Quality of Red Oak (*Quercus rubra* L.) Stands on Abandoned Agricultural Land

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The quality and wood yield of two middle-aged Red oak stands established on abandoned land in central part of Lithuania were assessed. For comparison, a number of native to Lithuania middle-aged English oak stands grown on the corresponding site type in the same climatic zone were evaluated. The Red oak stands at age 40 to 45 years produced 300 m³ of wood per ha. On the same site type and at the same age, Red oak was superior in wood yield over English oak: by 28-45 % in mean stand height, by 25-50 % in mean stem diameter and by 83-91% in mean stand wood volume. In comparison with English oak stands, Red oak stands grew faster up to the age of 50 followed by a gradually more slowly growth. However, in Red oak stands, a high proportion of curvy and forked trees with spike knots were found. These defects may be attributable to frost damage on trees with less suitable growth rhythm for a given temperature climate. A low intensity breeding programme was suggested to cover choice of appropriate provenance and selection of good quality trees within already introduced provenances. Based on this breeding programme, seed sources for afforestation of abandoned land with Red oak origins of appropriate growth rhythm may be selected. Red oak stands mixed with other tree species may be established, which would increase biodiversity of future forests on abandoned land and would produce wood of appropriate commercial quality on a relatively short rotation. Recommendations for management and establishment of an improvement programme for Red oak stands were given.

Key words: exotic species, frost damage, growth rhythm, stand management, selective thinning.

Introduction

One of the first written records on native to Canada *Quercus rubra* was made in 1735 by K. Linne, who named this species as Red oak owing to the reddish colour of its wood. In the natural range of occurrence, pure stands of Red oak occur quite seldom, it rather grows mixed together with ash, hornbeam, aspen, birch, maple, English oak, pine, spruce and fir species (Eizenreich 1959).

Red oak was introduced to Europe some 150 years ago (Chepatev and Pavlenko 1962) and to Lithuania in 1875 (Ramunauskas 1963). Similarly to other introduced species, Red oak was first planted in parks and later in 1890-1985 was used for establishment of forest. In Lithuania, Red oak stands of good quality may be found in Stanaičiai, Ažpurviai, Begėdžiai, Giruliai and Norkaičiai forest districts. During last several decades, a number of good quality Red oak stands were established in central Lithuania.

In comparison with English oak, Red oak's needs in soil fertility are somewhat low and grows faster. In particular, Red oak grows well and yields high volume of good quality wood in admixture with Norway spruce and Douglas fir. In Matrosov forest district of Kaliningrad region, Red oak trees in an 80-year-old stand reached mean tree height of 32 m, mean diameter of 24 cm and wood volume 860 m³/ha (Tuminauskas personal communication). Of all forest tree species, Red oak provenances introduced in Lithuania are least susceptible to insect damage and produce regular seed crops. In addition, Red oak is relatively more tolerant to air pollution and is well absorbing CO_2 and improving soil fertility. This may improve the success of establishment of Red oak stands. Wood quality of Red oak is not worse than that of English oak. Though wood of Red oak is 7.5% lighter than wood of English oak, it performed better in under crashing and breaking tests (Shutajev and Jacino 1974).

When grown at narrow spacing, Red oak is often infected by fungi *Stereum rugosum*. In forest stands, Red oak is usually capable to form young undergrowth and the second layer. According to Luderman (1987), it is worth to establish Red oak stands for the following purpose: (1) to form mixed broadleaved stands with admixture of Red oak, which would improve commercial value of the stands, (2) to improve stability of the stands by planting Red oak at the forest edge, (3) to establish fire prevention belts (good coppice and seed regeneration), (4) for decorative purpose, (5) commercial profit

on abandoned agricultural land as Red oak may form stable stands and may produce wood of high quality over a comparatively shorter period of time.

After study of growth characteristics of Red oak stands in Lithuania and Kaliningrad region, Gradeckas and Malinauskas (1990) have concluded that (1) wood yield of Red oak stands is the greatest on normally irrigated fertile and very fertile as well as on temporarily overmoistured fertile site types; on normally irrigated poor sites, Red oak may be established mixed with other species, (2) on normally irrigated fertile sites, at the juvenile stage, Red oak grows faster than English oak, however, at the later stages, no marked difference in growth rate between these species was observed; on this site type, larch, Black alder and birch grow faster than Red oak; as Red oak grows well in the understory, it may be mixed with all tree species (3) on average, at age of 50 years, Red oak stands may produce 700 m^3 of wood per ha; stem nucleus wood of Red oak is more hard than that of English oak, however, there is a higher proportion of curvy forked trees with coarse branches in Red oak stands than in English oak stands, (4) breeding towards high wood yield and wood quality may markedly rise the value of Red oak stands.

Fast growth, tolerance to environmental stresses, ability to grow well on a number of soil types and in mixture with many tree species, comparatively shorter rotation for production of high wood quality are the main advantages of Red oak which advocate for a broader use of Red oak in forestry by afforesting abandoned land. However, without selection of appropriate provenances and further breeding plan, commercial profit from Red oak stands may be minor. For instance, if early flushing provenances are planted on open land, the risk for spring frost damage will be high, which would markedly reduce the quality of Red oak trees (Danusevicius, 1999). After identification of the most suitable provenances for certain climatic zones, selection of the best individuals into seed orchards may further rise wood yield and quality. To facilitate the discussion on the possibilities to use Red oak in afforestation of abandoned land, a study on economically valuable properties of already existing Red oak stands would be of value.

The objective of this study was to discuss the advantages of afforestation of abandoned agricultural land with Red oak based on (1) assessments of economically valuable growth traits of Red oak trees in two stands established on abandoned land in Alytus forest district and (2) comparison of wood yield and quality of the Red oak stands with native to Lithuania English oak stands grown on corresponding site types in Alytus forest district.

Material and methods

Two artificially established stands of Red oak were selected in Alytus state forest enterprise, Alytus forest district: the first stand (stand No. 1) on site No. 47 in compartment No. 46, (area 1.2 ha, established in 1955, age 45) and the second stand (stand No. 2) on site No. 52 in compartment No. 46 (area 2 ha, established in 1960, age 40). The stands originate from Raminta and Labgala forest tracts in Prussia (presently Kaliningrad region). The stands were established with the initial spacing of 5000 trees per hectare (planting distance 2 x 1 m). The stands were thinned at pole stage by removing low quality trees. In addition, to compare Red oak wood yield traits with the corresponding traits of native to Lithuania English oak, the data from 8 Red oak and 12 English oak stands grown on normally irrigated rich site type in a number of environments were used (Danusevičius and Gabrilavičius 1997).

Wood yield and quality of the stands were assessed by means of sample plots established in the central part of the stands. Height, diameter, length of stem portion without branches, branch thickness, height to fork, stem straightness, presence of spike knots, amount of dwarf shoots on the lower part of the main stem and heath condition were assessed on all trees in the sample plots. From these measurements, total stand wood volume, bonitet and stocking level were calculated.

Results

On the same site type and at the same age, Red oak was superior in wood yield over English oak: by 28 - 45 % in the mean stand height, by 25 - 50 % in the mean stem diameter and by 83 -91% in the mean stand wood volume (Fig. 1). In comparison with English oak stands, Red oak stands grew faster up to the age of 50 followed by a gradually more slowly growth (Fig. 3).

In both Red oak stands, a sharp differentiation of trees into growth classes is on going, e.g. the coefficient of variation in tree diameter was from 46 to 56 %. The mean annual increment of Red oak stands No.1 and No. 2 was 6.9 and 7.1 m^3/ha, respectively, which on average is double as high as in the English oak stands (3.7 m^3/ha). Mean annual tree increment in Red oak stand No. 1 was 26.9% higher than in stand No. 2 (0.0085 m^3 and 0.0067 m^3 respectively). However, owing to a more narrow spacing and higher age, the mean wood volume was greater in stand No. 1 than in stand No. 2 (Table 1).

The patterns of tree height distribution curves reflect the outcome of competition among the trees meaning the necessity to perform a selective thinning

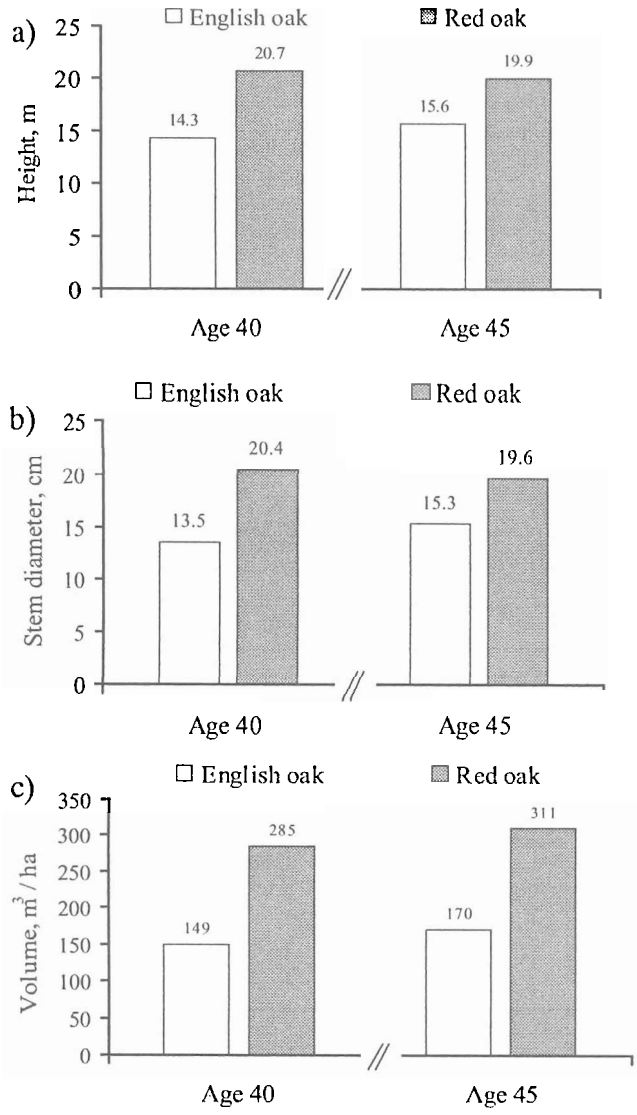

Figure 1. Mean stand height (a), mean stem diameter at 1.3 m height (b) and mean volume (c) of two English oak and two Red oak stands on normally irrigated fertile (Ncl) site type in Alytus forest district (measured on October 1, 2001). Red oak stand No. 1 is given to the right (age 45 years) and Red oak stand No. 2 is given to the left (age 40 years).

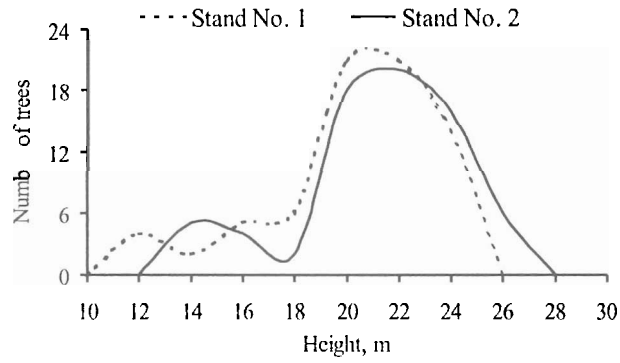

Figure 2. Height distribution curves of Red oak trees in sample plots established in stand No. 1 and stand No. 2 in Alytus forest district.

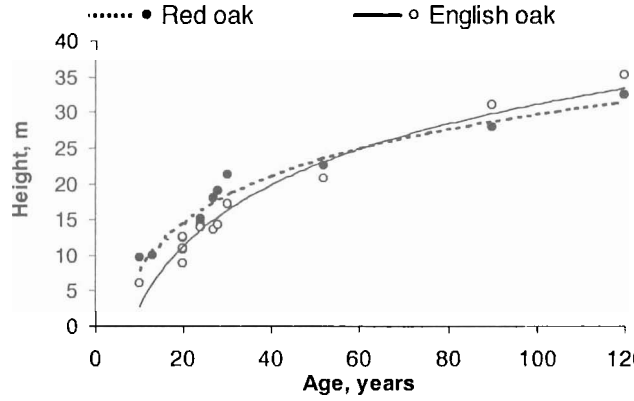

Figure 3. Height growth pattern of Red oak and English oak stands grown on rich soils in normally irrigated sites in Lithuania.

in the Red oak stands (Fig. 2). Trees up to 18 metres high form the second layer in the stands. It would be possible, on average, to obtain 20-25 m^3 of sawn wood per ha from selective thinning as well as to improve the quality of the oak stands and create a better light regime for increased seed yield (Table 1). The trees for removal were selected according to an index of the following criteria: if tree diameter is 25 % and more percent less than the mean tree diameter in the stand, curvy, forked trees and trees with spike knot, very coarse branches and a large number of dwarf shoots on the main stem as well as damaged by fungi (Table 2). In addition, spatial distribution of the trees was considered to avoid glades within the stands. This selective thinning was of a comparatively low intensity by removing 11% of trees in stand No. 1 and 12% of trees in stand No. 2. A successive thinning may be performed later by considering further development of the stands. Too intensive thinning may result in a dense cover of ground vegetation and lower shrub species, which may disturb natural regeneration of Red oak. The quality of the trees selected for removal was comparatively low (Table 2). Thus, the selective thinning improved the mean wood yield and quality parameters of the stands: all trees with observable fungi damage were removed, the proportion of minus trees decreased by 10% and 20 %, the proportion of forked trees decreased by 4 % and 6 %, and that of trees with spike knots lessened by 4 % and 8 % in stand No. 1 and No. 2, in stand No. and No 2, respectively (Tables 1 and 3).

Table 1. Growth traits of two Red oak stands in Alytus forest district (measured at 2001.10.01). Data on stand No. 1: compartment No. 46, site No. 47, area 1.2 ha, age 45, site type normally irrigated rich, bonitet I. Data on stand No. 2: compartment No.46, site No. 52, area 2.0 ha, age 40, site type normally irrigated rich, bonitet IA

Status of stand at the time of assessment	Number of trees		Mean tree H, m	Mean tree D, cm	Stocking level	Mean tree volume, m^3	Mean wood volume, m^3	
	in 1 ha	in stand					in 1ha	in stand
Stand No. 1								
Assessment before selective thinning	1038	1246	19.9	19.4	1.1	0.30	311	374
Assessment after selective thinning	923	1108	20	19.6	1.0	0.31	286	343
Stand No. 2								
Assessment before selective thinning	869	1678	20.7	20.4	0.9	0.34	285	571
Assessment after selective thinning	734	1469	20.7	20.4	0.8	0.34	250	500

Table 2. Growth traits of Red oak trees to be removed by means of selective thinning in two stands established in Alytus forest district (measured at age 45 and 40, respectively). Percentage values are expressed from the total number of the removable trees. For stand description see Table 1

Stand No.	Number of trees to be cut	Mean D, cm (min-max)	Mean H, m (min-max)	Mean V, m^3	Total volume of trees to be removed, m^3		% of forked trees	% of curvy trees	% of trees with coarse branches	% of trees with large many dwarf shoots in the stem	% of trees damaged by fungi	No/ % of minus trees	No./ % of average quality trees
					in 1 ha	in stand							
1	137	18 (12-40)	18 (15-25)	0.225	25	31	64	75	49	74	3.1	112/82	25/18
2	209	20 (8-40)	21 (11-27)	0.340	35	71	51	69	42	69	3.6	159/76	50/24

Table 3. Improvement of quality of the two Red oak stands by means of selective thinning (measured at 2001.10.01). The coefficient of variation is given in the brackets. For stand description see Table 1

Stand status	Tree number in stand	Average tree traits				Mean stand properties						
		Stem length, m		Stem straight. 1-v. curvy 2-curvy 3-steight	Branch thickn. 1-coarse 2-avg. 3-thin	Amount of dwarf shoots on stem 0-absent 1-avg. 2-many	% of trees with many dwarf shoots on stem	% of trees with spike knot	% of forked trees	% of productive trees	% of minus trees	Number of trees infected by fungi
		To dry branch	To living branch									
Stand No. 1												
Before thinning	1246	6.7(56)	7.4 (57)	2.3 (27)	2.1 (38)	0.8 (98)	18	19	19	38	27	7
After thinning	1108	7.0(54)	7.5 (55)	2.5 (26)	2.2 (32)	0.5 (91)	10	11	15	53	7	-
Stand No. 2												
Before thinning	1678	8.5(46)	9.9(37)	2.5(22)	2.1(37)	0.7 (107)	21	10	24	44	15	11
After thinning	1469	8.4(43)	10(36)	2.6(22)	2.3(33)	0.4 (90)	13	6	18	52	5	-

The following four distinct types of crown shape were found in the Red oak as well as English oak stands: brush-like, oval, round (broad branches) and forked (Fig. 4). The trees with brush-like and oval crown shape were of the highest wood yield and quality.

In comparison with English oak, the advantages of Red oak trees were fast growth, ability to form dense stands, abundant seed crop, good natural regeneration. Whereas, the disadvantages were the following: forked trees (almost each fourth tree), curvy stems (16-23% of the trees were with curvy stems), spike knots (an indicator of frost damage meaning inappropriate growth rhythm to the given climatic zone: 10-19% of trees were with spike knot), fungi infections in dense tree groups, many dwarf shoots on the upper part of the main stem (each fifth tree possessed a high number of dwarf shoots). These may be the quality criteria to be improved with the aid of selection and management of seed collection stands. Considering the possibility to raise the quality of Red oak stands by means of tending and selective thinning, it would be reasonable to establish Red oak stands with a relatively more dense spacing of some 8000 trees per hectare.

Conclusions

The provenances of Red oak introduced into the central part of Lithuania are suitable for production of commercial wood and may be used in afforestation

of abandoned agricultural land in this region. On normally irrigated site type with rich and very rich soils, Red oak performs well and grows faster than native to Lithuania English oak. In addition, it possess good potential for natural coppice and seed regeneration and there is no marked difference in susceptibility to fungi and insect damage from other native tree species.

Among the negative properties, a relatively higher proportion of curvy and forked trees as well as trees with spike knot were found. This may be a consequence of frost damage owning to inappropriate growth rhythm to a given temperature climate. The trees which start growth early in spring may suffer from late spring frosts or vice versa the trees which cease growth too late may be damaged by autumn frost or develop too low frost hardiness to stand winter frost damage (Hannerz 1998, Danusevičius 1999). As a first step to avoid the frost-related damage, a selection of seed trees with a suitable growth rhythm may be performed. As the second step, a provenance experiment to assess the most suitable origins as regards growth rhythm under a number of climatic zones may be established. If afforestation with Red oak will obtain a broader scale, a low intensity breeding program (selection of seed collection stands and plus trees from already introduced provenances and study of new foreign provenances in a number of field tests) would be of value. In addition, Red oak stands may be established with a relatively more dense spacing (not less than 8000 trees per ha) to make it possible to improve stand quality and condition by a series of tending or selective thinning.

The following management of the Red oak stands aiming at sustainable production of good quality wood is recommended:

- avoid high soil compaction in the stands in the course of management operations (this would decrease the potential of natural regeneration),

- allow coppice regeneration, which would decrease the abundance of ground vegetation and later may be removed by means of thinning (as coppice trees usually are of lower quality than seed trees),

- in the open spots (glades), groups of oak trees may be planted, which may later constitute a multi layer stand structure; for this purpose, 1.5 to 2 m high trees would be most suitable; also the stands may be enriched with other tree species (e.g. lime, maple, hornbeam).

- at age 50 years, 40 to 50 plus trees may be selected and scions of these trees may be taken to establish grafted (clonal) seed orchards to produce high quality and easy accessible seed,

- a progeny test of superior trees may be established with the objective to test the phenotypic superiority according to performance of the progeny and simultaneously use the progeny test for seed collection (as family seed orchards); selective thinning in these tests may be possible to a further rise in the quality of the seed crop,

- good quality Red oak stands may be approved as seed collection stands and included into the national list of seed collection sources.

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КАЧЕСТВО НАСАЖДЕНИЙ КРАСНОГО ДУБА (*QUERCUS RUBRA* L.) НА ЗАПУЩЕННЫХ ЗЕМЛЯХ ПОСЛЕ СЕЛЬХОЗПОЛЬЗОВАНИЯ

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Резюме

Интродукция красного дуба (Quercus rubra L.) в леса Литвы начялось 110 лет таму назад. Его насаждения можно обнаружить в различных частях края. Красный дуб отличается высокой адаптичностью. Он быстро растет, обильно плодоносит, устойчив к морозам, меньше чем обыкновенный повреждается оленьевыми.

Насаждения 40-45-летнего возраста продуцируют более 300 м³/га древесины. По продуктивности в выше указанном возросте он превышает дуба обыкновенного на 83-91%, по высоте – на 28-45% и по диаметру ствола – на 25-50%.

В насаждеиях дуба красного заметно много двухствольных и кривоствольных деревьев. Поэтому, при его разведении необходимо осуществить селекционные мероприятия в виде индивидуального отбора в древостоях, выросших в местных Литовских условиях, и создания клоновых семенных плантаций для получения генетический улучшенного семенного материала, а в древостоях лучших по качеству стволов произвести селекционные рубки с целью трансформирования их в семенные насаждения.

Ключевые слова: инродукция, обмерзание, ритм роста, семенное насаждение, селекционные рубки.