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D. N. Sen:

# Self-saprophytism in roots of *Tilia cordata* L.

In spite of the fact that the ecology of plant roots is so important from the scientific and practical standpoint, investigations in this direction have been neglected. So far as the morphology is concerned typical data are available in different records without any details, but not much is found on the relations of the plant roots to its environment, which at times has much to do on its morphological features also. The reason for this poor knowledge is the great amount of work this subject requires, especially the root system of the trees, the digging and reproduction of which is a difficult task. However in the recent past some work has been done in this direction in connection with the mycorrhiza problem of the trees. Keeping this fact in view a study of the root system and root ecology of *Tilia* species is undertaken by the author.

During the course of an investigation on the above mentioned subject, an interesting phenomenon of self-saprophytism was observed in the roots of *Tilia cordata* L. Vysockij (1899, sec. Laitakari, 1929) investigating on the ground water level (in the forest and open field) pointed out that due to the drying effect of tree roots it is deeper in the forest than in the open field in otherwise similiar conditions. It has also been established that the roots that penetrate deep into the soil use the channels of the rotten roots and various animals. Savitsh (1906, sec. Laitakari op. c.) also noted in connection with the root system of pine that the root sometimes grows in a hollow decayed root. Albert (1907) proves that a great quantity of roots indicate a vigrous root system, these roots have been found to develop especially where there are ready made deep root channels, in most cases the remains of hard woods. Alten (1909) distinguishes between enriching roots (Bereicherungswurzeln) and feeding roots (Ernährungswurzeln). Recently Rachteenko (1952, p. 26) has made a record where old roots were exploited by another succeeding species e.g., roots of *Pinus silvestris* L., in decaying *Betula* roots. Except for these sporadic observations and records, nothing much is available from the anatomico-ecological point of view. An unusual phenomenon of self-saprophytism is thought to be different in the case of *Tilia cordata* L., from all above observations in its specific character, that may be of some interest in the ecology of root system. So far as the author is aware there is no such record in the ecology of the root system of forest trees in literature.

## Locality and method of investigation

The locality where this investigation was carried out is near Poděbrady (Polesí Libice nad Cidlinou), Czechoslovakia. The geographical limits are determined by the parallels of 50°09′ north latitude and 32°50′ east longitude. The height of the place is 185 metres above sea level. It is a mixed deciduous forest consisting of *Quercus robur* L., *Fraxinus excelsior* L., and *Carpinus betulus* L., etc. On the forest floor there is a comparatively rich cover of herbaceous plant species e.g., *Aegopodium podagraria* L., *Poa nemoralis* L., and *Stellaria holostea* L., etc.

A sectorial transect was dug from the base of the specimen tree in the sample plot of the locality mentioned above. The roots showing this phenomenon were observed in deeper layers. The specimens after thorough washing were fixed in Formaline-Acetic-Alcohol. The customary procedures of infiltration and imbedding were followed. Sections were cut at 10—15 μ thick. The slides were stained in a combination of Safranin and Aniline blue.

Geological substratum is young alluvium with undeveloped brown forest soil type. The soil could be divisible into four distinct layers, excluding a layer of 2 cm high above ground level composed of semi-decomposed remnants of leaves of forest trees. A surface layer consisting of brown black humus is from 0 to 5 cm deep. The second layer consisting of dark brown loam richly occupied by roots of *Tilia* is from 5 to 55 cm. The third layer from 55 to 125 cm consisting of rusty brown sandy soil which is not very well grown by *Tilia* roots. The fourth layer is from 125 to 150 cm again more frequently occupied by *Tilia* roots, touches the water level. This zone which is sandy has striking differenciated dark grey spots around bunches of *Tilia* roots.

## Description of the specimen

Some of the roots found in the deeper layers of the soil were in appearance different from the normal form of the branches of the root system. It appears probable from the study of the specimen that fewer roots first enter into the old tubiform case of the dead root. These roots later produce many lateral branches growing parallel in the direction of the dead root, which ultimately exerts pressure on the decaying root case. This results into the breaking down of the cork mantle of the periderm of the old tubiform case at many places, through which new and young roots come out and reach into a new environment, which otherwise probably might have not been possible for them (Tab. I : 1). So in this way new roots produced inside the tubiform case of the old decaying root reach a new soil environment throughout the whole length of the dead root.

A variation in the morphology of the roots has also been noted down. They are distinctly differentiated into light coloured thick roots which do not have the ectotrophic mycorrhizae, and others are dark coloured end-roots of limited growth, many of them bearing mycorrhizae. The first type prevails inside the case of the old root, but often also bearing the end-roots of limited growth. And the second type is more common and distinct on those roots which have come out into the sandy environment. The thickened roots which are in the new sandy environment do not grow very long, due to the fact that their growing tip is unable to resist very long the unfavourable conditions of tapping the new areas for their normal necessities. All the root tips appear to be dead as they are blackened and abnormal in their shape and make up. At many places these roots have produced roots of limited growth also bearing mycorrhizae, which probably help in better relations for these new roots in their growth and development, ultimately resulting into the betterment of the tree as a whole.

The specimens were not very commonly found. It was observed that the old roots were not physically disconnected with the root system of the specimen tree. There are two reasons for it. Firstly, this phenomenon occurred in deep layers, which under normal circumstances as noted in the sectorial transect is not possible. Secondly, the cork mantle of the periderm of the old root is quite resistant even though the rest of the tissues inside it may be decayed, and so the whole root has a continuity, and probably decays very slowly.

In another specimen *Tilia* roots were seen to be saprophytic in the Oak roots also. This gives support to the view put forth by Jeník (1957, p. 62) for a closer phytosociological relations between the trees.

The anatomical structure of the cork tissue in its make up in the old tubiform case as well as the structure of the same in the very young roots inside, proves beyond doubt that they both belong to the same species. It appears that the origin of the cork takes place very early in the morphogenesis of the roots, and that the cork remains resistant and intact for a very long time even though the rest of the tissues inside are dead (Tab. I : 2).

In transverse section, the cork mantle of the periderm of the old root is 10 to 14-celled thick. The walls of these cells comparatively thick are filled with some content which take dark red stain with safrain. It has broken at many places due to the pressure of new and young roots, but still maintains the circular shape (Tab. II : 3). Not much phloem which seems to be disintegrating much earlier is to be seen anywhere. At places between the young roots some old disintegrated xylem can also be seen.

In a transverse section of the whole root case as many as 12 to 15 young roots have been counted inside it (Fig. 3). In transverse sections of young roots inside the old root, an outer zone of irregular rhizodermis which is incrusted with some deposit can be seen, together with cortex made up of varying number of cells in different sections depending on the age of the roots. This zone seems to possess mycorrhizae. Cortex is destroyed soon due to the growth of the cork inside it. The endodermis is visible as a distinct layer in young roots, which is soon lost due to cork which develops as a very prominent tissue. Stele is tri- to hexarc. Pith is absent. Some young roots show a prominent outer mantle of pseudoparenchyma formed by the mycorrhizal fungus as a dark brown or black tissue. Prominent mycelia can also be seen attached to this zone (Tab. II : 4).

## Discussion

This phenomenon is significant from the ecological relations of the roots to its environment, and consequently effecting the life of the tree as a whole. The following conclusion may be derived from the above observations.

The sandy layer of the subsoil layer near about which this phenomenon occurs is unfavourable for the growth of the new roots. So the old dead root of *Tilia cordata* L., forms a favourable environment for the expansion of young roots into the sterile depth of the subsoil. Chance penetration of a single root beyond the boundary of the favourable rhizosphere enables, after the dying of this pioneer root, a succeeding growth of a new and more extensive root system of the same tree. The cork in this case seems to be quite resisting to the internal destructive activity of the new and young roots and external environment of the soil microorganism.

Young roots after entering the tubiform case produce quite frequently a number of lateral roots. Probably they are attracted by the more available nutrients and other better ecological conditions of the aeration and moisture for their housing. So the term ,,ecotropism" is suggested here for such a phenomenon (Jeník, Kubíková and Sen, 1961). This fact is supported by the observations quoted by Laitakari (1929), but this specific case of self-saprophytism has not been mentioned, except by a preliminary report of Jeník et al. (1961). After growing for some time in the old case many well developed roots seem to be coming out into a new environment, because they are in a better position to tap the new area for their activity, which otherwise might have not been possible to be reached.

Mycorrhizal roots are more frequent on those roots which have come out from the tubiform case into the new environment, for they seem to be appreciative of better mycorrhizal relations outside than inside the dead root, which is so important for the better growth of the forest trees.

The phenomenon of self-saprophytism of *Tilia cordata* L., in comparison to the other studied species of Middle European trees is very striking. However, similar phenomenon is expected to be found in some other woody plants also.


Summary

1. An interesting and uncommon phenomenon of self-saprophytism is described here from the point of view of ecological relations in the roots of *Tilia cordata* L. Chance penetration of a single root beyond the boundary of favourable rhizosphere forms, after the dying of this pioneer root, a favourable environment for the succeeding growth and expansion of young roots of the same tree into a new soil environment.

2. The young roots of *Tilia cordata* L., are attracted by the more available nutrients and other better ecological conditions for their housing. This becomes more favourable probably due to the undisconnected condition of the dead root forming a channel; and with a more resistant tubiform case made up of the cork. As many as 12 to 15 young roots have been observed inside the old case.



Acknowledgement

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D. N. Sen:


**Autosaprofytismus u kořenů *Tillia cordata* L.**

V práci je popsán zajímavý a málo obvyklý jev autosaprofytismu u kořenů lípy (*Tilia cordata* L.). Náhodné proniknutí jednotlivého kořene za hranice ekologicky příznivé oblasti rhizosféry vytváří — po odumření pionýrského kořene — příznivé podmínky pro sukcesivní růst a větvení nových kořenů téhož stromu v neosídlených prostorech půdy.

Mladé kořeny lípy jsou přitahovány dostupnějšími živinami a dalšími zlepšenými podmínkami ve sféře odumírajícího kořene. Prorůstání kořenů je tím snažší, že starý kořen vytváří spojitý rourovitý kanál, jehož odolný plášť je tvořen korkem peridermu. Uvnitř rourovitého zbytku starého kořene bylo pozorováno 12 až 15 natěsnaných mladých kořenů.

References


Albert R. (1907): Besteht ein Zusammenhang zwischen Bodenbeschaffenheit und Wurzelerkrankung der Kiefer auf aufgeforstetem Ackerland? — Zeitschrift für Forst- und Jagdwesen.

Alten H. (1909): Wurzelstudien. — Botanische Zeitung 67 : 175—200.

Jeník J. (1957): Kořenový systém dubu letního a zimního. — Rozpravy Čs. Akademie Věd 67 : 1—85.

Jeník J., Kubíková J. et Sen D. N. (1961): Phenomenon of self-saprophytism in roots of *Tilia europaea* L. — Science and Culture, in Press.

Laitakari E. (1929): The root system of Pine (*Pinus silvestris*): A morphological investigation. — Acta Forestalia Fennica 33 : 307—380.

Rachteenko I. N. (1952): Kornevye sistemy drevesnych i kustarnikovych porod. — Moskva — Leningrad, ed. Goslesbumizdat.

Explanations of the photographs on the plates.

Tab. I. Fig. 1. Photograph of the whole specimen showing the phenomenon of self-saprophytism in *Tilia* roots. Nat. size, approx.

a. Roots lying inside the old cork of the root.

b. Light coloured thick roots.

c. Dark coloured roots of limited growth.

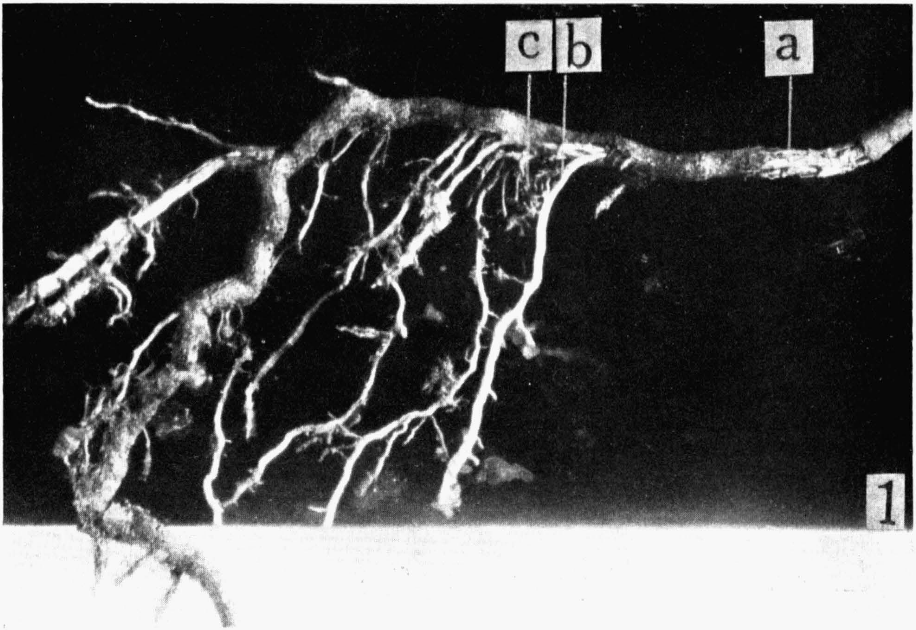
Fig. 2. Microphotograph of a part of specimen showing the prominent cork in old (a) and young (b) root. Enlarged × 80, approx.

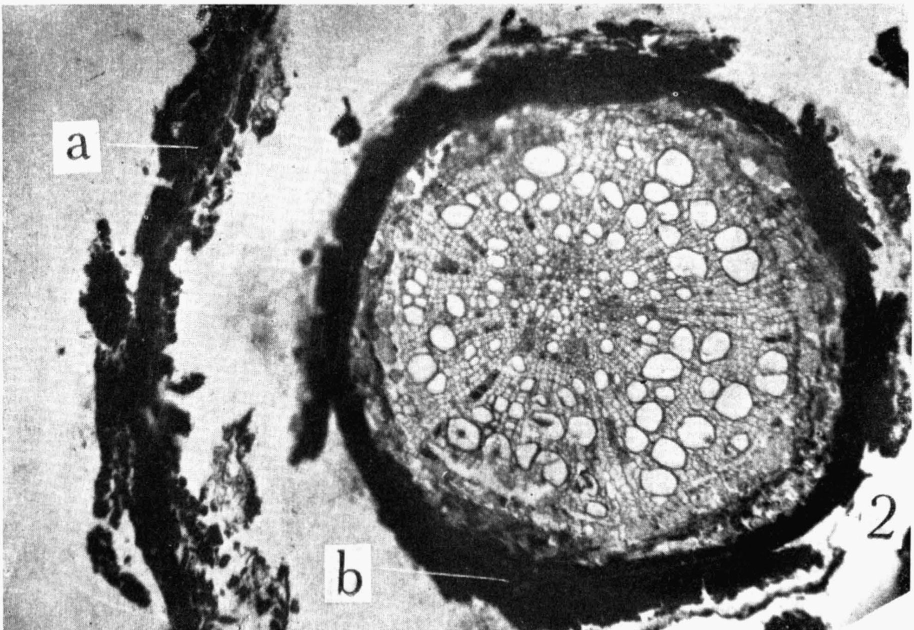
Tab. II. Fig. 3. Microphotograph showing the transverse section of old root together with many roots inside. Enlarged × 20, approx.

Fig. 4. Microphotograph of a part of Tab. II. showing the mycorrhizal mantle with attached prominent mycelia. Enlarged × 80, approx.

Author's Address:

D. N. Sen: Botanical Institute, Charles University, Praha 2, Benátská 2, Czechoslovakia,

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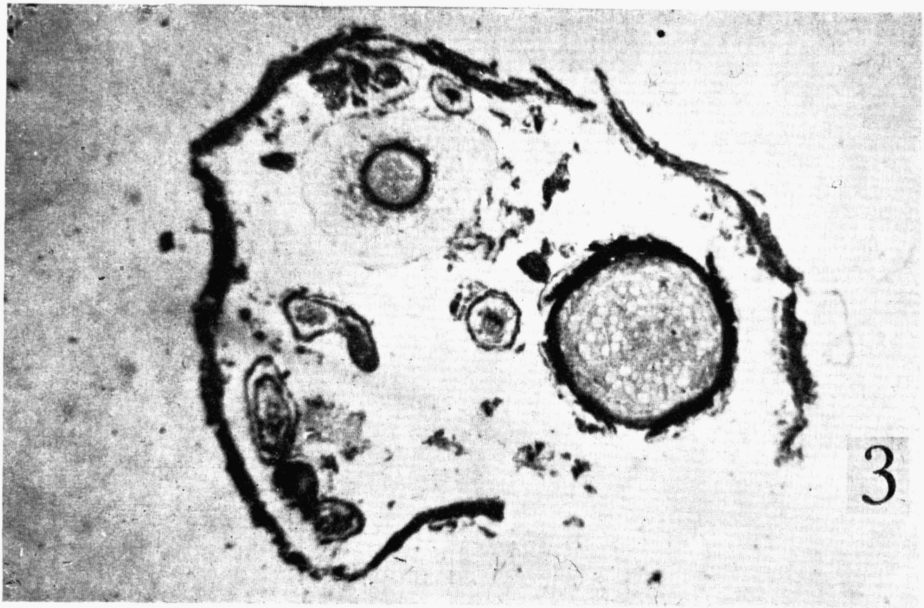


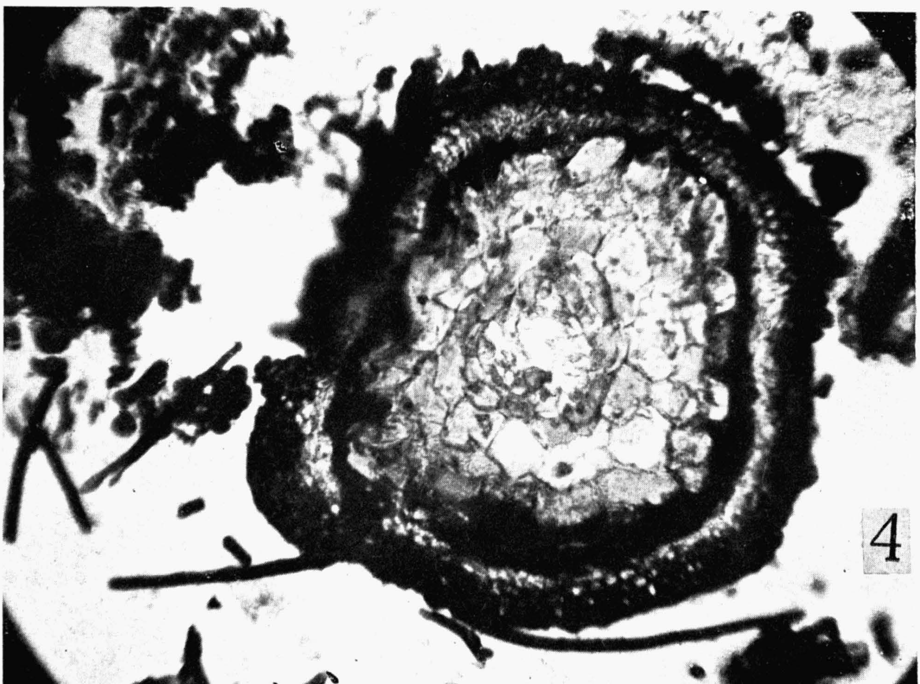


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