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The dependence of plant mass and productivity on the age of stands in oak forests of the Eastern Carpathians

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Abstract. On the basis of data on structure and productivity of oak (*Quercus robur* L.) forests of different age (33,54, 75, 106 year) in the Eastern Carpathians, plant mass fluctuation in the range of 120.5- 239.8 t · ha $^{-1}$ (absolute dry weight) were studied Mass of stems and roots changed in the range of 66.9- 146.5 and 27.9- 45.4 t· ha^{-1} respectively. The relationship between the mass of leaves to mass of thin roots for the studied plots was 3.5 – 4.0. The total aboveground plant mass surface was 104-164 thousand m^2 · ha^{-1}.
Key-words: Oak, forests, plant mass, productivity, age, Eastern Carpathians

Introduction

Oak forests were formed at the Eastern Carpathians in mid - Holocene (7,800-3,300 years ago). The area of oak forests decreased under the influence of anthropogenic pressure.

At present oak forests have small density of stocking. In the age of 70 years, and older density of stocking do not exceed 0,6. Oak forests in the Eastern Carpathians reached lower plant mass than oak forests in Belgium (Duvigneaud *et al.*, 1971; Kestemont 1971), Czechoslovakia (Vyskot 1976), France (Lossaint and Rapp 1978), Poland (Medwecka-Kornas *et al.* 1974), Sweden (Andersson 1970), Switzerland (Burger 1947), United Kingdom (Sykes and Bunce 1970) and USSR (Rodin and Bazilevich 1967; Goryshina 1974).

Our study has been carried out in order to find the dependence of oak forest plant mass and productivity on the age of tree stands in the Eastern Carpathians.

Materials and methods

Study plots were located in Eastern Carpathians hills at the altitude 330-360 m. about s. l. on the soddy podzolic soils. The stand analyses were performed inside the 2000 m^2 (40m x 50 m) plots. Within the plot the number of trees was counted. Each tree was numbered for easy identification. The breast height (1.3 m aboveground height on the uphill side of the tree) was permanently marked around each trunk with point. In all trees the trunk diameter at breast height (D B H) was measured.

Sample of 21 trees represented the range of different diameters and heights for each stand. Samples (model trees) were cut at the end of vegetation period (August - September) in the neighbourhood of the plots. The stem was divided into 1 m sections, which were weighed. Sample discs 5 cm tall, were cut at the base of each log and taken for annual ring analysis. In each section the mass, surface of separate fractions of stems, branches and assimilative organs were determined.

Different fraction of aboveground mass (branches, leaves, fruits) were analyzed after the recommendation (Newbould 1967; Rodin and Bazilevich 1967; Andersson 1970; Nihlgard 1972; Utkin 1975; Lochmus and Oja 1983).

The determination of below ground mass was performed on trees of different diameters from each stand. Finer roots or roots having a diameter less than 0.5 cm including tree and shrub roots and the below ground organs of ground flora were sampled from pits 50 x 50 x 60 cm giving the fine root mass.

The litter fall in the studied plots was collected in 20 litter traps (50 x 50 x 30, placed 25 cm above the ground surface). The traps were emptied once a month.

The mass of the ground vegetation layer was estimated of 25 plots for every stand, each 1 m^2.

Obtained data were analysed by the methods of variation statistics. The determination of fraction indices was done with the approximation of 2-5%.

Results

1. Total plant mass of oak forest in age ranging from 33 to 106 years (the absolute dry weight) was between 120.5 t · ha^{-1} in 33-year old forest to 239.8 t.ha^{-1} in 106-year old forest (Fig .1).

Dry mass was higher (355.4 t·ha^{-1}) in 120 years old (Duvigneaud *et al.*, 1971) then in 66 year old forests (213.3 t·ha^{-1}; Kestemont, 1971) in Belgium. In Moravia forest the dry mass was 360 t . ha^{-1} in 96 year old forest.

2. The main mass of organic matter was concentrated in the tree layer. Mass of stems increased with age 2.2 times (from 67 t · ha^{-1} to 147 t · ha^{-1}; Fig. 2) and roots 1.6 times from 27.9 t.ha^{-1} in 33-year old forest to 45.4 t ·

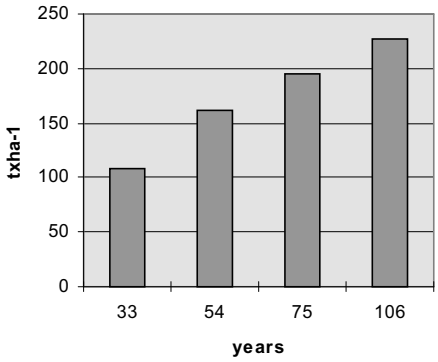

Fig. 1. Total plant mass of studied oak forests

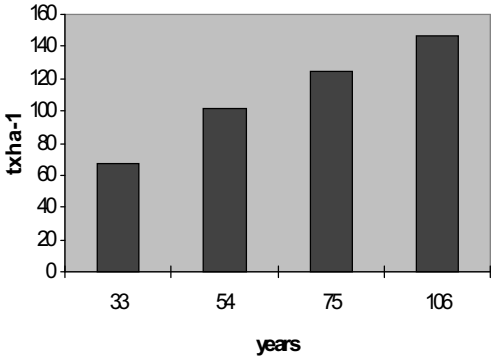

Fig. 2. The mass of branches in studied oak forests

ha^{-1} in 106-year old forest (Fig. 3).The relation of the aboveground plant mass to the underground was 2.9 for 33 years and 4.0 for 106 year old forests. This confirms faster increase of above ground mass than under ground with age.

3. The mass of branches increased with age more than 3,5 times (from 9.7 t · ha^{-1} in 33-year old forest to 32.1 t · ha^{-1} in 106-year old forest; Fig .4).

4.Thin roots (less than 0.5 mm) are of major importance in exchange between soil and plants. In oak forests thin roots reached 1.6-3.4 % of the general mass of roots. The proportion of thin roots decreased with the age of a stand. Relation between leaves and thin roots equalled 3.5 - 4.0. It was 2 times more than in beech forest (Kozak and Holubets, 1997).

5. Phytomass was 6.9 - 11.8 t · ha^{-1} in the below vegetation. It equalled 3 - 10 % of the plant mass in general. The mass of grasses level depended on the quality of light under trees. In the condition where the percentage of grass in ground cover was 40 - 50 %, the mass reserve was 0.9 - 1.4 t · ha^{-1}. In altered stands, where the density of forest was 0.6, the total mass reserve at grass level was 6.0 t · ha^{-1}.

6. The total contact surface of aboveground part

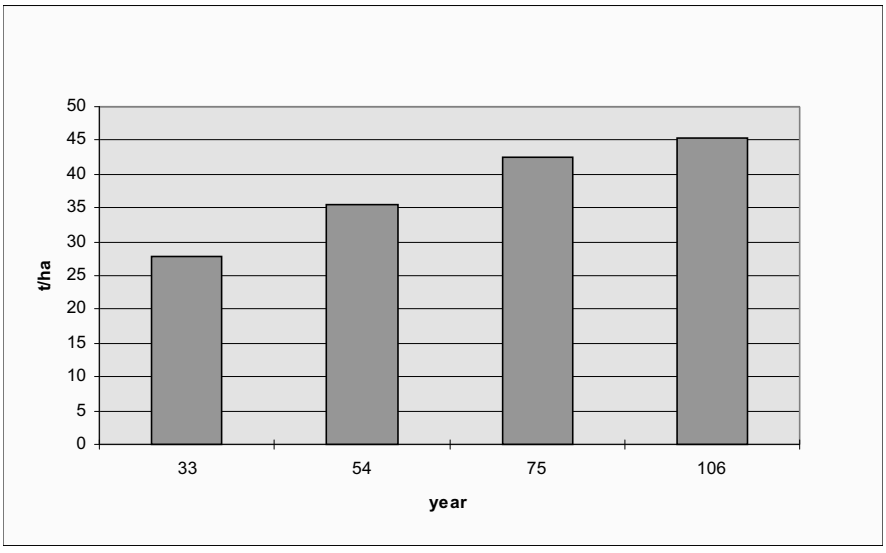

Fig. 3. Total mass of stems in studied oak forests

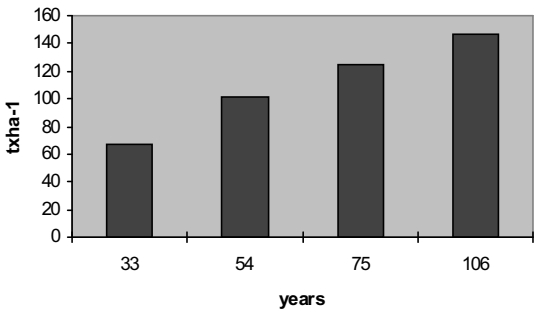

Fig. 4 Total mass of roots in studied oak forest

of oak forests was 104 - 164 thousand $m^2 \cdot ha^{-1}$. That confirms the important role of the surface in the functioning of oak forest ecosystems. The leaf area index decreased with age of the stand.

Discussion

Oak forests are distributed in the lower parts of the Eastern Carpathians. Those forests do not reveal high accumulation of organic matter. Following Bazilevich and Rodin (1975) those forests were estimated as a VII class.

For example in the Caucasus, the average plant mass of oak forests was 182 t · ha^{-1} and productivity 10.7 t · ha^{-1} (Aliev and Gasanov 1974; Gasanov 1980). The total above ground mass at the stand age of 29 years was 175.5 t· ha^{-1} (as dry matter)in oak forests (type group Carpineto - Quercetum) on the alluvial soil in the Nitra river in Czechoslovakia (Tokar 1987). The highest part belongs to trunk mass (86.1 % as fresh matter and 87.3 % as dry matter). In our research plots the highest proportions belonging to trunk mass are 55.5 % in the 33 years old stand, and 61.1 % in the 106 years old stand (as dry matter).

Oak forest stands have the high leaf area index (8.5 ha· ha^{-1} in the 33 year old oak forest stand). For example in oak forest in Czechoslovakia (Tokar 1987) the leaf area index makes 6.02 ha · ha^{-1} in 29 year old forest stand.

In the Eastern Carpathians region oak forests are drying. The density of oak forests decreased (from 0.8 in 33 year to 0.6 in 106 year old stands). As a result of this the productive function of oak forest ecosystems in the Eastern Carpathians decreased.

Conclusions

In the Eastern Carpathians oak forests did not reveal high accumulation of organic matter. The main part of this mass was accumulated in stems (from 56% in 33 yeas old forest stand to 61% in 106 year old stand). Nineteen percent of plant mass in 33 year old stand and 23% in the 106 year stand was accumulated in roots. 8-13% of plant mass was accumulated in branches and 2.7-1.2% in leaves. 0.7-2.5% of the plant mass was in the grass layer.

Oak forest stands have the highest leaf area index. That is important indicator of the transformation functions of the oak forest communities.

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