

UDC 581.1 : 582.475.4 (497.11)
Original scientific paper

MILA BOGDANOVIĆ, GORDANA DRAŽIĆ, MILICA VUČKOVIĆ

**SEASONAL CHANGES OF PIGMENT CONTENT IN THE NEEDLES OF
DOUGLAS FIR (*PSEUDOTSUGA TAXIFOLIA* BRITT.) IN NATURAL
CONDITIONS**

INEP, Institute of Biotechnological Research, University of Belgrade,
Zemun-Beograd

Bogdanović, M., Dražić, G., Vučković, M. (1992-1993): *Seasonal changes of pigment content in the needles of Douglas fir (Pseudotsuga taxifolia Britt.) under natural conditions*. – Glasnik Instituta za botaniku i botaničke bašte Univerziteta u Beogradu, Tom XXVI-XXVII, 15 - 20.

The results of investigations have shown that the age of the tree of the yellow form of Douglas fir may not be involved in chlorophyll and carotenoid contents of its needles. In all trees examined, needles of the past year had more chlorophyll and carotenoids. In the yellow form of Douglas fir there were only slight variations of pigment content in the needles during the year. Green variety needles, however, have a twofold pigment content than the yellow form, accompanied by greater variations. Interdependence of chlorophyll and carotenoid metabolism is discussed.

Key words: *Pseudotsuga taxifolia*, chlorophyll, carotenoids, seasonal changes.

Ključne reči: *Pseudotsuga taxifolia*, hlorofil, karotenoidi, sezonsko variranje.

INTRODUCTION

First investigations of conifer photosynthetic pigments date back to the past century. Most data to be found in the literature refer to *Pinus* (Gerhold, 1959a, 1959b; Bogdanović et al., 1981; Bogdanović & Mančić, 1989), and are likely to produce a conclusion that the seasonal changes of the amount and composition of conifer photosynthetic pigments in natural conditions may reflect their metabolism.

From theoretical aspects, investigations of conifers lead to the understanding of metabolism control mechanism of leaf pigments throughout the year. On the practical side these investigations are interesting because many coniferous trees are used for the industry or landscaping of human settlements. In our country, Douglas fir (*Pseudotsuga taxifolia* Britt.) is widely spread both as a culture and the ornamental plant. Most commonly encountered are varieties *viridis* and *glauca*. The variety *viridis* occurs in its yellow form (Vidaković, 1982).

The objective of the present study was to examine the nature of the seasonal changes of pigment contents and their ratios in the needles of green and yellow Douglas firs in natural conditions.

MATERIAL AND METHODS

Needles of the first and second vegetation year of the green Douglas fir, age 30 years, and yellow forms aged 30 and 5 years of age were used as experimental material. All trees were grown in the garden of the Institute for the Application of Nuclear Energy in Zemun.

Needles for pigment analysis were sampled monthly for a year, always from the same shoots due to variability of material.

Chlorophylls were determined using spectrophotometry according to Vernon (1960), and carotenoids according to Holm (1954). The results are the means of four replications.

RESULTS

The seasonal variation of chlorophylls and their ratios in the needles of Douglas fir are shown in Fig. 1. The content of total chlorophyll in the current needles of a young yellow tree remains almost unchanged. A slight raise may be noticed in May and June, and then again in February (Fig. 1A). The needles of the preceding year contain more chlorophylls, however, with a content stable throughout the year. The ratio of Chl.a/Chl.b shows similar variations in both the current and preceding needles. Beginning summer, this ratio drops and then raises again as a consequence of the variations in the content of Chl.b.

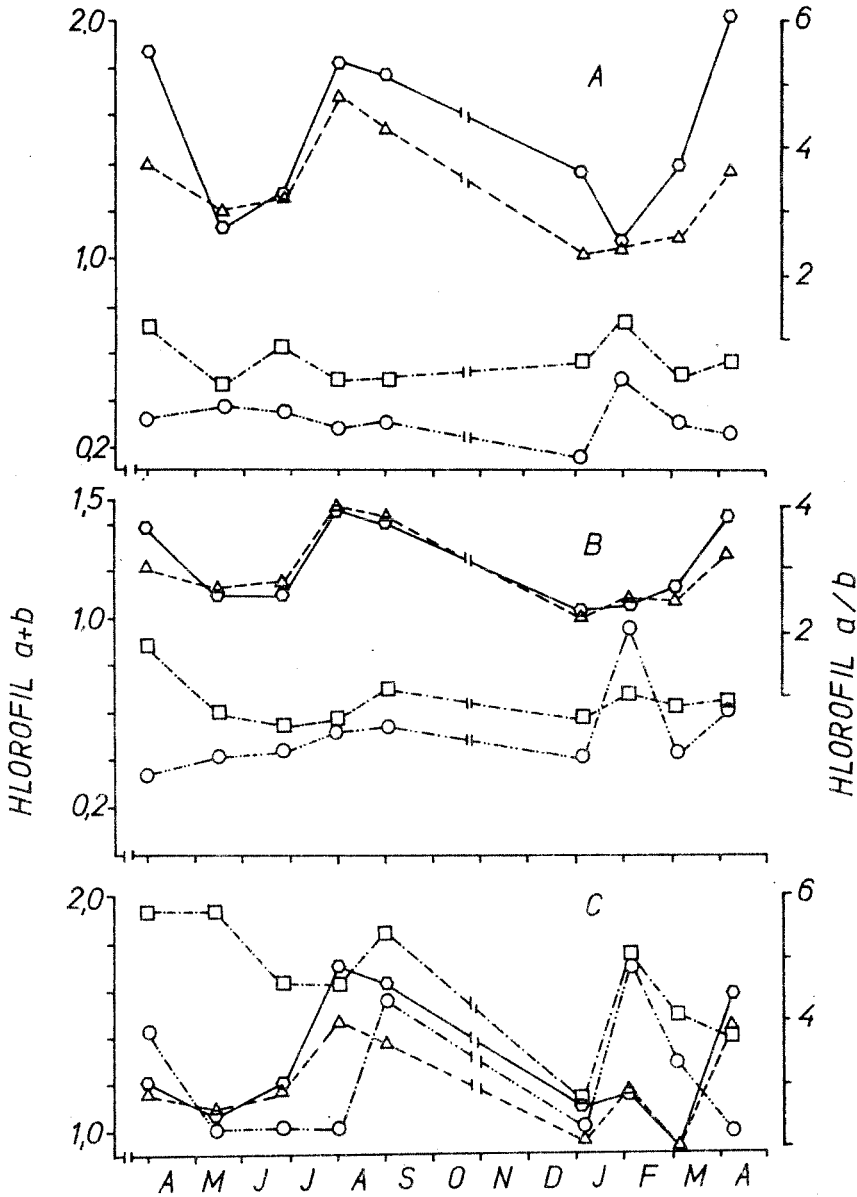


Fig. 1. - Seasonal variations of total chlorophylls (mg/g fresh matter) and Chl a/b ratio in the needles of: A - young yellow tree, B - adult yellow tree, and C - adult green tree.

- - - - ○ Chlorophyll content of current needles.
- - - - □ Chlorophyll content of a year-old needles.
- - - - ○ Chl a/b ratio in current needles.
- △ - - - △ Chl a/b ratio in a year-old needles.

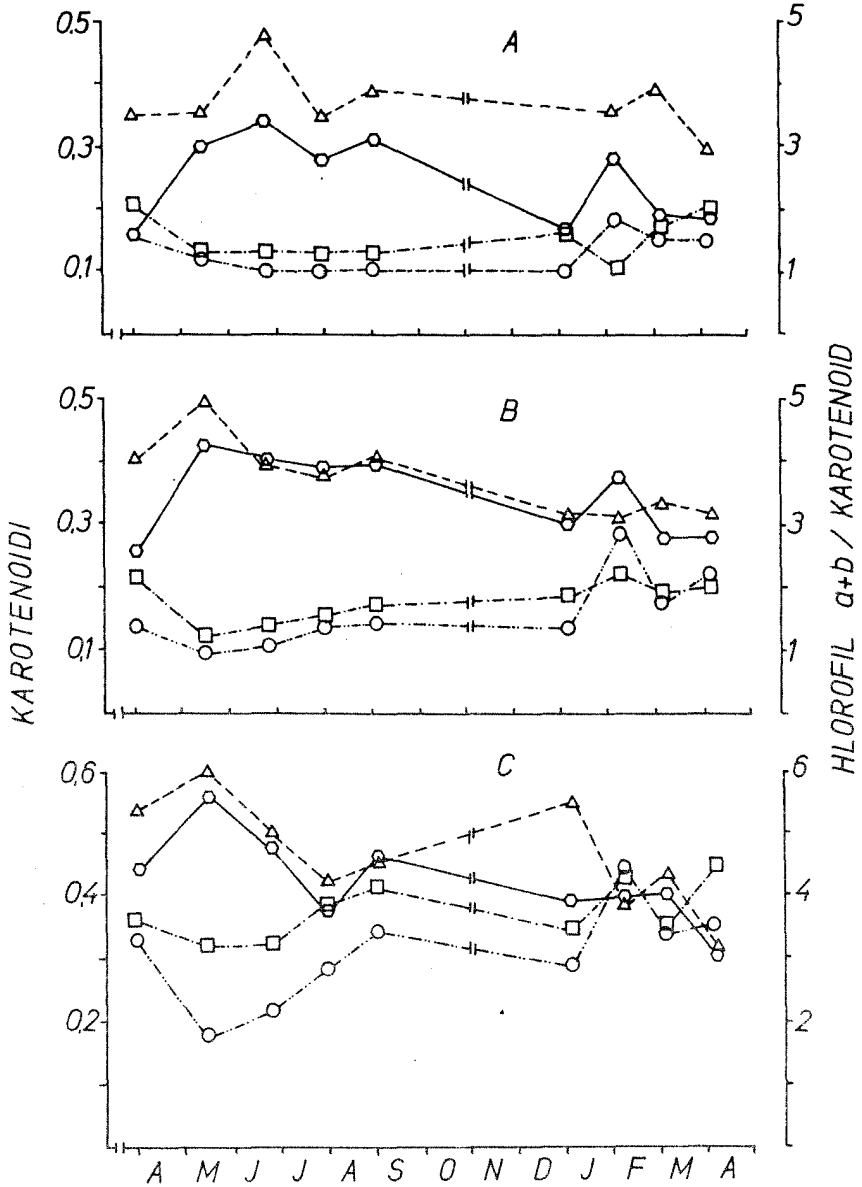


Fig. 2. – Seasonal variations of total carotenoid content (mg/g fresh matter) and of total chlorophyll/total carotenoid ratio in the needles of: A – young yellow tree, B – adult yellow tree, and C – adult green tree

- - - - ○ Carotenoid content of current needles.
- - - - □ Carotenoid content of a year-old needles.
- - - - ○ Chl/carotenoid ratio in current needles.
- △ - - - △ Chl/carotenoid ratio in a year-old needles.

The needles of the old yellow tree follow the same chlorophyll variation pattern, however, the content of chlorophyll in its needles is somewhat higher (Fig. 1B), and concerns needles of both the current and the preceding year. On the other hand, Chl a/Chl b ratio varies less than in a young tree needles, and throughout the year shows values typical of mature leaves of the majority of green plants.

The needles of the full-grown green tree have double chlorophyll content whose variation pattern is similar to that of an old yellow tree. The ratio Chl a/Chl b is most often about 3. In spring it tends to increase and remain at a higher level, to drop during summer months. The tendency is the same in the current and a year-old needles.

Figure 2 shows variations of carotenoid contents and varying ratios of total chlorophyll/total carotenoid. Carotenoid content is mostly stable throughout the period of investigation, with slight oscillations noticed in the spring.

Older needles contained slightly more carotenoids than the current needles. No significant differences could be noticed between needles of the young and the old yellow tree (Fig. 2A, B). A slight variation of the ratio total chlorophyll/total carotenoid was noticeable during summer months. The raise of this ratio was the consequence of the increased chlorophyll content, while carotenoids remained at the same level.

The needles of the green Douglas fir had an almost twofold carotenoid content than the needles of yellow trees. A slight raise of carotenoids could be noticed in summer (Fig. 2C). The ratio Chl a+b/carotenoid in the needles of a mature Douglas fir tends to vary during the year, showing a sudden increase in the spring and a gentle drop in the summer.

DISCUSSION

It was shown that the content of chlorophyll and carotenoids tended to vary during the year in the young seedlings of Scotch pine. These variations depended on the temperature (Bogdanović & Mančić, 1989), leading to reddening of the needles in the winter and their greening in the spring. However, needles of the adult Douglas fir are green or yellowish throughout the year. This would suggest a genetical determination of the colour which tempted us to investigate the metabolism of chlorophyll and carotenoids in the needles of both yellow and green varieties of Douglas fir over a year period.

Khodasevich et al. (1978) reported that the yellow form of *Pinus sylvestris* had more carotenoids than the green one. However, our results have shown less chlorophyll and carotenoids in the needles of the yellow form than that in the needles of green variety. It may, therefore, be suggested that certain photobleaching of chlorophyll occurred in our experimental conditions, leading to the prevalence of yellow colour of the needles.

The investigations of Krivosheeva and Shavnin (1988) showed that oxygen evolution system of the needles of Siberian pine operated until November and was followed by the inactivation of primary photosynthetic processes. Two-year old needles proved more stable at low temperatures than the current needles. A stable pigment ratio of Douglas fir during the year suggested a normal photosynthesis process in the yellow form regardless of the temperature. In the green variety, though, it may be assumed that photosynthetic processes were more active in the summer.

In both the yellow and green variety of Douglas fir, needles of the preceding year had a higher pigment content. Similar results were obtained by Godnev et al. (1969)

who studied seasonal variations of pigments in spruce needles. It was noted that the Chl a/b ratio varied to a greater extent in the needles of a young yellow tree. This would suggest a greater variation of chlorophyll b in the needles of the yellow Douglas fir, without significant differences between the current and a year-old needles. These results are likely to point out to a similar metabolism of pigments in young and old needles of the same tree regardless of its age, thus supporting the idea of a genetically determined characteristic.

REFERENCES

- Bogdanović, M., Stojanović, D., Rastović, A., Mančić, A., Đurđević, M. (1981): Neke fiziološke karakteristike sezonskog crvenjenja četina belog bora. – Šumarstvo 2-3: 13-20.
- Bogdanović, M. i Mančić, A. (1989): Sezonsko variranje sadržaja pigmenta i crvenjenja četina belog bora. – Zbornik radova Instituta za šumarstvo i drvnu industriju XXXII – 33.
- Gerhold, H. D. (1959a): Seasonal variation of chlorophyll pigments and nutrient element in the needles of geographic races of Scotch pine. – *Silvae genet.* 8: 113-123.
- Gerhold, H. D. (1959b): Seasonal discoloration of Scotch pine in relation to microclimatic factors. – *Forest Sci.* 5: 333-345.
- Godnev, T. N., Khodasevich, E. V., Arnautova, A. I. (1969): Seasonal variation in absolute and relative amounts of pigments in conifers in natural conditions with relation to air temperature. – *Fiziol. rast.* 16(1): 102-105.
- Khodasevich, E. V., Arnautova, A. I., Mychkovetz, E. N. (1978): The structural organisation of chlorophylls related to reversible degradation of pigment pool in conifers. – *Fiziol. rast.* 25(4): 810-814.
- Holm, G. (1954): Chlorophyll mutations in barley. – *Acta Agric. Scand.* 4: 457-471.
- Krivosheeva, A. A., Shavnin, S. A. (1988): Seasonal and temperature induced changes in primary photosynthetic processes in Siberian pine needles. – *Fiziol. rast.* 35(6): 1064-1070.
- Vernon, L. P. (1960): Spectrophotometric determination of chlorophylls and pheophytins in plant extracts. – *Anal. Chem.* 32: 1144-1150.
- Vidaković, M. (1982): Četinjače, morfologija i varijabilnost. – Sveučilišna naklada Liber, Zagreb.

Rezi me

MILA BOGDANOVIĆ, GORDANA DRAŽIĆ, MILICA VUČKOVIĆ

SEZONSKO VARIRANJE PIGMENATA U ČETINAMA DUGLAZIJE
(*PSEUDOTSUGA TAXIFOLIA* BRITT.) U PRIRODNIM USLOVIMA

INEP, Institut za biotehnoška istraživanja, Univerzitet u Beogradu,
Zemun-Beograd

Ispitivano je sezonsko variranje pigmenta u četinama žute i zelene forme duglazije (*Pseudotsuga taxifolia* Britt.). Rezultati istraživanja su pokazali da starost stabala žute forme duglazije nema uticaja na sadržaj hlorofila i karotenoida u četinama. Četine prethodne godine sadrže više hlorofila i karotenoida kod svih ispitivanih stabala. Variranje sadržaja pigmenta u toku godine u četinama duglazije je neznanto kod žute forme. Četine zelenog varijeteta sadrže dvostruko više pigmenta od četina žute forme i više variraju. Diskutovana je međusobna zavisnost metabolizma hlorofila i karotenoida.