SOME ASPECTS CONCERNING THE INTERACTION BETWEEN NEEDLE SURFACES AND SOLID INDUSTRIAL POLLUTANTS

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ABSTRACT. The investigations made by us about the micromorphology of the foliar surfaces of two species of gymnosperms in the industrial areas Bicaz (the Neamţ District, Romania). The investigations of electronic microscopy (S.E.M.) made up at the level of necrotic and/or chlorosis surfaces (top, middle, basis) of the acicular leaves of *Pinus sylvestris* and *Pinus nigra* showed changes of the cuticular surface, their contortion, caused by the total disappearance of the parallelism between the cuticular prints, the chaotic setting of the stomata and their less dimensions, the presence of cuticular clefts, the closing of the ostiols with amorphous wax, which could be an indicator of the "suffering" of the leaf mesophyll in general. The analysis of the foliar surfaces by means of the S.E.M. revealed the role of the solid deposits of industrial origin in the phenomenon of partly defoliation or total one of the individuals, oftenly during the full season of vegetation.

Keywords: needle surfaces, industrial pollutants, micromorphology

INTRODUCTION

The investigations of electronic microscopy (S.E.M.) made up at the level of necrotic and/or chlorosis surfaces (top, middle, basis) of the acicular leaves of *Pinus sylvestris* and *Pinus nigra* showed changes of the cuticular surface, their contortion, caused by the total disappearance of the parallelism between the cuticular prints, the chaotic setting of the stomata and their less dimensions, the presence of cuticular clefts, the closing of the ostiols with amorphous wax, which could be an indicator of the "suffering" of the leaf mesophyll in general.

The analysis of the foliar surfaces by means of the S.E.M. revealed the role of the solid deposits of industrial origin in the phenomenon of partly defoliation or total one of the individuals, oftenly during the full season of vegetation. Such deposits deactivate important photosynthetic active parts; they hinder the respiration and perspiration by obstructing the stomata ostiols; they modify the characteristic cuticular relief by disorganizing the model of the cuticular striations; they modify the percentage between the crystallized wax and the amorphic one in the favour of the latter, which can partly contribute to the closing of the ostiols; there can be sometimes observed the lowering in quantity or even the absence of the epicuticular wax.

The solid deposits favour the growth of a microflora on the foliar surface (fungi and algae) which, as a rule, affect the general condition of the leaf. No matter of the chemical nature of the pollutant, the appearance of this microflora is an indicator of an early aging of the leaves and a possible cause of the defoliations which happen during the full season of vegetation. It is obvious that, alike the foliar surfaces, the appeared microflora is subjected to the impact with the industrial pollutants which can inhibit or, on the contrary, stimulate the extending.

MATERIAL AND METHODS

To examine the micromorphology of the needles we have used the scanning electron microscopy methods: the leaf samples were dehydrated using physical methods, metallised and analysed at the Tesla BS-340 scanning electron microscope. Microphotographs were taken from S.E.M.

RESULTS AND DISCUSSIONS

On the surface of control leaves from ***Pinus sylvestris*** were observed stomata disposing by parallel series, uniseriat, with a suprastomatal chamber bounded by a thin-tubular epicuticular wax form with reticular aspect. Between two stomata were observed some cuticular striations disposed parallel on main axis of epidermic cells (Plate 1, Figure 1).

On leaves surfaces from ***Pinus sylvestris*** from plants with visible "suffering" symptoms (partly defoliations in July) we noticed: presence of some solid deposits with a crustose aspect grouped together in compact structures by variable thickness (10 µm – 80 µm); presence of mycelian hyphae with a disposition like a "network" on the cuticular surfaces and, sometimes, even a penetration inside of large opened ostiols from stomata; the ostiols were obstructed with a mixture made by amorphous wax and some solid substance stranger from leaves – especially cement and lime powder; the epicuticular wax was prevalent amorphous and abundant on few portions; cuticular striations disposed parallel on main axis of epidermic cells became invisible, because of their deformation and incomplete enlightened, which could be an indicator of structure modifications of the cuticular surfaces; as consequences of these modifications, the typical disposition of stomata in parallel series was affected; solid deposits seems to be, from here and there, an important support for mycelian hyphae (Plate 1, Figure 2 and Figure 3).

On leaves surfaces from ***Pinus sylvestris***, which falling down together with the microblast, when they were mechanical touched, there were noticed the presence of some deposits which compactly occupied these areas and became unrecognizable (the cuticular striations are not observed); when the leaf was younger, it doesn't formed those striations maybe, because of these deposits; mycelian hyphae were absents, probably, because of the alcalin deposits which limited spore germination or became a barrier for stomatic and cuticular hyphal penetration (maybe hypha were "unable" to "recognize the host"); typical cuticular profile was both missing from here and there or is camouflaged by solid deposits a long of cuticular striations (Plate 1, Figure 4); from here and there, ostiols of stomata were closed either with amorphous wax or with a mixture by amorphous wax and polluting deposits (Plate 1, Figure 5); on the cuticle surface were observed some isolated micelian hyphae which, sometimes, surrounding stomata, without a penetration through ostiols (we suppose that it could be some hyphae from a epiparasite mycelium, or hyphae with a cuticular penetration, but we did not observed cuticle modifications from this point of view; we suppose, that some changes of hyphae "behavior" which "moving off" closed ostiols, could be another possibility); deformation, detachment and damage of parallelism in cuticular striations; crystallized wax which surrounded stomata would be unsettled and replaced by amorphous wax.

On leaves surfaces from ***Pinus sylvestris*** with necrotic and/or chlorotic areas, there were observed that the parallelism in cuticular striations was complete missing, a striations contortion, a disorganized disposition of stomata and the presence of few cuticular fissures; ostiols are closed by amorphous wax and another deposits (Plate 1, Figure 6 and Plate 2, Figure 7); the absence of micelian hyphae could be an indicator of the "suffering" of the leaf mesophyll; where it is kept, cuticular striations had a discontinous disposition; on areas where the polluting deposits are bigger, all stomata were smaller (from 30-35 μm to 15-25 μm) (Plate 2, Figure 8). We supposed that the polluting deposits abandoned necrotic areas because of losing contact with cuticular surfaces and because those tissue is dead deep inside of it. This is, we supposed, the main reason for those "spectacular" deformations resulted after the deposits from foliar surface were falling down.

Leaves surfaces from ***Pinus nigra*** indicated the presence of stomata in parallel and uniseriate ribs as at the ***Pinus sylvestris*** and the presence of some cuticular striations with a parallel disposition, the distance between striations is larger comparatively with previous specie. Epicuticular wax is mainly amorphous; black halo which surrounded stomata were from suprastomatic chambers (Plate 2, Figure 9).

On leaves surfaces from individuals which presented almost total defoliations it was registered a cuticle without a compact disposition, with cuticular structure very difficult to observe; solid deposits were situated in spaces between striations, but the ostiols are not closed by amorphous wax or solid deposits; micelian hyphae were not present (Plate 2, Figure 10 and Plate 3, Figure 11); sometimes, without significant deposits, we noticed some deformations of cuticular striations and different closing phases of ostiols with amorphous wax; crystallized wax could be observed between cuticular striations. In the same time, around stomata, at suprastomatic chambers level we observed amorphous wax agglomerations which often covered stomata completely (Plate 3, Figure 12); other times, adherent deposits was associated with isolated hyphae which was situated on cuticular surfaces; some stomata were deformed (Plate 3, Figure 13).

On leaves surfaces with necrotic bands on top (Plate 3, Figure 13), on basis near by the microblast or at the middle area (Plate 3, Figure 14) we observed an atypical cuticular profile with striations without parallel disposition but which were intensely curved, probably because of the highest dehydration of those surfaces; it could be noticed a tendency to be closer of stomata ribs, and, in the same time, ostiols were closed by amorphous wax and solid deposits. Similar with necrotic areas from ***P. sylvestris*** leaves, a falling down process of former crusts through contracting of foliar surfaces gave us the possibility to observe all deformations.

Sometimes, besides polluting deposits it was observed some big structures, which are not amorphous wax deposits, but they were observed only on polluted leaves surfaces.

CONCLUSIONS

Analysis on foliar surfaces with electronic microscopy (S.E.M.) showed the role of solid deposits of industrial origin in the phenomenon of partly defoliation or total one of the individuals, often during the full season of vegetation. Those deposits deactivate important photosynthetic active parts; they hinder the respiration and perspiration by obstructing the stomata ostiols; they modify the characteristic cuticular relief by disorganizing the model of the cuticular striations; they modify the percentage between the crystallized wax and the amorphous one in the favour of the latter, which can partly contribute to the closing of the ostiols; sometimes, there can be observed the lowering in quantity or even the absence of the epicuticular wax.

The solid deposits favour the growth of a microflora on the foliar surface (fungi and algae) which, usually, affect the general condition of the leaf. No matter of the chemical nature of the pollutant, the appearance of this microflora is an indicator of an early aging of the leaves and a possible cause of the defoliations which happen during the full season of vegetation. It is obvious that, alike the foliar surfaces, the appeared microflora is subjected to the impact with the industrial pollutants which can inhibit or, on the contrary, stimulate the extending.

Sometimes, defoliation phenomenon presents particular manifestations: acicular leaves falling down together with microblasts (*Pinus sylvestris*), completely detachment of branches with leaves on them, because of bigger noxa solid deposits (*Pinus nigra*).

Plate 1

FIGURE 1. *Pinus sylvestris* - adaxial surface of the control needle

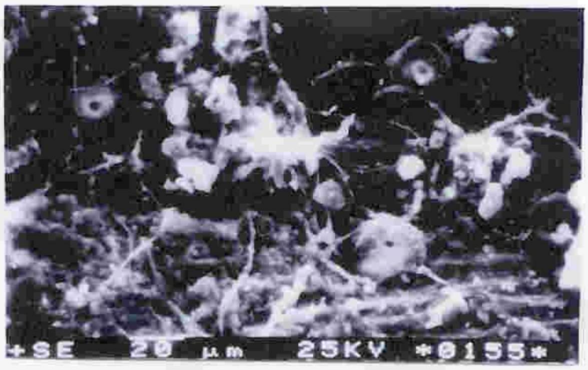

FIGURE 2. *Pinus sylvestris* – adaxial surface of the polluted needle

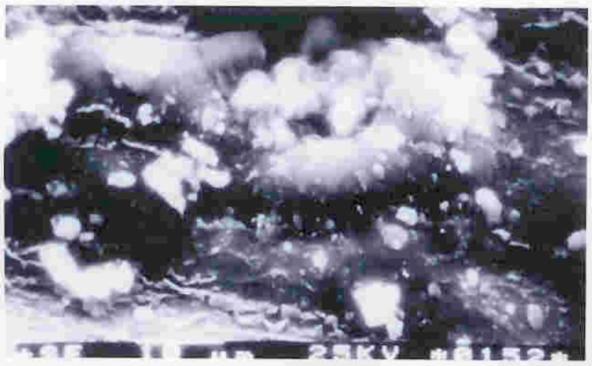

FIGURE 3. *Pinus sylvestris* – adaxial surface of the polluted needle

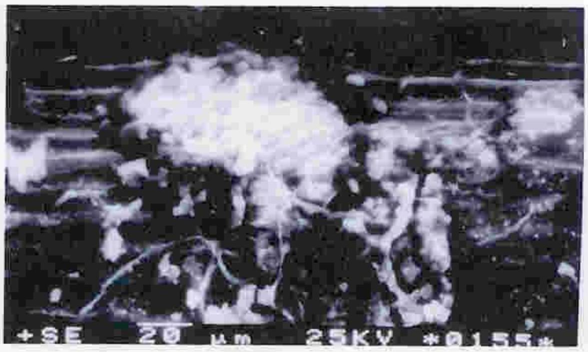

FIGURE 4. *Pinus sylvestris* – adaxial surface of the polluted needle

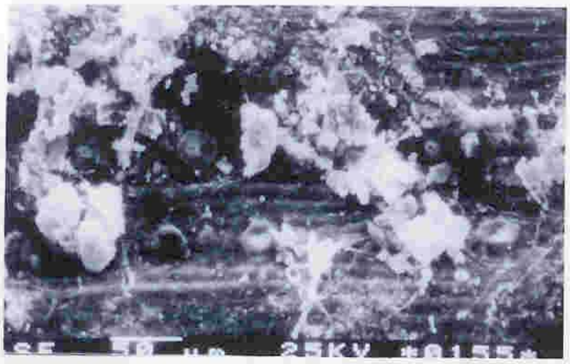

FIGURE 5. *Pinus sylvestris* – abaxial surface of the polluted needle

Figure 6. *Pinus sylvestris* – abaxial surface of the pollute needle

Plate 2

FIGURE 7. *Pinus sylvestris* – abaxial surface of the polluted needle

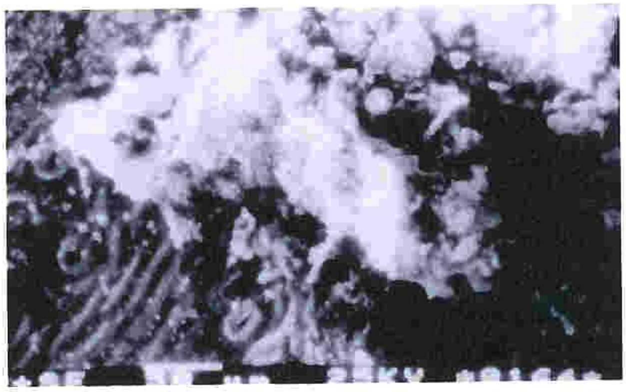

FIGURE 8. *Pinus sylvestris* – abaxial surface of the polluted needle

FIGURE 9. *Pinus nigra* – adaxial surface of the polluted needle

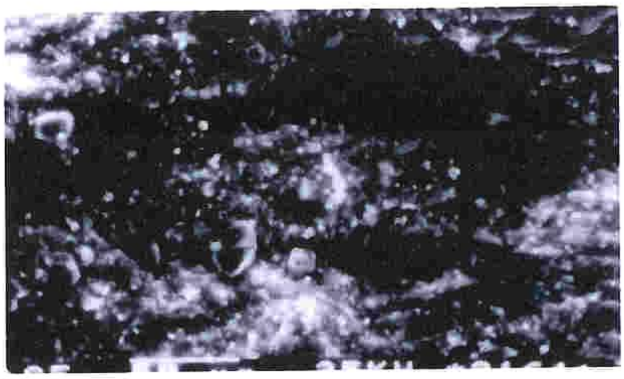

FIGURE 10. *Pinus nigra* – adaxial surface of the polluted needle

Plate 3

FIGURE 11. *Pinus nigra* – adaxial surface of the polluted needle

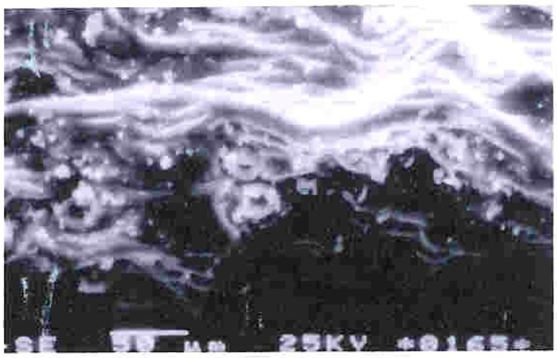

FIGURE 12. *Pinus nigra* – abaxial surface of the polluted needle

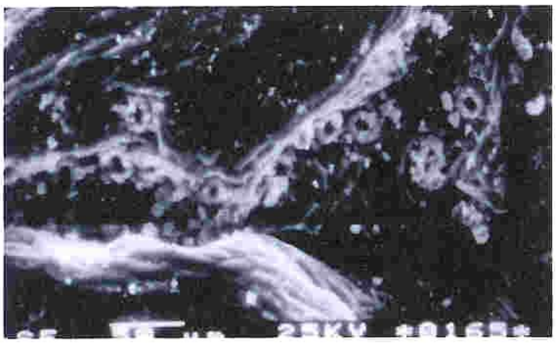

FIGURE 13. *Pinus nigra* – abaxial surface of the polluted needle

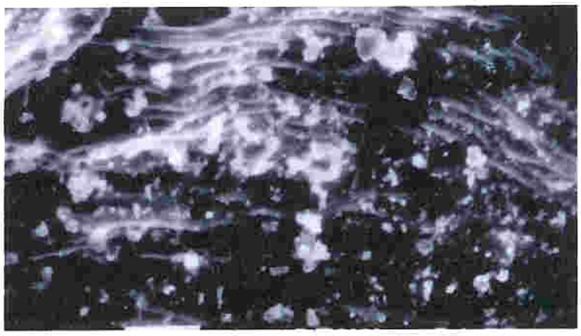

FIGURE 14. *Pinus nigra* – abaxial surface of the polluted needle

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