species were collected from an area relatively free from industrial pollution near Kokotek, Forest District Lubliniec, and from three stands influenced by a zinc-plant at Miasteczko Śląskie. They were: the Żyglinek stand at a distance of 0.9 km north-east of the zinc-plant, Brynica I and Brynica II — 2.5 km and 5 km, respectively, to the east. They represent stands with different levels of pollution, which are always high: 2150 mg Zn/kg dry soil in the 0-5 cm layer, 2800 mg Pb/kg d.s. and 33 mg Cd/kg d.s. at Żyglinek, and respectively, 920, 1100, 16 mg/kg d.s. at Brynica I, and 130, 133 and 5 mg/kg d.s. at Brynica II. The character of the stands is typical for moist coniferous forest. The control area at Kokotek, located 24 km apart from the other stands in north-east direction, represents a stand with a much lower degree of pollution, the content of Zn, Pb and Cd being 22, 38 and 0.6 mg/kg d.s., respectively.

The year-round cycle of research started in the beginning of November 1976 and ended in November 1977. From every dwarf shrub, taken from hundred specimens randomly chosen, one shoot was collected. In the case of *Vaccinium vitis-idaea* it contained current-year, biennial and triennial leaves, in that of *Vaccinium myrtillus* — there existed only current-year leaves. After transportation to the laboratory, the leaves were torn off under dimmed light. All dead and necrotic parts were removed and the remaining material was carefully mixed; every leaf was washed with cool water in order to remove surface impurities, the same was done with the control leaves from Kokotek. The content of chlorophyll *a*, *b* and total carotenoids was determined, in 8 replications, in the leaves cut into small, ca. 1-mm pieces, according the Linder (1974) method. Faster formation of *Vaccinium myrtillus* leaves made it possible to measure their pigment content as early as

the third decade of May, whereas for *Vaccinium vitis-idaea* it was possible only a month later.

The substantial changes in water content in the leaves, particularly in the current-year ones, during the study period (the greatest change of dry matter equalled 34 and 29% of the highest value for *Vaccinium myrtillus* and *Vaccinium vitis-idaea*, respectively) made it necessary to express the content of the pigments in milligrams per 1 gram of dry weight, i.e. in relation to the dry matter of leaves, this way of presentation being most frequently used. The authors tried to avoid the error connected with expressing the pigment level in relation to the leaf area unit. In the latter case, instead of taking into consideration the material characteristic for a large area, a typical feature of every eco-physiological approach, one would have to rely on a few leaves only; also cutting the discs out of very small, young leaves would not be possible.

RESULTS

Seasonal changes of chlorophyll *a* concentration in leaves of *Vaccinium myrtillus* and *Vaccinium vitis-idaea*, together with the changes in dry matter, as dependence of air pollution, are shown in Figs. 1 and 2.

When considering the changes of chlorophyll *a* level in the leaves from the unpolluted area, one sees that in the period from July to the end of September, the current-year leaves of both *Vaccinium* species show a similar level of chlorophyll *a* concentration, about 3.0 mg/g d.w. — with ca. 10% more for *Vaccinium myrtillus* than for *Vaccinium vitis-idaea* — they differ, however, greatly in the earlier period, i.e. in May and June, in favour of *Vaccinium myrtillus*.

The newly formed leaves of the latter species show a chlorophyll *a* level of ca. 6 mg/g d.w., almost two-times higher than the mean content during the greater part of the vegetation period; an intense decrease in the extremely high starting level occurs from the third decade of May, or perhaps even earlier, till the half of June. The last possible measurements of chlorophyll *a* level before the *Vaccinium myrtillus* leaves fall prove that the pigment concentration is only by 20% lower than the mean summer value. The decrease corresponds to the period of stabilisation of the leaf dry matter, it seems therefore to be of a different character than concentration decrease observed in the earlier period.

The *Vaccinium vitis-idaea* leaves, after a temporary decrease in December, preserve the chlorophyll *a* concentration during the winter period strictly equal to the mean summer value and keep it constant

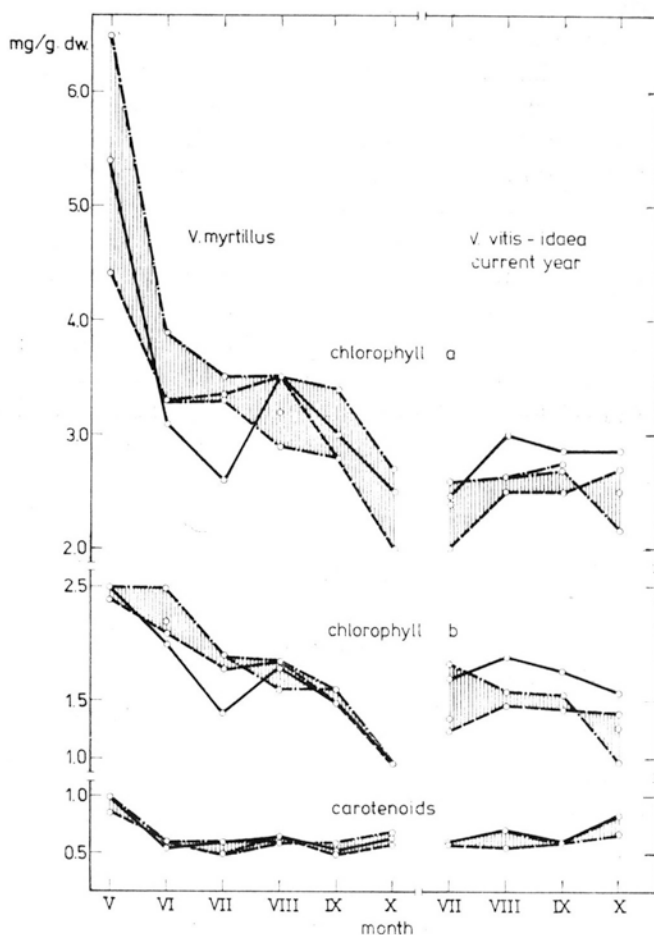


Fig. 1. Seasonal changes of chlorophyll *a*, *b* and total carotenoids in the leaves of *Vaccinium myrtillus* and in the current-year leaves of *Vaccinium vitis-idaea*; the Kokotek control stand is represented by a continuous line, Żyglinek stand by a dotted one. The dashed area contains the values for all three polluted stands, including Brynica I and Brynica II.

during the whole second year of the leaf life with the exception of the spring period (May) when a temporary decrease, by ca. 30%, occurs. It is compensated, to some extent, by the increase in dry matter. During the third year, in general, the leaves contain by 10% less of the pigment than the biennial ones and the spring depression, although it does not become deeper, lasts almost three months.

The influence of pollution on the chlorophyll *a* level also was different in the not injured leaves of *Vaccinium myrtillus* and *Vaccinium vitis-idaea*. The intensification of pollution increases its mean concentration in *Vaccinium myrtillus* during early summer, by ca. 20%, but

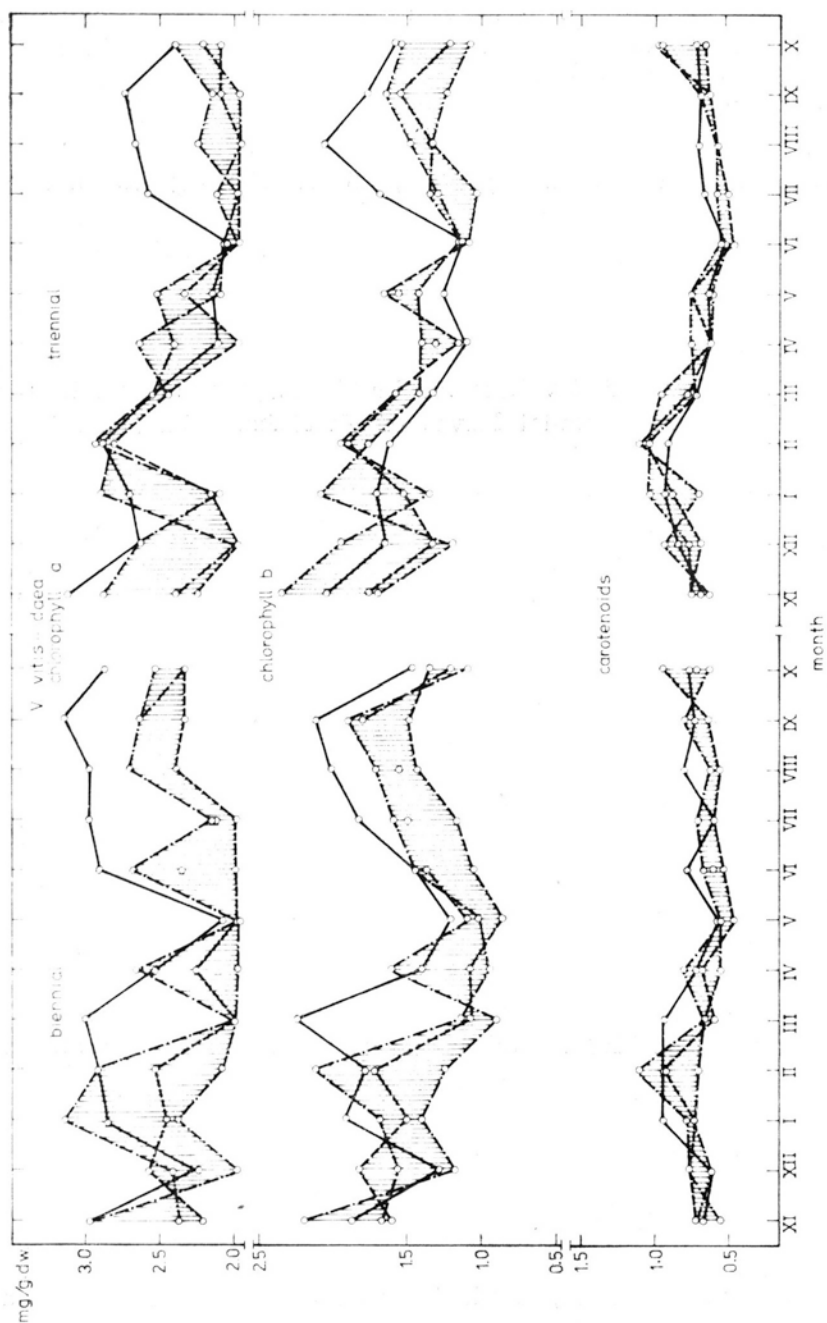


Fig. 2. Seasonal changes of chlorophyll a, b and total carotenoids in biennial and triennial leaves of *Vaccinium vitis-idaea*; for other explanations — see Fig. 1.

results also in its distinct decrease in late autumn, which does not take place in the current-year *Vaccinium vitis-idaea* leaves.

In general, the curves showing changes of chlorophyll *b* content are similar to those for chlorophyll *a*, however, there appear differences in the absolute values because chlorophyll *b* concentration corresponds to the range of 1.5-2.0 mg/g d.w. It is characteristic that the mean summer level of chlorophyll *b* is higher for the current-year leaves of *Vaccinium vitis-idaea* than of *Vaccinium myrtillus*, 1.8 vs. 1.5 mg/g d.w., and that the early spring depression lasts longer: from April till mid June for the biennial leaves, and as long as four months, starting from mid March, for the triennial ones.

The *Vaccinium vitis-idaea* leaves also show a little higher level of total carotenoids than those of *Vaccinium myrtillus*, ca. 0.8 as compared to ca. 0.65 mg/g d.w. This level reaches its highest values of ca. 1.0 mg/g d.w. for the bi- and triennial leaves of *Vaccinium vitis-idaea* in the period of January and February.

The difference between the location of all investigated stands and the content of chlorophyll *a* and *b* was found significant for the leaves of *Vaccinium myrtillus*, but not for the current-year leaves of *Vaccinium vitis-idaea*. The calculations were performed according to Snedecor (1956).

DISCUSSION

Vaccinium myrtillus possesses only current-year leaves while *Vaccinium vitis-idaea* also has biennial and triennial ones. Therefore only the current-year leaves of both species were comparable from the point of view of seasonal changes of pigment content. The real difference, in favour of the newly formed *Vaccinium myrtillus* leaves (in the first month of their life) proves that the seasonal shedding of *Vaccinium myrtillus* leaves requires, from the very beginning, a higher concentration of chlorophyll *a*. This resembles the behaviour of the *Larix* species leaves, also with a one-year life period, growing in the same ecosystem, and contrasts with the multi-seasonal leaves of *Pinus silvestris* (Czuchajowska, Niemtur, 1978).

The influence of industrial emissions on the pigments level in current-year leaves of *Vaccinium myrtillus* and *Vaccinium vitis-idaea* is not very pronounced, however, it shows some differences between the species during summer, particularly in July, what is not at all surprising if we consider the marked differences in the morphology and anatomy of both species. In view of this fact, together with the previously noticed differences in the seasonal changes of the buffer capacity of the

leaves of the two *Vaccinium* species (Czuchajowska, 1979) it is reasonable to expect their different reaction towards factors disturbing their life processes.

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Sezonowe zmiany stężenia barwników w liściach Vaccinium myrtillus i Vaccinium vitis-idaea oraz wpływ emisji przemysłowych

Streszczenie

Tegoroczne liście obydwu badanych gatunków *Vaccinium* wykazują w ciągu lata podobny poziom stężenia chlorofilu a, około 3 mg/g s.m., rys. 1 i 2, różniąc się natomiast w najwcześniejszym okresie, w którym możliwe jest wykonanie

oznaczenia; wówczas liście *Vaccinium myrtillus* wykazują poziom aż 6 mg/g s.m. Poziom ten ulega obniżeniu do połowy w ciągu czerwca. Jesienne zmniejszenie stężenia tego barwnika, zaobserwowane przed opadnięciem liści *Vaccinium myrtillus*, wynosi około 20%. Jednoroczne i dwuletnie liście *Vaccinium vitis-idaea* utrzymują na ogół stały poziom chlorofilu *a*, u pierwszych odpowiada on poziomowi typowemu dla liści tegorocznych, u drugich jest niższy średnio o 10%, przy czym zaznaczają się depresje wczesno-wiosenne.

Stężenie chlorofilu *b* utrzymuje się dla liści tegorocznych w okresie lata na poziomie 1,4 do 1,9 mg/g s.m., sezonowe zmiany poziomu tego barwnika wykazują podobieństwo do zmian stężenia chlorofilu *a*.

Wpływ zanieczyszczeń powietrza na krzewinki znajdujące się w miejscach oddległych o 0,9 km (Żyglinek), 2,5 km (Brynica I) oraz 5 km (Brynica II) od huty cynku w Miasteczku Śląskim jest nieznaczny w odniesieniu do stężenia badanych barwników w liściach nieuszkodzonych (liście nekrotyczne były wyeliminowane z oznaczeń). Niemniej wpływ zanieczyszczeń powietrza na obydwa badane gatunki był różny co ujawniło się w przebiegu zmian pojemności buforowej w pełni okresu wegetacyjnego.