RADIAL INCREMENTS DISTRIBUTION ON SILVER FIR TREES' STEMS AFFECTED BY MISTLETOE (*VISCUM ALBUM* SSP. *ABIETIS*). A CASE STUDY IN EASTERN CARPATHIANS

DISTRIBUȚIA CREȘTERILOR RADIALE PE FUSUL ARBORILOR DE BRAD PARAZITAȚI DE VÂSC (*VISCUM ALBUM* SSP. *ABIETIS*). STUDIU DE CAZ ÎN CARPAȚII ORIENTALI

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Abstract. *Viscum album ssp. abietis (Wiesb) Abrom L. has negative effects on forests and trees health. The present study, regarding the influence of mistletoe infection on radial increments distribution on silver fir trees stems, was carried out in natural stands of Forest District Solca (North part of Eastern Carpathians). The mistletoe infection was presented according to the damage degree of silver fir trees from 0 (healthy trees) to 3 (heavily infected trees). The measurements were carried out on twelve trees, three trees for each infection class. It was found that mistletoe's impact on the radial growth distribution on the stem is higher once the infection degree goes up.*
Key words*: Viscum album ssp. abietis, silver fir, radial increments distribution, damage degree*

Rezumat. *Viscum album ssp. abietis (Wiesb) Abrom L. are un efect negativ asupra sănătății arborilor si arboretelor de brad. Prezentul studiu, care urmărește influența atacului de vâsc asupra distribuției creșterilor radiale pe fusul arborilor de brad parazitați a fost realizat în Ocolul silvic Solca (partea nordică a Carpaților Orientali). Impactul atacului de vâsc este prezentat în acord cu gradul de infecție al arborilor de la 0 (arbori sănătoși) la 3 (arbori puternic parazitați). Măsurătorile au fost realizate pe un număr de 12 arbori, câte 3 arbori pentru fiecare clasă de infecție. S-a constatat că impactul vâscului asupra distribuției creșterilor radiale pe fus crește pe măsură ce crește gradul de infecție.*
Cuvinte cheie*: Viscum album ssp. abietis, arbori de brad, creșteri radiale, gradul de infecție*

INTRODUCTION

Viscum album ssp. *abietis* is one of the three subspecies of *Viscum album* parasitizing species of *Abies*. The mistletoe impact on the host trees can be seen from physiological and anatomical point of view, mistletoe affecting trees growth on the one hand and wood quality on the other (Hawksworth et Wiens, 1996).

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The presence of the cortical strands and of the haustors causes a host reaction manifested by tissue hypertrophy - thickening of the branches or trunk - on the area of mistletoe infection (Anonyme 1934; Plagnat , 1950; Barbu , 2009).

According to Barbu, 1995 and Noetzli K. et. al., 2003, silver fir trees become susceptible to mistletoe infection after 70 years, others authors considering that the host trees are infected after 120 years (Plagnat,1950).

The present study analyzes the distribution of radial increments on silver fir trees with different infection degree. The main objective was to show whether infected and uninfected trees show differences in their growth behavior.

MATERIAL AND METHOD

The research was carried out in a sample plot of one hectare placed in a 120 years old silver fir stand from Forest District Solca (North part of Eastern Carpathians, Romania), where more than 70% of the trees have mistletoe related damages. The coordinates of study plot are: $47^0$43 ‘17” latitude, $25^0$49 ’57” longitude and 520 meters altitude.

For each tree of the sample plot the degree of mistletoe infection was assessed using 4 class rating system: (i) class 0 - healthy trees; (ii) class 1 - low infection; (iii) class 2 - moderate infection and (iv) class 3 – heavy infection (Barbu, 2009). Diameter at breast height (DBH) and height were measured as well. For the measurements, 12 trees - pre-dominant and dominant (according to Kraft’s classification) (Kramer et. Ak□a , 1987) were selected and felled, three tree of each infection class. The crown condition, DBH and height were similar for each triple of trees (Barbu, 2012).

After felling each tree was cross-cut at different levels on the stem (0.3 m, 1,3 m, 12 m, 20 m, 23 m, 26 m, 29 m). A stem disk was taken from each cross section. Annual growth increment was measured on four representative radii of each stem disk (in areas with and without haustors) using a tree-ring analysis machine (LINTAB, Rinntech) with a precision of 0.001 mm.

The age of mistletoe attack was determined using the “laboratory method” (Noetzli et. al., 2003). With this method it was possible to count the number of growth rings of the host stem penetrated by mistletoe haustors. This number corresponds with the number of years since the mistletoe has been established on the tree.

RESULTS AND DISCUSSIONS

In the evolution of the radial growth of **healthy trees (A0)**, three periods of ascending growth can be observed (1915-1930, 1945-1965, 1990-2000), alternated by three descending growth periods (1930-1945, 1960-1985, 2000-2005). Out of these periods, the most pronounced decrease in growth can be observed between 1975 and 1987 (figure 1A, B, C, D). This is the period when, all across Europe forests were in crisis, as a consequence of high pollution levels. After 1987, the intensity of die-back of the trees has decreased significantly, due to the improvement in environmental conditions.

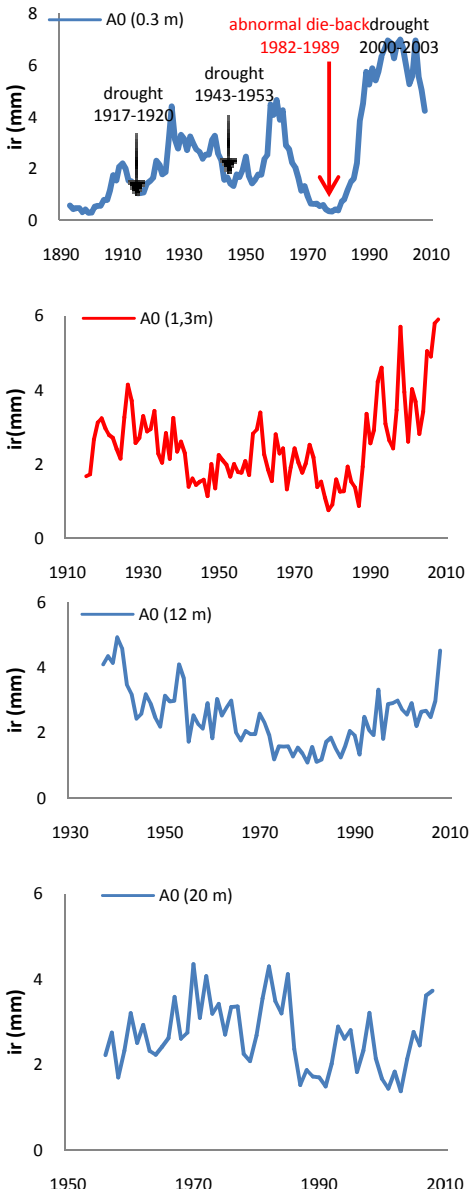

Fig. 1 - Mean radial increments for healthy trees – A0 (class 0 of infection) at different levels on the stem

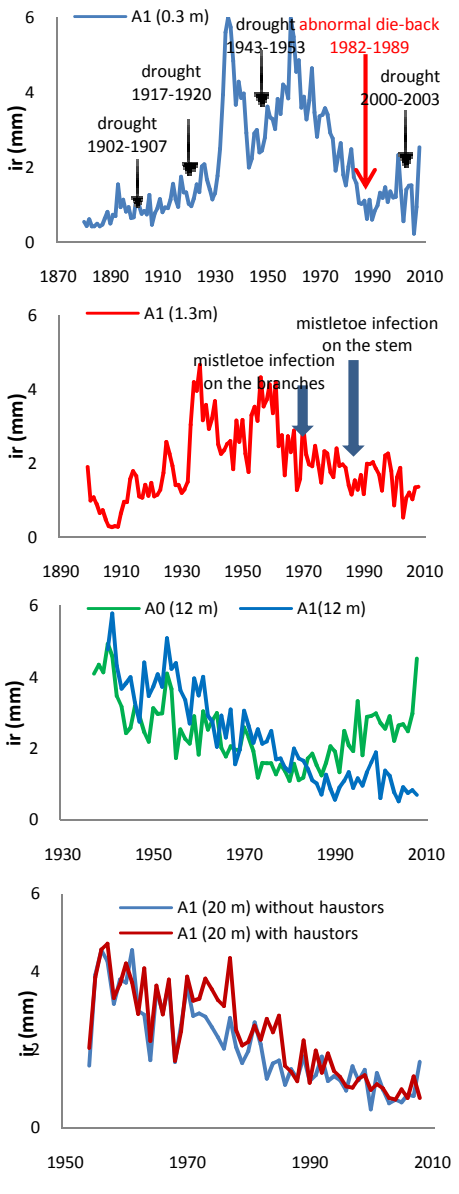

Fig. 2 - Mean radial increments for the trees of 1st infection class – A1 (low infection) at different levels on the stem

For the trees of 1st class of infection (low infection) (A1) the age of mistletoe infection is 20-25 years. In this case, we estimate that the infection on the branches dates back to 1965, with a descent to the stem (by endophytic system – cortical strands and haustors) in 1985 (figure 2 A, B). After this date, the radial

growth in the 1.3 m section remains very low and shows no signs of recovery. The same trend can be observed in all the others sections (figure 2 C, D).

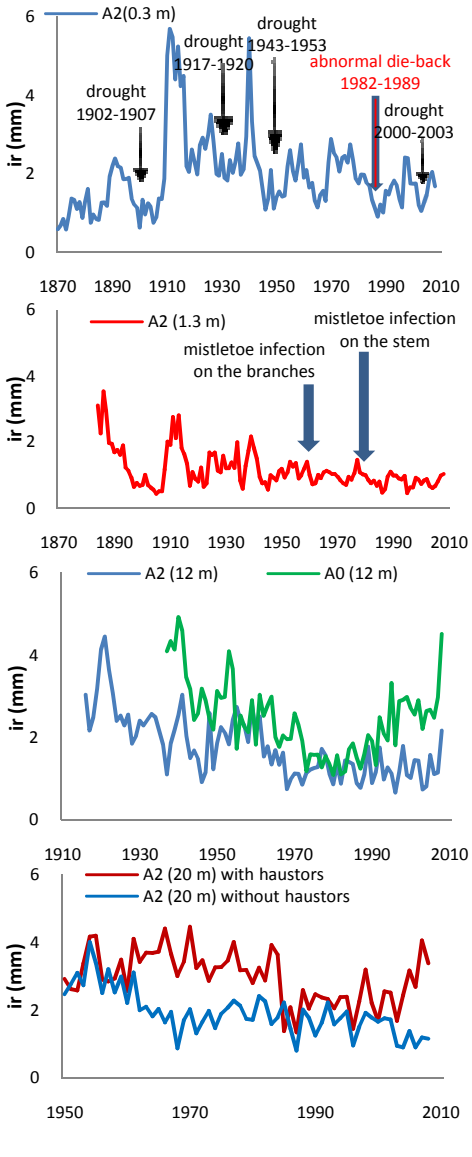

Fig. 3 - Mean radial increments for the trees of 2nd infection class – A2 (moderate infection) at different levels on the stem

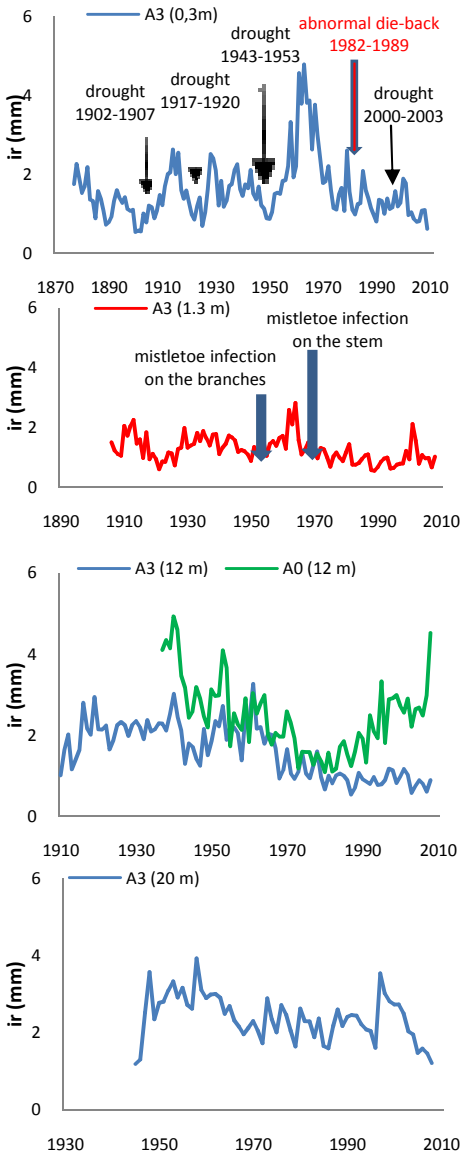

Fig. 4 - Mean radial increments for the trees of 3rd infection class – A3 (heavy infection) at different levels on the stem

For the trees of 2nd class of infection (moderate infection) (A2) the age of the infection has been estimated at 40-45 years. In this case, the infection on the

branches dates back to 1953-1955, after the drought of 1943-1949 (Topor N.,1963). The infection spread to the stem between 1960 and 1970. The downward trend of the radial growth after this period is visible not only in the section located at the base of the stem, but in all the other analyzed sections (figure 3 A, B, C, D). After the mistletoe infection has settled, the growth of the tree is close to minimum, similar to the growth during the 1945-1947 drought. This suggests that the mistletoe infection has the same effect as a severe drought, as noticed in the growth rings after 1970.

For the trees of 3rd class of infection (heavy infection) (A3) the age of the infection has been estimated at 45-50 years. The infection settled on the branches between 1950 and 1955, after the 1943-1949 drought. The infection became systemic in the 1960-1970 interval. After 1965, a noticeable decrease in growth can be observed (figure 4 A, B, C, D).

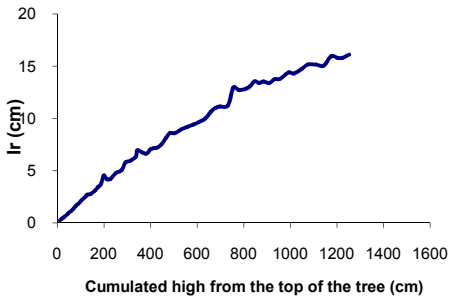

Fig. 5 - Height and radial increment in the first 15 meters from the top of healthy trees (A0)

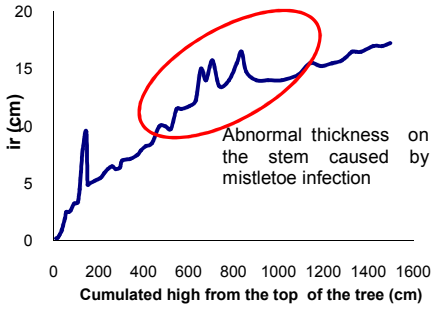

Fig. 6 - Height and diameter increment in the first 15 meters from the top of trees from 1st infection class (A1) – low infection

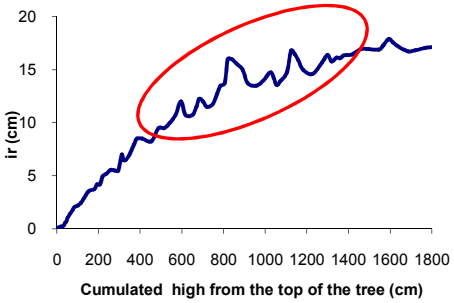

Fig. 7 - Height and diameter increment in the first 20 meters from the top of trees from 2nd infection class (A2) – moderate infection

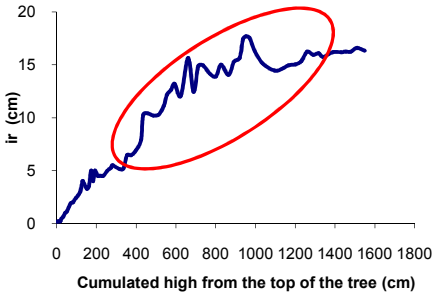

Fig. 8 - Height and diameter increment in the first 18 meters from the top of trees from 3rd infection class (A3) – heavy infection

Initially, the infection manifests itself on the branches. At this time, the influence of the parasite on the host tree increments is negligible. Once the

mistletoe descends through its endophytic system to their insertion point on the stem and then to the stem itself, the effect is visible compared to healthy trees. Once the infection of the stem is complete, the growth becomes uneven, with infected areas showing a much higher increase in wood mass (figures 5, 6, 7, 8). This abnormal growth inhibits the normal growth in diameter and instead forms thickenings around the sinkers.

CONCLUSIONS

1. Before the onset of infection, trees currently assessed into 1st, 2nd and 3rd class of infection had similar growth with healthy trees.

2. Although the radial growth in areas with haustors are higher, overall radial growth of infected trees is much smaller.

3. The mistletoe have a more negative impact on its host's radial growth distribution once the infection degree goes up.

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