*Ann Sci For* (1993) 50, 607-614



**Original article**

# Improvement and silviculture of oaks in Hungary

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(Received 6 January 1993; accepted 2 June 1993)

**Summary** — The most important tree species in Hungary are the indigenous oak secies (*Quercus sessiliflora, Q robur, Q cerris*). They form mixed stands, most frequently with hornbeam (*Carpinus betulus*) and beech (*Fagus sylvatica*). They occupy nearly 35% of the Hungarian forests. For oak timber, the allowable cut exceeds demand; it is therefore possible to export the more valuable mixtures. Producing valuable oak timber is of great importance for Hungarian forestry. Veneer logs of good quality can be harvested from mixed 2-storied oak stands (*Carpineto quercetum, Querceto fagetum*). The majority of these stands should be regenerated naturally. The success of regeneration depends on the acorn yield, the opening of crown closure, as well as the game population. The number of seedlings per ha varies between 50 and 100 thousand, which should be decreased to 150–450 stems per ha by the rotation age of 100–130 yr, depending on site quality. The results of research on natural regeneration and thinning are employed in forestry practice. The yield tables and tending models for unmixed and mixed oak stands have become basic references for valuable oak timber production. The importance of oaks in Hungarian forestry will remain decisive. The recent oak decline has caused considerable damage and is only improving slowly. This does not, however, reduce the importance of oaks which are not only a source of valuable timber, but also an indigenous structural part of stable forest ecosystems.

**valuable oak / stand model / mixed and unmixed forest**

**Résumé — Amélioration et sylviculture des chênes en Hongrie.** *En Hongrie, les plus importantes essences forestières sont les chênes indigènes (*Quercus sessiliflora, Quercus robur, Quercus cerris*). Les chênes constituent le plus souvent des peuplements mélangés avec le charme et le hêtre. Ils occupent près de 35% de la surface forestière. La possibilité de l'exploitation du chêne dépasse les besoins du pays et l'on peut exporter les assortiments ayant la plus grande valeur. L'importance de la production de chêne de qualité est décisive pour la sylviculture hongroise. On peut produire des grumes de bonne qualité pour l'industrie de placage, en premier lieu dans les chênaies mélangées à double étage (*Carpineto Quercetum, Querceto Fagetum*). On doit les régénérer dans la majorité des cas par voie naturelle. Le résultat dépend, outre l'importance de la glandée, de l'ouverture du peuplement et de l'importance du gibier. En général, la densité de semis, qui au départ varie de 50 000 à 100 000 tiges/ha, est progressivement réduite et atteint au moment de la coupe définitive (100 à 130 ans) 150 à 450 tiges/ha (en relation avec le type de station). Dans la pratique, pour la régénération naturelle et les coupes d'amélioration, on utilise couramment les résultats de la recherche. Les tables de production créées pour les chênaies pures et mélangées et les modèles de*

*sylviculture sont devenus des aides essentielles pour la production du chêne de grande valeur. Dans l'avenir, les chênes continueront à avoir une importance décisive pour la sylviculture hongroise, tant par la production de bois de grande valeur, que comme composante essentielle de la stabilité des écosystèmes forestiers. Le dépérissement du chêne, qui a causé au cours des dernières années des dégâts considérables, diminue maintenant.*

***chêne / forêt mélangée et pure / modèle de sylviculture***

## THE ROLE OF OAKS

Hungary is the home of broad-leaved forests, predominantly oaks. The country's ecological conditions are mainly favourable for sessile oak *(Q sessiliflora)* pedunculate oak *(Q robur)* and Turkey oak *(Q cerris)*. All 3 species are autochthonous in Hungary and together cover 34.2% of the forested area in the country. The growing stock of oak stands amounts to 40% of the total of all forests. The percentages of the 3 oak species, in numerical order, are as follows: sessile oak 12%, Turkey oak 11.3%, pedunculate oak 9.2%. The remaining 1.7% is composed of pubescent oak *(Q pubescens)* and red oak. According to estimations, 9 different oak species are found in the country.

Oaks in Hungary form pure and mainly mixed stands. The oak–hornbeam *(Quercus–Carpinus)* and oak–hornbeam–beech *(Quercus–Carpinus–Fagus)* as well as oak–Turkey oak mixed stands are the most characteristic. The existence of oaks at a relatively high production rate can be attributed to their good sprouting capacity. An unfavourable factor is that the ratio of sessile: Turkey oak stands of coppice origin is high, *ie* 51% coppice to 39% seed origin and the value of pedunculate oak stands is ≈ 8%. The coppice system has spread in connection with fuelwood production, although valuable oak timber can be produced in coppice forests in a smaller quantity. However, growing high-value timber is most expedient in oak stands of seed origin, mixed with hornbeam, beech and lime *(Tilia parvifolia)*.

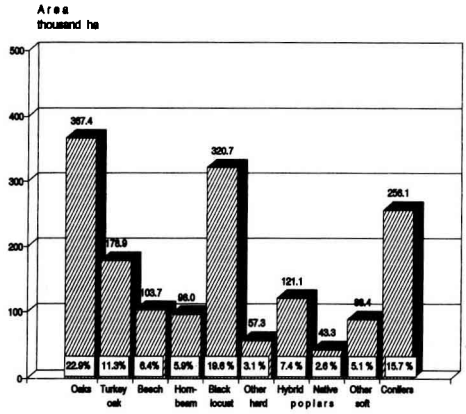


**Fig 1.** Distribution of the forest area by the main species.

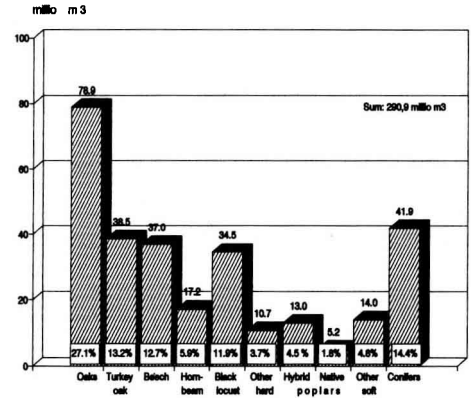


**Fig 2.** Stock of growing timber by the main forest species.

**Table I.** Forests in Hungary: management by several owner groups (sectors).

| *Sector* | *Area for forest management (in 1 000 ha)* | *Growing stock (million $m^3$)* |
|---|---|---|
| State forest enterprises | 1 039 | 185 |
| Other forest enterprises | 80 | 13 |
| State farms | 76 | 7 |
| Water management | 11 | 1 |
| Other, state-owned | 26 | 2 |
| Agricultural cooperative | 491 | 59 |
| Municipal communities | 5 | 1 |
| Other, non-stage-owned | 5 | 1 |
| Total | 1 733 | 269 |

| *Species group* | *Annual* | |
|---|---|---|
| | *Regeneration (in 1 000 ha)* | *Afforestation (in 1 000 ha)* |
| Oaks | 4.5 | 1.7 |
| Beech | 0.7 | – |
| Black locust | 6.5 | 1.4 |
| Other hardwoods | 1.2 | 0.4 |
| Soft broad-leaved | 3.7 | 2.4 |
| Conifers | 2.6 | 1.7 |
| Total | 19.2 | 7.6 |

The role of oak stands will not decrease in Hungarian forestry practice in the future. Their area is increasing slightly. Production of valuable oak timber will remain the principal goal even in times to come wherever site and stand conditions are suitable.

## SITE CONDITIONS AND OAK SPECIES

Considering the country's site conditions, sessile oak is of the greatest importance. Mixed with hornbeam and beech, it forms the most favourable stable ecosystems in mountainous and hilly regions. Pedunculate oak is the tree of the lowlands. In view of the lowland character of Hungary, pedunculate oak would be the country's most important species, if the stands that covered much of the good-quality areas for this tree had not been removed in former centuries to make way for valuable agricultural land. A proportion of its most favourable sites has been occupied by fast-growing hybrid poplars during the last decades. At the same time, Turkey oak covers larger areas; this oak species, owing to its abundant acorn crop and excellent sprouting capacity, is to be found on many sites and not only on dry, shallow soils. In many

instances, it has displaced pedunculate oak and sessile oak stands even from sites of better quality. The site requirements of all oak species have been determined by research work. On the basis of the results achieved, in the future it will be possible to choose the oak species to be planted according to site quality.

## TRADITIONS OF OAK GROWING AND THE RESEARCH IN FORESTRY

It also follows from the above-mentioned brief statements that growing oak stands for production of high-value timber is of primary importance. The economic benefit of producing large-sized timber of excellent quality and high value is indisputable. For this purpose suitable ecological conditions have to be taken into account. This fact has been previously recognized by forestry in Hungary though, in the course of the earlier centuries, oak stands were utilized mainly for masting (pig-breeding) and producing fuelwood. However, in the last century, the sawmill and panel industries (veneer production) developed rapidly, and the demand for the products of these industries increased the importance of growing valuable oak timber. Proof of this is indicated by the fact that the one-time European shipbuilders preferred the good-quality oak timber produced in Hungary. This demand also contributed to the decrease in the area of the earlier oak stands. Both centuries-old experience and the large proportion of oak stands promoted the development of oak-growing in Hungary.

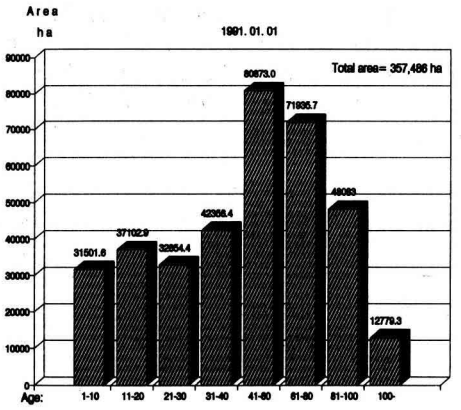


**Fig 3.** Distribution of age classes by oaks.

Organized forestry research started in Hungary 95 years ago. Oak growing was a high-priority theme in the initial period of research. In recent decades, research on oak has further increased. The national network of long-term forest tending and yield experimental plots has been developed in the last 30 yr. A short review will now be given of research results and practical experience relating to growing oak stands of high value on the basis of the repeated inventory of experimental plots. Several researchers have been and still are engaged in this research work: they include Z Fekete, G Róth, R Kiss, A Szappanos and A Béky. For the time being, this research is directed by A Béky.

Forestry research provides tables which given information on the results attainable by growing oak species all over the country, and on the preconditions for producing high-value oak timber on suitable sites. Oak species to be chosen for the various site-types and growing target are determined on the basis of these tables in management plans which remain valid for 10 yr.

Possible objectives are: 1) production of high-value oak timber; 2) production of lower value assortments in larger quantities; 3) production of assortments of varied quality.

The future directives on oak growing have been compiled by researchers according to ecological conditions. Among them the following are the most important:

– the role of oaks in Hungary will be of determinative importance and their area will increase to a slight degree;

– production of high-value oak timber is to be a target of primary importance, where site conditions are suitable for this purpose;

– better quality oak coppice forests are to be converted into stands of seed-origin as soon as possible;

– sessile oak and pedunculate oak stands have to reforest those sites which are suitable for them and were lost as a result of exaggerated poplar and conifer plantations, or due to incorrect silvicultural practice;

– Turkey oak is to be restricted to its suitable sites.

## GENETIC ASPECTS

In Hungary great importance is attached to population genetics in the production of high-quality oak timber. Our provenance trials verify the genetic diversity of oak stands and the possibilities indicated *via* breeding for production of high-value large-sized oak timber. The oak genetic stock in Hungary also constitutes a considerable value at the international level. Our aim is to preserve this gene stock in its natural variation. There are seed crop stands in sufficient quantity to supply the whole country with good quality acorns produced by controlled methods. These stands and the surrounding reservations provide the basis for growing high-value oak timber in the future.

The oak tree periodic acorn production remains a problem in Hungary. In the course of research on flowering biology and fruit setting, protection against pathogens has been developed. As a result, this periodicity has been somewhat moderated. In addition, some methods aimed at the increase of acorn crops have been developed for the most excellent stands. Collection and storage of acorns produced by controlled methods, however, present problems. There are well-proven and successful techniques for seedling production. In general, traditional methods have been implemented, although vegetative propagation is also practiced to a small degree with promising results.

## SOME PROBLEMS OF REFORESTATION AND AFFORESTATION WITH OAKS

The natural regeneration ability of oak is excellent, both as regards regeneration from seeds and from sprouts. In spite of this, the quality of oak regeneration in Hungary is questionable in many instances, the main reason being damage due to game. Growing of high-value oak timber and its stand-structural basis is disturbed by game species on many occasions. In some areas, the valuable young growth has been totally nibbled away, oak plants frequently become completely extinct and their area is occupied by hornbeam or by an even less valuable species.

To grown high-value oak timber, the establishment of new oak forests by natural regeneration from seeds or artificially by acorn-sowing is necessary.

The generative ability of oak species is promoted by the weight, high water content and protective seed-coat of acorns, by vigorous cotyledons and vigorous rooting of seedlings. At the same time, in oaks the susceptibility of germinating plants to frost and dryness and the high oxygen demand of acorns are unfavourable traits. Oak acorns are a favourite source of food for game, and this is also disadvantageous. It is considered favourable, on the other

hand, that abundant leaf fall after acorn fall promotes the development of water content and the well-oxygenated environment necessary for the germination of acorns. Forest-floor litter remains moist, because the condensation during nighttime cooling ensures a high vapour content and favourable conditions for germination.

The best seed bed is provided by dense pedunculate oak stands, because their soil surface is not overgrown with grass as in sessile oak stands. Maintenance of a denser stand structure, required for growing high-value oak timber, also helps natural regeneration.

## METHOD OF NATURAL REGENERATION

In Hungary the shelterwood regeneration method, beginning with uniform opening of stands and lasting for 6 to 12 yr, is widely applied due to the rarity of acorn crops. The first acorns appear, in general, when the tree is aged 50 yr; then, every 6th to 10th year the crop is more abundant. Turkey oak and red oak are exceptions. The abundant acorn crops of these oak species make up for the lack of sessile oak and pedunculate oak acorn crops in the intercurrent periods. According to research, the flowering of these latter species is also abundant, but frosts and various pathogens may decimate or spoil the crop. Therefore we prefer individuals and stands of later budding, if they are of sufficient quality.

## ARTIFICIAL REGENERATION

Though we encourage natural regeneration, ≈ 75% of our oak stands have to be artificially reforested owing to several failures of natural regeneration and other reasons. When an acorn crop is abundant, sowing in rows is widely practiced, generally by using 600 to 800 kg acorn per hectare. Stand establishment *via* planting seedlings is usually successful. For the time being, 6 to 10 thousand seedlings per ha have been planted. This number of seedlings is enough, mainly if hornbeam, beech and accessory species from natural regeneration fill in the vacant areas.

## SOME RECOMMENDED PRACTICES FOR GROWING OAK TIMBER OF HIGH VALUE

Following reforestation and afforestation in oak stands tending tasks, are extremely complicated due to the very diverse structure of stands. In addition to the general directives, specific practices are to be determined by subcompartments.

Frost sensitivity, the vitality of accessory species, the formation of wild offshoots and the demand for increased light with age all cause difficulties in regenerating stands. At the same time, the good regenerative ability, the considerable differentiation between trees at young ages and the potential for longevity, all indicate favourable solutions. Research on tending, which has been conducted for 3 decades in long-term experimental plots, has determined the following:

– after successful reforestation or afforestation with oak species, sprouts of oaks and undesirable subordinate species are removed. However, to produce high-value oak timber, heavy opening of stands should always be avoided. The first cleanings, which have to be repeated every 4 to 6 yr, are generally characterized by group selection;

– thinnings begin at age 30 to 40 yr when the choice of plus (superior) trees is possible. The number of plus trees ranges be-

tween 150 and 450 per ha. The thinning cycle is 6 to 8 yr in young stands, and 10 to 14 yr at later ages. It is an important rule that thinning operations cease 15–20 years before the final cutting age. Efforts have to be made to ensure that the stands are composed of the highest quality trees and that they are fully stocked by that age.

As a result of the research carried out, tending regime tables are at our disposal for pure stands of all of our oak species and for mixed oak–hornbeam, oak–hornbeam–beech and oak–beech stands. These tables provide directives on the time (age) and intensity of cleanings and thinnings, the recycling time, and provide normative information on the following data of the remaining stand: number of stems ($N$/ha), total basal area ($G$ m$^2$/ha), mean DBH ($D_m$), mean height ($H_m$), wood volume ($V$ m$^3$/ha) and spacing. In addition, tables give the age of final cutting and the number of plus trees. All these data are shown in tables by yield classes.

## TENDING OF MIXED OAK–HORNBEAM–BEECH STANDS

Considering the limited length of this paper, description of the methods on growing high-value timber for all valuable oak stands in Hungary is not possible. On this occasion, only the tending of mixed oak-hornbeam–beech stands will be described as they produce the most valuable oak timber.

The site requirements of pedunculate oak, beech and hornbeam are simular, though some of their traits, *eg* light requirement, growing vigour, etc, are considerably different. First, the growth of tree in height and in diameter must be equalized. Both factors are very important for producing high-value oak timber. The common base is the depth of tilth which determines the water regime of the soil and the growth of these species.

The first task in these stands is to regulate the mixture of species of the following 4 tilth depth categories: 41–60 cm, 61–80 cm, 81–100 cm, and > 100 cm. Up to 60 cm the role of hornbeam is increased, from 61–80 cm beech is increased in the mixture, over and above oaks, and between 81–100 cm the proportion of beech and oak should be nearly the same, because in this case beech trees are already in the dominant (upper) crown story and not in the lower one.

Taking into account the growth of trees: up to tilth depth of 60 cm on a dry site, the growth of pedunculate oak is the most vigorous oak species. In the course of thinnings and cleanings, limitation of hornbeam and beech does not constitute a problem.

If the depth of tilth ranges between 61–80 cm and the water supply is favourable, owing to their higher vitality, hornbeam trees are able to grow better than the 2 other species. Their limitation therefore demands more labour. Pure hornbeam consociations have been developed in Hungary on these sites due to faulty tending operations.

On fresh and half-dry sites with tilth of 80–100 cm deep, beech trees grow vigorously. Hornbeam tree growth is restricted, but sufficient growing space is to be ensured for oak trees in due time.

Soils with tilth of > 100 cm can be found in Hungary mainly in valleys where all 3 species grow well. Due to the frequent risk of frost and late frosts, beech tree growth is retarded and hornbeam trees become dominant. Individual stems of oaks grow excellently on these sites.

For oak stands mixed with beech and hornbeam the regime tables, different from those generally used, were prepared in the course of the research. In these tables,

consider the extraordinarily wide diversity of these stands, the time for cleaning, thinning and final cutting, and the data of the remaining (to be maintained) stand relating to the finishing point of time of these operations are given. In addition to the mixture proportions to be attained in stands depending on the age, the tables also show the above-mentioned data ($N$, $G$, $D_m$, $H_m$, V) for the 3 species – oak, hornbeam and beech.

Only the major problems of growing high-value oak timber have been outlined. These problems will continue to be given priority in the country's forestry research programme even in the future. In my opinion, as regards international research coordinated within the frame work of IUFRO and the European Community, Hungary could provide most scope in the establishment, maintenance and development of mixed, stable broad-leaved forests, especially in connection with growing high-value oak timber. The political and economical changes which took place in our country in 1989–1990 have favourably promoted international cooperation in forestry research amongst other areas. We therefore propose to initiate research cooperation in the theme of managing mixed natural forests, by drawing into this study all those interested in our continent.

## REFERENCES

Solymos R (1962) Research on forest tending and yield-science in ERTI. *Az Erdõ* 11 (12), 560-565

Solymos R (1965) Thinning investigations in the sessile oak stands at Lajosforrás. *Erdészeti Kutatások* 61 (1-3), 29-38

Solymos R (1969) New yield tables for the Hungarian forests. *Az Erdõ* 18 (3), 125-129

Solymos R (1978) Trends in thinning. *Az Erdõ* 27 (10), 472-476

Solymos R (1980) Selection and treatment of seed-crop stands. *Az Erdõ* 29 (9), 400-401

Szappanos A (1969) Exposure to light of sessile oak stands and its effect on renewal growing. *Erdészeti Faipari Egy Tud Közl* 2, 89-104

Szappanos A (1983) Directive on growing sessile oak elite trees and plus trees. *Erdészeti Faipari Tud Közl* 2, 85-100