FOLIA FORESTALIA POLONICA
Seria B, zeszyt 24, 1993

MICROSCOPIC CHARACTERISTICS OF THE BEECH (*FAGUS SILVATICA* L.) ROUNDWOOD DOTE PROCESS

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Microscopic analysis of the entire process of beech (*Fagus silvatica* L.) logs dote provides evidence of the occurrence of its first phase in the from of a membranous layer on the scalariform perforation plate and a variability of manifestations of other dote phases.

INTRODUCTION

A great attention has been paid to the problem of the investigation of the dote in beech wood raw material because of the abundant occurrence of beech in Slovakia. The most important works concerned with this problem are those published by Jurášek [5 - 8]. Until now, there were known three phases of the beech wood dote, namely tyloses formation, oxidation of tannins and rot. It has been found [3, 4] that due to the dote of beech sawn timber similar membranous layers were formed on the scalariform perforation plate of the late wood vessels as described with birch and alder dote [2, 9]. These membranous layers were found even beyond the brown-colored zone, on the basis of which we have assumed that they represent the first phase of the dote. In 1991 our research was aimed at finding out whether this phase precedes those alredy known ones at roundwood dote too, as well as the intensity of other phases occurring in a log. This paper gives above all the documentation of microscopic analyses of the process and variability of its characteristics.

MATERIAL AND METHODS

The process of dote was investigated for 19 weeks during the summer period. The samples for microscopic analyses were obtained from the doted butt ends (200 cm) and from the cores using the Pressler's borer at the distances of 10, 20, 30, 60 and 100 cm from the butt end. The resulting state of dote was analysed after the termination of the experiment following the cutting of logs at regular distances from the butt ends. A detailed methodology and results obtained from the investigation of the dote spreading process as well as the final depreciation of logs are given in separate works.

The changes in wood structure were observed mainly by a scanning electron microscope (SEM) after silver plating of samples. The magnification in figures is expressed in um depicted in a white bar. The bar length represents the given size in micrometres.

RESULTS AND DISCUSSION

The scalariform perforation plates of the beech late wood vessels occur predominantly in a thin layer situated before the annual ring border. On radial sections, therefore, we can find only 1 - 3 vessels with the scalariform perforation plate near the annual ring border. The structure of the beech wood scalariform perforation plate is variable. Apart from the regular bars we can also find some transitions to the reticulate perforation plate (Fig. 1), but only rarely a typical reticulate perforation plate (Fig. 2) or an irregular perforation plate (Fig. 3). There are also cases, where the vessel element has a scalariform perforation plate on one end and a simple perforation plate on the other one.

The membranous layers on the scalariform perforation plate are formed in different intensity in adjacent vessels. Fig. 1 shows one perforation plate with the initiation of the membranous layer and the other one with the almost complete membranous layer.

The membranous layer is initiated at the beginning of the parenchyma irritation caused by the dote, by secretion from the living cells into vessels. It has been found that the membranous layer formation in logs precedes both the tyloses formation and the oxidation of tannins. After finishing the experiment carried out on a log with a diameter of 30 cm and a length of 200 cm we have found the occurrence of the membranous layers in all (84) positions along and accross the stem, while the other features did not occur in some positions. The developed membranous layers occur most frequently in the middle, the perforation rim being free (Fig. 1, 4). The surface of the membranous layer can be smooth but it is more frequently covered by wartlike formations (Fig. 4). The authors, Bonsen, and Walter [1] referring to our work [4], found calcium concentrations in these wartlike formations using the chemical analyzer in the SEM. The inner surface of the beech late wood vessels is regularly covered by the above formations. Proceding from our results, the formation of the membranous layers has also been proved by Schmitt and Liese [10].

The tyloses formation depends on the intensity of moisture gradient and thus on the intensity of parenchyma dying. Due to a quick parenchyma dying caused, e. g. by air penetration into butt ends, only small tyloses are formed

(Fig. 6, 7). Due to a gradual tyloses formation the outgrowths are blocking the vessels (Fig. 8). In this figure the membranous layers on the scalariform perforation plates can also be observed. In the first growth phases the tyloses feature a thin-walled membrane, the developed tyloses blocking the vessel lumina are thick-walled.

The brown discoloration of beech wood due to the dote is caused by the oxidation of tannins in parenchyma (Fig. 5). The light microscopic observations revealed that only parenchyma cells were discolored (Fig. 6). A macroscopically visible discoloration shows a continuous light brown shade. In the process of the dote, the logs were investigated as for the gradual parenchyma dying according to the proportion of the living cells occurrence and the changes in the moisture content of wood as well. The moisture content drop ranging between 65 - 50% resulted in the formation of membranous layers and tyloses. The oxidation of tannins occurred at a moisture content lower than 50% accompanied by an intensive parenchyma dying. These results correspond to Jurášek's findings [5 - 7].

The results of our analysis coincide well with those of Jurášek [6, 8] showing that on the quickly desiccating butt ends the tyloses formation is reduced to the advantage of the tannin oxidation phase. Similarly, only two phases occurred with the rough sawn wood dote, namely the formation of membranous layers and the discoloration. After finishing the experiment and after examining the middle plate obtained from the investigated logs, we have found out that a 2 – 4 cm broad streak on the butt end was brown followed by a white rot in the middle of the log. The hyphae did not act so intensively like in deeper layers which is due to the reduced moisture content.

At the dote phase initiation the hyphae cause the parenchyma dying, local destruction of pit membranes and secretion of substances from parenchyma (Fig. 9). A more advanced decomposition is closely connected with the hyphae of wood-destroying fungi and decomposed membranes (Fig. 10). The fungi enzymes decompose both the tyloses (Fig. 11) and the membranes on the scalariform perforation plates (Fig. 12, 13). Fig. 13 reveals a very interesting phenomenon. A hypha is covered by wartlike formations. This means that the initiation phase of these formations occurred after the penetration of hyphae into vessels. These formations contain calcium [1], which leads to the hypothesis that they originate as deposits created by water conducted in vessels. Similar wartlike formations are typical of the inner surface of the beech late wood vessels. There is no explanation why calcium is concentrated only in the late wood vessels. In the soft rot the conidiospores are created by the hyphae (Fig. 14). The wood-destroying fungi acting at the dote phase are lignovorous, decomposing first the compound middle lamella. At the stage of wood discoloration and that of hard rot, the beech wood exposes different shades of brown colour. Friable or soft rot is of yellow-white or white colour.

The decomposition of the middle lamella begins already at the stage of the hard rot and it becomes more characteristic at the stage of soft rot. It is manifested by loosening the cells on the transverse section (Fig. 15) and by separation of the secondary layer on the cleavage face (Fig. 16). The decomposition is manifested also by loosening the middle lamellas in the parenchyma of the medullary ray (Fig. 17). Fig. 17 reveals at the same time a complete membranous layer on the scalariform perforation plate and a vessel tylosis as well. In the process of white rot the decomposition of not only the membranous layer but also that of the scalariform perforation may occur (Fig. 18).

CONCLUSIONS

1. The analyses carried out in the process of the beech logs dote proved that the formation of membranous layers on the scalariform perforation plate of vessels preceded the phases known up to this time.

2. The tyloses formation is uneven, mainly as for the size of tyloses which in most vessels continue their development due to parenchyma dying caused by drying out and fungi enzymes.

3. After 134 days of summer period the decomposition due to lignovorous fungi was locally changed to white rot.

Received in May 1993

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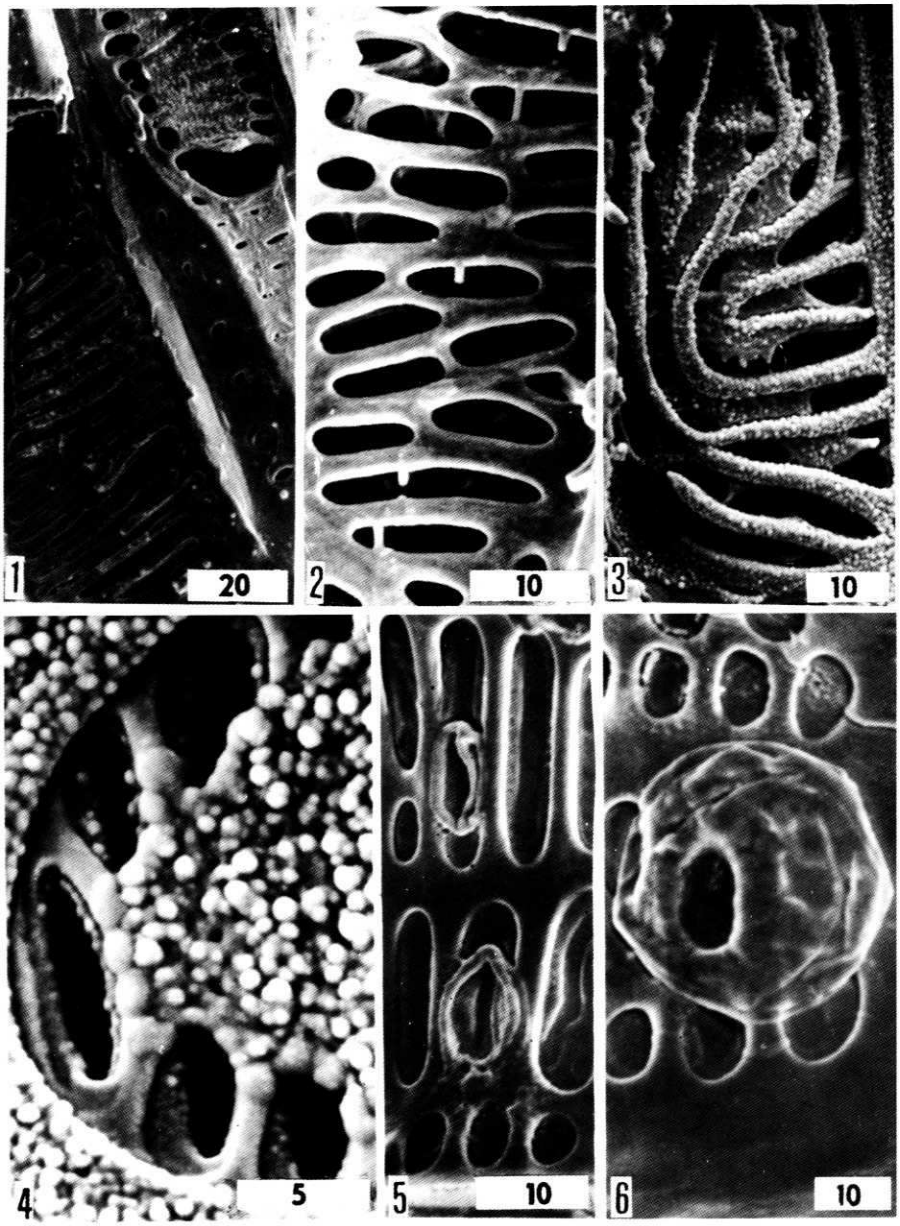

Fig. 1. Origin of the membranous layer formation on the left at the bottom. In the upper part, the membranous layer being already formed in the middle of scalariform perforation plate. A free space remains on the rim

Rys. 1. Po lewej stronie u dołu powstawanie utworu błonkowatego. W części górnej warstwa błonkowata już powstała, w części środkowej płytki drabinkowej członu naczynia. Wolna powierzchnia pozostaje na skraju

Fig. 2. Reticulate perforation plate

Rys. 2. Płytka siateczkowa członu naczynia

Fig. 3. Irregular perforation plate with formation of the membranous layer

Rys. 3. Nieregularna płytka perforowana z tworzącą się warstwą błonkowatą

Fig. 4. Detail of the membranous layer with a open margin and warty surface

Rys. 4. Szczegół warstwy błonkowatej z otwartym obrzeżem i powierzchnią brodawkowatą

Fig. 5 and 6. Small tyllae stopped growing because of the parenchyma dying due to fungi

Rys. 5 i 6. Małe wcistki przestały się powiększać z powodu zamierania miękiszu, wywołanego przez grzyby

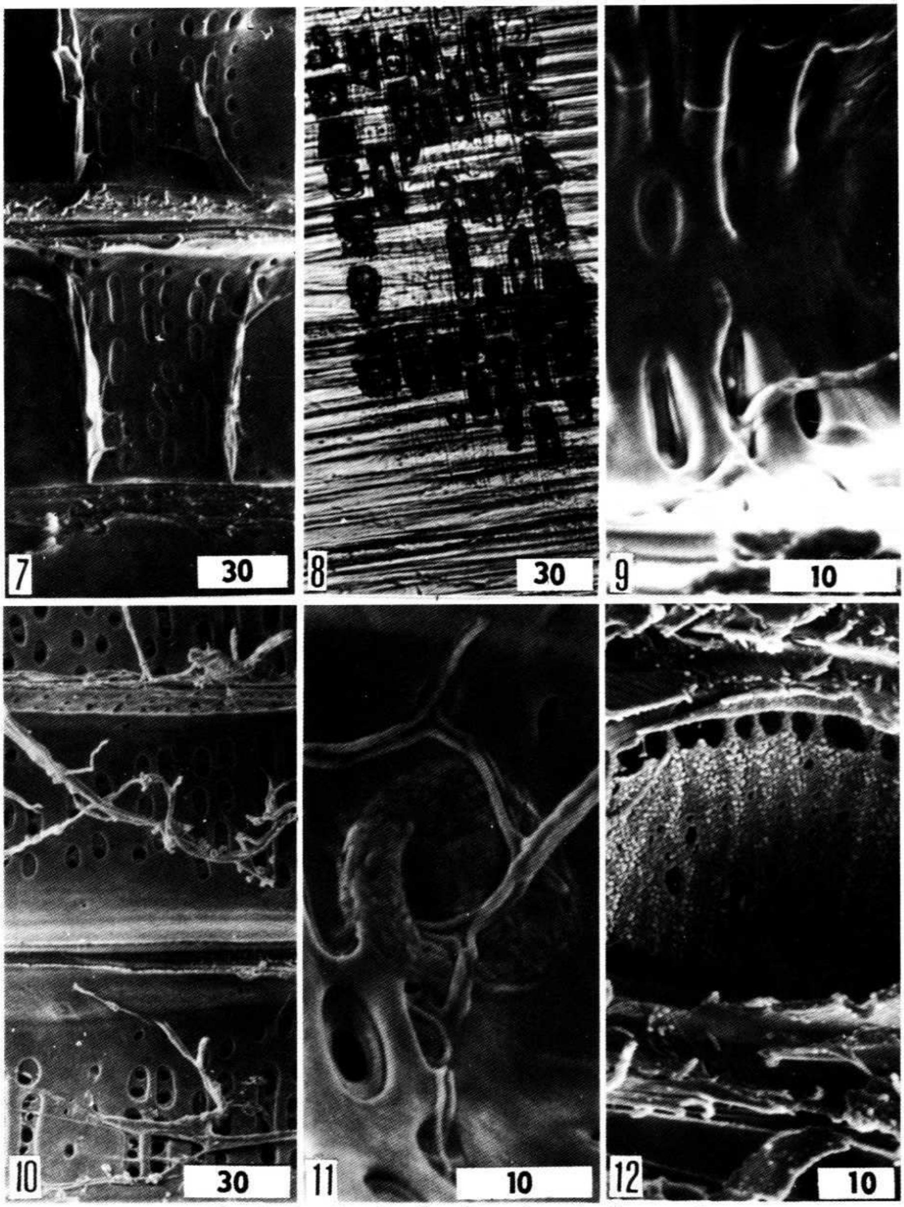

Fig. 7. Developed tyllae from bars in the vessels

Rys. 7. Rozrośnięte wciski wytwarzają przegrody w naczyniach

Fig. 8. Brown or red-brown discolaration of wood is only a consequence of the oxidation of a part of parenchyma

Rys. 8. Brunatne i czerwonobrunatne przebarwienie drewna jest jedynie wynikiem utleniania części miękiszu

Fig. 9. Hyphae corroding the pit membranes so that a part of the protoplasm leaks from parenchyma to vessels

Rys. 9. Strzępki powodują korozję błony jamek – część protoplazmy wypływa z miękiszu do naczyń

Fig. 10. Hyphae corroded the membranes of vessel constrictions

Rys. 10. Strzępki powodują również korozję zwężeń w naczyniach

Fig. 11. Hyphae corroding the tyllae

Rys. 11. Strzępki korodujące wcistki

Fig. 12. Hyphae corroding also the membranous layer on the scalariform perforation plate

Rys. 12. Strzępki korodujące także warstwę bony na płytce z perforacją drabinkową

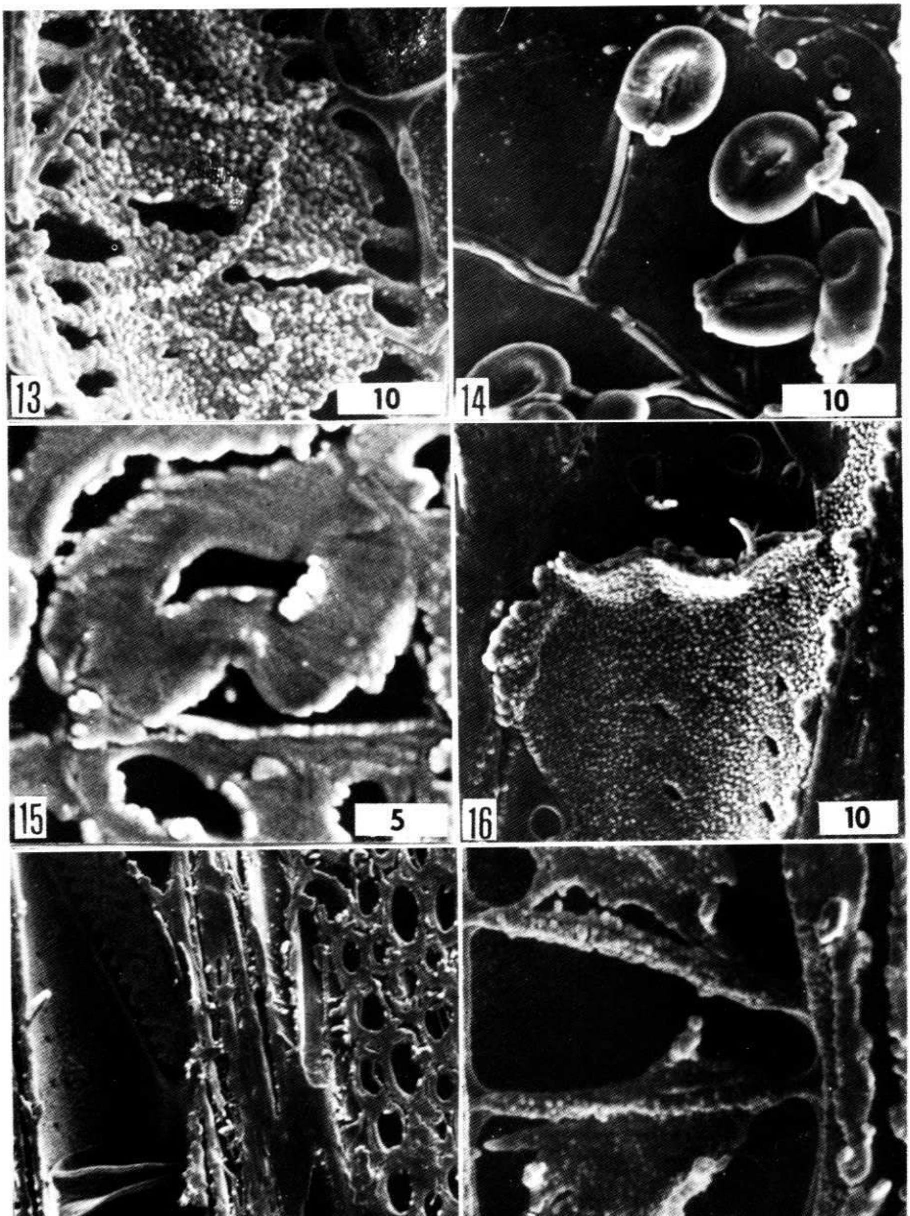

Fig. 13. Hypha was acting before the formation of the membranous layer by which it was covered

Rys. 13. Strzępka działała przed powstaniem błony, przez którą została pokryta

Fig. 14. Hyphae in vessel formed conidiospores

Rys. 14. Strzępki w naczyniu tworzą zarodniki konidialne

Fig. 15. Due to advanced effect of the white-rot fungus the middle lamella was loosened

Rys. 15. Na skutek zaawansowanego oddziaływania grzyba białej zgnilizny blaszka środkowa została poluźniona

Rys. 16. Loosening of the middle lamella as vieved on the longitudial section

Rys. 16. Poluźnienie blaszki środkowej widziane na przekroju podłużnym

Fig. 17. Vessel with the membranous layer formed on the scalariform perforation plate and the tyllae

Rys. 17. Naczynie z warstwą błoniastą powstałą na płytce z drabinkowatymi perforacjami i wcistkami

Fig. 18. Disintegration of the membranous layer on the scalarifrom perforation plate due to fungi

Rys. 18. Rozpad warstwy błoniastej na płytce z drabinkowatymi perforacjami na skutek działania grzybów

MIKROSKOPOWA CHARAKTERYSTYKA PROCESU ZAPARZENIA SUROWCA BUKOWEGO

Streszczenie

Przeprowadzono obserwacje nad zmianami struktury drewna bukowego, zachodzącymi w procesie jego zaparzania, z uwzględnieniem tworzenia się powłok na drabinkowej perforacji ścian naczyń, co stwierdzono wcześniej w drewnie brzozy i olszy. Rozwój zaparzenia obserwowano w okresie letnim, przez 19 tygodni, na wyrzynkach o długości 2 m. Badania potwierdziły tworzenie się powłok na powierzchniach drabinkowych perforacji naczyń późniejszego drewna buka. Tworzenie się powłok stanowi pierwszą fazę zaparzenia drewna bukowego lub zachodzi równocześnie z utlenianiem garbników. Powłoki tworzą się również w naczyniach w pobliżu czół surowca bukowego, kiedy podczas szybkiego wysychania drewna nie powstają wcistki lub mają one małe wymiary. Rozwój grzybów rozkładających substancję drzewną, w ostatnich fazach zaparzenia powoduje uszkodzenia zarówno powłok jak i wcistek.

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